MARY SOMERVILLE AND MARGARET HUGGINS: A COLLABORATIVE VOICE AT THE EMBRYONIC STAGES OF NINETEENTH-CENTURY ASTRONOMICAL SPECIALIZATIONS

JEAN KOO

A DISSERTATION SUBMITTED TO
THE FACULTY OF GRADUATE STUDIES
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

GRADUATE PROGRAM IN HUMANITIES
YORK UNIVERSITY
TORONTO, ONTARIO

April 2013

ABSTRACT

This dissertation investigates the authorial presence of two practitioners at the embryonic stages of two specializations in nineteenth-century astronomical research. Mary Somerville used prismatic analysis to separate solar rays and Margaret Huggins applied photography to spectrum analysis. How these scientific persons wrote about their experiments and outcomes in scientific papers will be assessed. My work will demonstrate that both Somerville and Huggins wrote most effectively in a collaborative voice although they wrote for different audiences. Their voices linked their own work with that of their peers as spectrum analysis provided a more "intimate" way to look at the stars.

DEDICATION

In memory of my parents
Victor and Eva

ACKNOWLEDGEMENTS

"They have wakened the timeless Things"
Rudyard Kipling (1896)

When I was earning my master's degree in English I happened upon a talk on Victorian Science. It was at this seminar that "timeless Things" or insatiable curiosities were awakened within me. My interest shifted to Science and Humanities and it is in this discipline that I now make my home.

In the writing of this PhD dissertation I have been generously aided on many fronts. This acknowledgement does not express how deeply grateful I am to the following people: Ruth R. Rogers, the Special Collections Librarian at Wellesley College, assisted me in researching the fragile Hugginses Notebooks. Mariana S. Oller, the Associate Curator of the Special Collections at Wellesley College, granted me permission to photograph various pages of the Notebooks and aided in the endeavour.

Hannah Westall, the archivist at Girton College, Cambridge secured the photographs for the Somerville Section, at minimal cost, for this dissertation.

Rajiv Nariani, librarian at the Steacie Science & Engineering Library, answered countless questions for the construction of this dissertation.

Dr. Barbara Becker helped me formulate key questions before I began looking through the Hugginses material at Wellesley. I also thank Barbara for sharing her extensive knowledge on the Hugginses with me.

I thank Dr. Katharine Anderson for breathing new life into the dissertation process at its most dormant hour. Katey's knowledge of narration has been a great asset to me. As well, I thank Katey for her encouraging words, as the years dragged on, that "dissertations do not write themselves."

I am very grateful for the extensive contribution made by Dr. Bernard Lightman. Bernie has relentlessly, and honestly, aided in the editing of this dissertation. I thank Bernie also for his valuable knowledge on Victorian Science and Culture, which he has shared with me through the years.

This dissertation would not have been possible without the enormous contribution by Dr. Martin Fichman. Martin's knowledge of the rise of modern chemistry and its impact on nineteenth century astronomy helped me sort out the numerous debates that Mary Somerville and Margaret Huggins took on in their life-times. Most of all, I thank Martin for his truthful comments, for maintaining his humour through the years, and for always ending our revision sessions on a positive note.

There were many times when I wanted to stop the writing process yet continued only because of the enormous amount of work that Katey, Bernie, and Martin had put into this dissertation. Although this dissertation relied on the input of my supervisory committee, any inaccuracies, omissions, and faults are my own.

Dickson and Donald, my sons, I thank for their love, support, and understanding. I hope that you will find passions to awaken you at various stages in life. My greatest thanks go to my best friend and husband, Stephen, for taking care of our family.

TABLE OF CONTENTS

Abstract ii
Dedication iii
Acknowledgments iv
Table of Contents vi
List of Illustrations ix

Introduction 1

Chapter One: Mary Somerville and Spectrum Analysis 19

Chapter Two: Mary Somerville: The Research Papers 52

Chapter Three: Mary Somerville and Writing for a Public Audience 75

Chapter Four: Emerging Fields of Inquiry 112

Chapter Five: Margaret Huggins and Entering a Practice 135

Chapter Six: The Research Papers: 1876 – 1889 158

Chapter Seven: Margaret Huggins and Engagement 178

Conclusion: Comparative Analysis 203

Bibliography 212

LIST OF ILLUSTRATIONS

Figure 1:
Portrait of Mary Somerville by Samuel Lawrence (1836) 67

Figure 2:
Portrait Bust of Mary Somerville by Lawrence MacDonald (1922) 111

Figure 3:
Observations of Mars (1856) 119

Figure 4:
"Catalogue of Photographs of Stellar Spectrum" 144

Figure 5:
"Lockyer" 192

MARY SOMERVILLE AND MARGARET HUGGINS:

A COLLABORATIVE VOICE AT THE EMBRYONIC STAGES

OF NINETEENTH-CENTURY ASTRONOMCIAL SPECIALIZATIONS

INTRODUCTION

*****

Mary Somerville and Margaret Huggins

Authors disseminate information in imaginative ways as they cultivate distinct identities in narration. Post-structural theorists include in their definition of author that of "a 'space' in which conventions, codes, and circulating locutions precipitate into a particular text, or else as a 'site' wherein there converge, and are recorded, the cultural constructs, discursive formations, and the configurations of power prevalent in a given cultural era."[1] This dissertation compares the "cultural constructs, discursive formations and configurations of power" that participated in the coming into being of two authors, Mary Somerville (1780 – 1872) and Margaret Huggins (1848 – 1915), during the rise of two particular specializations in astronomical study. [2] My aim is to illuminate Somerville and Huggins, the authors, through a textual analysis of their published and unpublished documents. I will demonstrate that Somerville and Huggins constructed their most influential narrative presence when they engaged and collaborated with the theories of noted scientific men. Yet, Somerville's and Huggins' individual narration was not that of a passive secondary practitioner because their added voice provided growing solidity to new and often shaky arguments. As their authorial presence became more visible in their

[1] M. H. Abrams, *A Glossary of Literary Terms* (Boston: Heinle & Heinle, 1999), 15.
[2] Mary Somerville will be referred to as Somerville. Margaret Huggins will be referred to as Huggins.

fields of inquiry, Somerville and Huggins were able to use this process, collaborating with major scientific figures, to gain greater access into the inner layers of scientific society.

This dissertation will examine the published papers of Somerville and Huggins in *Philosophical Transactions* and *Proceedings of the Royal Society of London* in order to investigate how this methodology, for these two women, slowly solidified their presence in scientific journals. From this topography the dissertation will examine the production of other texts Somerville and Huggins became involved in and investigate the fluidity of writing between scientific papers, popular artifacts and personal Notebooks. This comparative study invites a reinterpretation of the authority of the collaborative voice in various texts as two astronomical specializations, namely spectrum analysis and astrophotography, began to emerge in the nineteenth century.

By analyzing the scientific papers of Somerville in a chronological order I will map the evolution of her narrative presence in various debates, which held the attention of the scientific community in the 1820s, 1830s, and 1840s. On occasion, the addition of her supportive voice made available avenues that were otherwise restricted to the well-connected practitioners. The William Huggins' and later the Hugginses' papers will also be examined in chronological order. Huggins first established her authority in the Hugginses Notebooks before she began publishing alongside William in *Proceedings*. I will outline Huggins' slow and careful emergence as a member of the inner core of astro-photographers from the late 1870s to the early 20th century. Somerville's and Huggins' involvement reveal that collaborative writing made entry points into publication possible for those seeking greater access to the various circles of experimenters and practitioners of science.

In addition, this analysis of these two women forces a reinterpretation of gender in scientific culture in the 1800s. The use of this method, that is supporting a position or engaging in an experiment with a well-known practitioner to establish an entry into science, was a tool employed by male practitioners during this period as well. For example, Michael Faraday's (1791 – 1867) early mention in *Philosophical Transaction* was in Humphry Davy's (1778 – 1829) experimental papers. In "On the Fallacy of the Experiments in which Water is said to have been formed by the Decomposition of Chlorine" Davy stated that Faraday had "assisted" in these sets of experiments.[3]

Somerville and Huggins were similarly published in scientific journals; however, Somerville's status as a well-regarded researcher was not gained in the initial stages of her practical work. She was most prominent when her experimental outcomes were published as part of François Jean Dominique Arago's (1786-1853) and John Herschel's (1792-1871) working hypotheses. From her work with Herschel, Somerville moved on to popular writing creating an amiable chatter format in her first publication on mechanical astronomy and a conversationalist format in her second book on atmospheric conditions. *On the Mechanism of the Heavens* (1831) [4] and *On the Connexion of the Physical Sciences* (1834)[5] secured Somerville's reputation as a popularizer. Somerville's *Mechanism* was also a work of collaboration as she transformed and translated the theories in Pierre Simon, Marquis de Laplace's (1749 – 1827) *Traite de Mecanique*

---

[3] Humphry Davy. "On the Fallacy of the Experiments in which Water is said to have been formed by the Decomposition of Chlorine," *Philosophical Transactions of the Royal Society of London* 108 (1818): 171.

[4] Mary Somerville, *On the Mechanism of the Heavens* (London: John Murray, 1831).

[5] Mary Somerville, *On the Connexion of the Physical Sciences* (London: John Murray, 1834).

Celeste (1799 – 1825) for a popular reading public. *Connexion* offered no new hypotheses but rather illuminated to the reader the broad theories, which contributed to the early to mid-nineteenth century understandings of the workings of the cosmos.

Like Somerville, Huggins' experimental observations were most noted when her findings supported the theories of a famous practitioner, namely William Huggins (1842-1910). The Hugginses published joint papers in *Proceedings of the Royal Society of London* between 1889 and 1906. By looking at the Hugginses Notebooks in unison with the *Proceedings* papers I will argue that Huggins and William each created a distinct narrative identity as they introduced Huggins to *Proceedings*. Her narrative voice was carefully brought forth as the couple participated in several debates in the "New Astronomy" from the mid-1870s onwards. The published papers reveal the slow processes of Huggins' coming into being as a distinguished astronomer. Excitingly, these papers, when studied in chronological order, also map the slow rise of photography as a credible tool in spectrum analysis.

In addition, Huggins wrote privately in a set of Notebooks, which recorded not only scientific data but also the daily practices at Tulse Hill Observatory. Huggins distinguished her authorship from William with her point by point entries, which noted every outcome as the experiments were taking place. This ability made her of great value as a scientific narrator, and indeed Huggins was to take over the narration of the Notebooks from the period she began working at Tulse Hill. By examining the private Notebooks one can concentrate on the arduous processes that were undertaken to reach the often much needed collaborative stance used to publish their joint papers in *Proceedings*. As the years passed, Huggins' growing confidence as an experimenter is revealed in these documents, yet her name was not added to print for seventeen years. The circumstances surrounding her first publication will illustrate the tensions the Hugginses underwent to include Huggins in papers published in *Proceedings*.

Mary Somerville

Somerville performed original research in 1825 which focused on finding a causal relationship between solar rays and magnetism. Her findings revealed that when solar rays were refracted through a prism, certain colours held magnetic influence. This outcome was documented in a paper titled, "On the Magnetizing Power of the more Refrangible Solar Rays" (1825).[6] "Magnetizing Power" was read before the Royal Society and published in the prestigious *Philosophical Transactions of the Royal Society of London*. The paper and research marked Somerville's entry as an experimenter in starlight analysis, yet for her to maintain credibility proved to be a process that relied on the support of other practitioners.

In the early 1820s when Somerville began her research, magnetism was a developing field of inquiry and claims pointing to a causal relationship with the sun's rays were yet to be solidified. Davy stated in "On a New Phenomenon of Electro-Magnetism" (1823), "[...] the science [magnetic study] is in a state too near its infancy to expect the development of any satisfactory theory."[7] It was in this developmental period that Somerville, a woman who was unaffiliated with any scientific society and had no access to equipment from any institution, was able to experiment, collect findings, support a theory, and put forth a new hypothesis in a prestigious scientific journal.

---

[6] Mary Somerville, "On the Magnetizing Power of the More Refrangible Solar Rays," *Philosophical Transactions of the Royal Society of London* 116 (1825): 132- 139.

[7] Humphry Davy, "On the New Phenomenon of Electro-Magnetism," *Philosophical Transactions for the Royal Society of London* 113 (1823): 153.

Somerville's research could be carried out because the tools and apparatuses she employed in her analytical work were domestic everyday items and because she had formed a cooperative relationship with numerous important men of science. Somerville's initial authorial presence in the magnetism/solar ray debate set out to verify a highly contentious theory and promote a new hypothesis. A close reading of various papers focusing on the magnetism/solar rays correlation indicates that at the beginning of this debate Somerville, aside from establishing an authorial identity, was cited and often present as a collaborating experimenter in the works of others such as Samuel Christie. I will argue that although a dilettante experimenter, Somerville's findings were much valued by seasoned men of science because she initially set out to substantiate a hypothesis. Somerville participated further in solar research by looking to separate the properties of the sun's rays in the 1840s. These sets of papers will be examined in order to demonstrate that Somerville was, again, most prominent when she engaged the work of well-regarded astronomers.

The alliances Somerville forged while investigating solar rays and magnetic communication, in turn, led to the endorsement of her first popular work, *Mechanism,* by astronomer John Herschel (1792 – 1871). As demonstrated by Herschel's endorsement Somerville, by this time, was becoming well-connected with established astronomers. Although *Mechanism* did not propose any original ideas, Somerville was engaging with the well-established theories of Laplace, yet her translation proved much more than straightforward. Somerville added a lengthy "Preliminary Dissertation" for the purpose of disseminating and promoting British astronomical and scientific ideas to the reader.

The narrative personality that Somerville created in the Dissertation was that of an educated English lady chatting with her readers on British scientific matters. Chatter is informal and lively as portrayed by Emily Bronte, in *Wuthering Heights* (1847). As Heathcliff states upon entering the great house, "[...] but I believe at Wuthering Heights the Kitchen is forced to retreat altogether into another quarter: at least I distinguished a chatter of tongues, and a clatter of utensils ..." [8] This usage encloses the participants of chatter within a place that is intimate and inviting as Bronte's kitchen in *Wuthering Heights* is a place full of life, warmth, generosity, light, and abundance. Chatter suggests sanctuary and one feels security as one retreats to the innermost part of the home to chat. At the same time chatter has the ability to put one at ease, suggests a jovial tone, and promotes goodwill between the speaker and listener. "So I chattered on; and Heathcliff gradually lost his frown and began to look quite pleasant ..."[9] Most importantly, chatter, in the oral tradition, can be used to teach and pass on knowledge. As young Cathy points out, "I see, by my tales, and songs and chatter: you have grown wiser than I, in these six months ..."[10] Somerville's style in the "Preliminary Dissertation" embodies the characteristics of chatter which Bronte brings out in her many usages of the word in *Wuthering Heights*. Somerville's style puts the reader at ease, projects an enclosed space for friends to chat, and embodies the warmth and informality a good read can bring.

Somerville's second popular book on atmospheric matters, *On the Connexion of the Physical Sciences*, showed maturity as she projected the confidence of an organized and well-researched conversationalist who was reiterating the findings of scientific men as they formulated theories about the cosmos. Gone was the "chatter of tongues" and

---

[8] Emily Bronte, *Wuthering Heights*, (New York: Vintage, 2009), 3.
[9] Ibid., 65.
[10] Ibid., 299.

joviality present in *Mechanism;* yet, as the popularity of *Connexion* demonstrated, this more mature format was greatly admired by her readers. Again, Somerville proposed no new concepts but her writing engaged existing theories in a way that made them accessible to the reading public.

Work has been done on Somerville by contemporary scholars of the nineteenth century. Elizabeth Chambers Patterson in *Mary Somerville and the Cultivation of Science* (1984), and Alan Chapman in Mary *Somerville and the World of Science* (2004), give biographical accounts of Somerville and portray her as a successful woman of science.[11] As well, two semi-autobiographical accounts of Somerville's life were published. *Mary Somerville: Personal Recollections from Early Life to Old Age* (1873) is a biography that was put out by her daughter, Martha Somerville, after Somerville's death. The other, *Queen of Science: Personal Recollections of Mary Somerville* (2001), is by Dorothy McMillan.[12] In addition, Kathryn Neeley in *Mary Somerville: Science, Illuminations and the Female Mind* (2001) argues that Somerville was praised for her ability to "illuminate" the workings of the universe for her readers.[13] A more detailed investigation of the reviews of *Mechanism* and *Connexions* will be undertaken to reveal that Somerville's versions of particular mathematical models were not always well regarded. Previous scholarship has focused largely on Somerville as a popularizer. By conducting a textual analysis of her papers in scientific journals, I will contribute to existing scholarship by

---

[11] See Elizabeth Chambers Patterson, *Mary Somerville and the Cultivation of Science, 1815 – 1840* (Boston: Martinus Nijhoff Publishers, 1984). Allan Chapman, *Mary Somerville and the World of Science* (Bristol: Canopus Publishing Limited, 2004).

[12] See Martha Somerville, *Personal Recollections from Early Life to Old Age of Mary Somerville* (London: John Murray, 1873). Dorothy McMillan, *Queen of Science: Personal Recollections of Mary Somerville* (Edinburgh: Canongate Classics, 2001).

[13] Kathryn A. Neeley, *Mary Somerville: Science, Illumination, and the Female Mind* (Cambridge: Cambridge University Press, 2001).

demonstrating that Somerville's development as a scientific practitioner and popularizer was through collaboration.

The goal in the Somerville section can be outlined in three stages and will be set out in three chapters. Chapter One will centre on the twelve years prior to the publication of Somerville's translated work, *Mechanism.* Hans Christian Orested's (1777 – 1851) four page tract on electro-magnetic induction, "Experimenta circa Effectum Conflictus Electrici in acum Magneticam" (1820), initiated an awakening in scientific circles and work on this force of nature began in London, including at the Royal Institution and the Royal Society. Somerville was socially active with key members at the Royal Institution who shifted their experimental interests to magnetism at this time and so she became aware of possible openings for research. I will conduct a textual analysis of the papers submitted to *Philosophical Transactions* by members of the Royal Institution in order to tease out the sudden attention paid to magnetism. This close reading will focus on the practitioners who most influenced Somerville, and the experimental material that Somerville had access to when she began experimentation.

From this terrain I will demonstrate that Somerville's scientific associations, which she formed by working on the magnetic properties of solar rays, secured the publication and success of *Mechanism.* The social endeavours Somerville undertook were her keys into one layer of the inner circles of science. She evolved from a scientific hostess to an experimenter and was able to further immerse herself in scientific culture. From this opportunistic position Somerville corresponded with Herschel as a fellow solar rays enthusiast. These acts and experiences were later projected into her scientific and popular publications. I will argue that Somerville's popular chatter format was developed by her years of being a hostess and her exposure to scientific conversations. This chapter will center on these nuances which shaped Mary Somerville, the author.

Chapter Two will investigate the authorial identities that Somerville portrayed in her scientific papers. A close reading of her work in *Philosophical Transactions* and her submission, by correspondence via Arago, to *Comptes rendus hebdomadaires des séances de l'Academie des Sciences* will be analyzed. Previous scholars have never undertaken a close reading of Somerville's research papers, and these will be compared with the works of other scientists who were conducting solar ray research at the time. My task is to position Somerville among her contemporaries in order to mark her position within the network of a small yet concentrated group of magnetic experimenters that spanned London, France, and Italy. I will demonstrate that Somerville was most influential when she acted as a supportive voice in papers following the leads of Morichini, Herschel, and Arago. In this way, Somerville was able to add her observational results to working experiments and her findings were much praised in this usage. This analysis will demonstrate that scientific papers did not simply convey theories but were sites of exchange regarding procedures and methods. They outlined acts of collaboration and were arenas where new and rising practitioners were introduced into scientific circles. This analysis forces a reinvestigation of gender and science in the early nineteenth century as novice male practitioners utilized the same route.

Chapter Three will investigate the circumstances surrounding the translation of Laplace's *Mecanique Celeste* (1799 – 1825) in order to demonstrate that Somerville again engaged with an established theory to enter into popular writing. Somerville's move toward popularization reveals the friction between appealing to the popular English reader and maintaining an accurate translation of a French cosmos. Somerville was so uneasy about this tension that she added a substantial "Preliminary Dissertation," numbering seventy pages, to the text. This addition allowed Somerville to introduce a new writing format in the "Dissertation" as she established a narrative presence in popular readership. Neeley argues that Somerville's work was considered "illuminating" by her contemporaries. My work moves beyond this current interpretation of Somerville and demonstrates that the language in the "Preliminary Dissertation" was commonplace or chatty, and this informality enhanced the text's popularity. Finally, Somerville's other popular work, *Connexion*, will be analyzed to demonstrate that Somerville had gained much experience from *Mechanism*. By the time she wrote *Connexion*, Somerville had developed a more mature conversationalist format while maintaining familiarity with the reader.

Margaret Huggins

Margaret Huggins established an authorial voice at the embryonic stage of astrophotography with her contributions to the Hugginses Notebooks and published papers. By the mid-1860s photography in observational astronomy was highly popular,[14] and the Hugginses applied this tool to spectrum studies at Tulse Hill. Photography in astronomy in the mid-1860s, which relied on the wet plate method, was limited to bright objects such as the sun and moon. The introduction of the dry plate method in the mid-1870s, which was less tedious than the wet plate made this technique more employable for the Hugginses. As the years progressed Huggins and William were able to capture clearer and clearer line signatures of stars, novas, the sun, and comets.

[14] In 1852 Warren De la Rue's photographs of the moon were highly praised. See Jennifer Tucker, *Nature Exposed: Photography as Eyewitness in Victorian Science*, (Baltimore: John Hopkins University, 2005), 196.

Initially, the photograph was used as a verification device and consulted after hand drawn images of the bands were achieved. Yet, by the late 1880s and early 1890s Huggins and William came to rely solely on photography to capture the spectra of heavenly light. This dissertation will analyze Huggins' formidable passage into authorship at the beginning of astrophotography. Huggins, similar to Somerville, was able to become a practitioner at the embryonic stages of a specialization because photography was still a developing tool in the "New Astronomy." The instability of photography, coupled with the unsteady progression of determining the key chemical signatures of certain stars, invited a collaborating voice or a second eyewitness to experimental events. Huggins had established authority in the Hugginses Notebooks from writing about the photographic process, and the Hugginses added Huggins' findings to their published papers utilizing this opportunistic space.

As with the section on Somerville, I will conduct a textual analysis of the Hugginses' papers in *Proceedings* in order to expose the writer through her works. I will demonstrate that Huggins still held a clearly supportive position in the couple's published work, yet she held a more dominant voice in the Hugginses' Notebooks. This dual analysis, which point out a contradictory authorial stance for Huggins in the Notebooks versus the published works, allow for a more inclusive exploration of the Hugginses relationship than past scholarship has undertaken.

The early modern study of light first reached publication in 1672 with Isaac Newton's "New Theory of Light and Colour."[15] In this study, a small stream of light was passed through a prism, and a rainbow of colours appeared on a screen. In 1802 William

[15] David Dewhirst and Michael Hoskin, "The Message of Starlight: The Rise of Astrophysics," in *The Cambridge Concise History of Astronomy,* ed. Michael Hoskin (Cambridge: Cambridge University Press, 1999), 224.

Hyde Wollaston (1766 – 1828) passed sunlight through a slit and this alteration allowed the natural philosopher to see seven distinct lines.[16] Joseph Fraunhofer also passed light through a slit rather than a circle and discovered not Newton's hazy rainbow, nor Wollaston's seven lines, but 600 distinct lines. Fraunhofer published his results on the solar spectrum in 1817. In 1859 Robert Bunsen and Gustav Kirchhoff announced that particular grouping of lines or line signatures corresponded to specific terrestrial chemicals.[17] Reproducing these signatures in the laboratory, Bunsen and Kirchhoff identified nine elements that were present both on earth and the heavens above.[18]

William was greatly influenced by Kirchhoff's findings and as early as 1862 William was already aware of work on the stellar spectrum.[19] William began to investigate the physical makeup of various celestial objects. William's reputation steadily grew in spectrum analysis and during these early years numerous astronomers and chemists visited Tulse Hill as noted by the "Visitors Log" at the observatory.[20] By the time Huggins began her research Tulse Hill was well-known. Huggins was able to participate fully in developing new practices in spectrum photography because it was at the embryonic stage of growth and still within the grasp of the amateur. At the end of the Hugginses' careers institutionalized astrophysical observatories, which were built to ensure scientific precision, dominated research. Charlotte Bigg states in "Staging the Heavens: Astrophysics and Popular Astronomy in the Late Nineteenth Century":

---

[16] Ibid., 224.

[17] Ibid., 225.

[18] John North, *The Norton History of Astronomy and Cosmology*, (New York: W.W. Norton & Company, 1995), 442.

[19] William had read a paper on the stellar spectrum on November 14 1862 at the RAS. See Barbara Becker, *Unravelling Starlight: William and Margaret Huggins and the Rise of the New Astronomy*, (Cambridge: Cambridge University Press, 2011), 52.

[20] "Visitor Log" in Notebook Two, The Huggins Collection in the Special Collections, Wellesley College.

> As popular science became the domain of professional museologists and popularisers, and scientist themselves increasingly shut the public out of their laboratories and observatories, the fate of amateurs was sealed in the early twentieth century, as they were pushed to the margins of scientific establishment. In its most fertile decades, however, popular astronomy supplied an imaginative, playful and participatory alternative to established science, with its own take on observatory techniques and narratives.[21]

The Hugginses were aware of this shift. This can be seen in their published papers, which read as documents of affinity and became saturated with references to larger observatories. The papers became an arena where William's and Huggins' authorial presences on the page were intertwined with supporting documentation. These references also indicate that the Hugginses were looking to be part of global projects. As we will see, the Hugginses were involved in several long range international endeavours.

Work has been done on William and Huggins and their collective contribution to spectrum analysis and photography.[22] Marilyn Bailey Ogilvie in "Marital Collaboration: An Approach to Science" gives an account of the Hugginses' joint work at Tulse Hill. Barbara Becker in *Unravelling Starlight: William and Margaret Huggins and the Rise of the New Astronomy* (2011) provides an in depth analysis of William's and Huggins' research in a chronological order. In both *Unravelling Starlight* and in "Dispelling the Myth of the Able Assistant: William and Margaret Huggins at the Tulse Hill Observatory" (1996) Becker further argues that Huggins' work went much further than

---

[21] Charlotte Bigg, "Staging the Heavens: Astrophysics and Popular Astronomy in the Late Nineteenth Century," in *The Heavens on Earth: Observatories and Astronomy in Nineteenth Century Science and Culture,* eds. David Aubin, Charlotte Bigg, and H. Otto Sibum (Durham: Duke University Press, 2010), 309.

[22] See Barbara Becker, "Dispelling the Myth of the Able Assistant: William and Margaret Huggins at the Tulse Hill Observatory," eds. Nancy G. Slack, Helena M. Pycior and Pnina G. Abir-Am *Creative Couples in the Sciences* (New Brunswick: Rutgers University Press, 1996). Barbara Becker, "Eclecticism, Opportunism and the Evolution of a New Research Agenda: William and Margaret Huggins and the Origins of Astrophysics." PhD. diss., John Hopkins University, 1993. Barbara Becker, *Unravelling Starlight: William and Margaret Huggins and the Rise of the New Astronomy* (Cambridge: Cambridge University Press, 2011).

just assisting William. My textual analysis of the Hugginses' published papers and unpublished documents confirms Becker's assertion. I move the scholarship forward by demonstrating that Huggins, however, always employed a collaborative stance, and yet this authorial position holds many levels of interpretation. I will argue that the Hugginses' desire to add Huggins' name to *Proceedings* after seventeen years of work was done with much caution. Huggins' presence in *Proceedings* slowly became synonymous with Williams' as subsequent papers lost the distinctive "Mrs. Huggins" notation for Huggins' contribution in the text. Similar to Somerville, this supportive stance provided an entry point for Huggins to penetrate the various levels of scientific membership.

The Huggins Section can be outlined in four stages and will be set out in four chapters. In Chapter Four I will briefly focus on William's research from the time Tulse Hill was constructed to the time Huggins entered into practice. My goal is to establish the social, cultural, and scientific configurations which were in play when Huggins began work in narration, photography, and light analysis. This study will parallel chapter one and will allow for a comparative analysis of Somerville's and Huggins' emergence as practitioners.

In Chapter Five I will examine Huggins' early days at Tulse Hill and demonstrate that she mapped herself onto this site with her meticulous method of record keeping. I will conduct a close reading of the Notebooks in order to pinpoint the presence of her voice on the page and the evolution of her authorial identity in these documents. As the years progressed Huggins' voice came to dominate the Notebooks and William's work was recorded through her words.

In Chapter Six I will analyze the research papers that William submitted to the Royal Society in conjunction with the Hugginses' Notebooks. Huggins' determination in recording successful and failed experimental results made her a most valuable collaborator at the site. I will demonstrate that the Notebooks became a familiar space for Huggins and that she came to record aspects of her daily life in them as well. Although still not visible in publication, the Notebooks reveal the various levels of engagement Huggins undertook as the astronomers met the challenges of determining the chemicals present in starlight. At the same time, Huggins was making herself known in the astronomical community by associating herself, similar to Somerville, with key players. As well, the Notebooks and William's papers illuminate the slow acceptance of photography in astrophysics.

Chapter Seven will be a textual analysis of the Hugginses' published papers. I will demonstrate that Huggins' appearance as a voice of engagement was cultivated within three key hypotheses, which in turn gave her credibility among her peers. The addition of Huggins' name was done with much caution and little fanfare, yet it proved to be highly rewarding as this inclusion demonstrated her position as a scientific practitioner.

Comparative Analysis

Somerville and Huggins invite a comparative analysis because both practitioners were successful using a similar tool to enter and distinguish themselves in science writing and various levels of scientific society. An investigation of their scientific papers reveals that both writers employed the collaborative voice to enter into publication. As with male practitioners, this supportive position, in turn, gained these women access into the complex world of scientific alliances. As their specializations matured Somerville and

Huggins forged greater alliances with fellow experimenters, and their findings were cited within a network of those investigating similar phenomena. From this platform we can investigate the other authorial positions these two women undertook in other texts, and a textual analysis of these works will reveal how these documents intersected with, influenced, and were influenced by their science writing.

In addition, the births of Somerville and Huggins were separated by more than six decades. Thus firstly, a comparative study of their careers and lives will illuminate the shifts in various fields of science and scientific practice. The application of spectrum analysis to starlight had accelerated after the success of Robert Bunsen's and Gustav Kirchhoff's discoveries in the late 1850s. Using a prism Somerville and Wollaston separated sunlight to assess its properties. By the time Huggins and William studied the spectrum they were able to pinpoint certain elements present in stars and, as time progressed, they were able to capture photographic images of certain bands.

Secondly, studying Somerville and Huggins will reveal the changes in the way scientific papers were written for *Philosophical Transactions* and later *Proceedings of the Royal Society of London.* A textual analysis of the Somerville and Huggins papers demonstrate notable transformations in how scientific persons wrote about the processes of experimentation and observation as the nineteenth century became the age of mechanical devices. Yet, distinct similarities remained and most noteworthy is the fact that both Somerville and Huggins situated their own experiments within the work of other practitioners.

Thirdly, Somerville's and Huggins' story adds to a more comprehensive understanding of how new practitioners, both women and men, entered into scientific practice and gained recognition in various scientific realms. Along with this analysis issues looking at gender, practice, and gendered spaces are considered. This is particularly important as both Somerville and Huggins were dedicated to the status of science more so than the promotion of women in science. As well, the home is traditionally considered a gendered space in scholarship. Yet, in this comparative study the home proves to be more gender neutral than anticipated.

CHAPTER ONE

MARY SOMERVILLE AND SPECTRUM ANALYSIS

*****

Solar Rays and Magnetism

Many early nineteenth century natural philosophers such as Mary Somerville and Samuel Hunter Christie (1784 – 1865) looked into generating magnetic influence from various celestial and terrestrial sources. Working with magnetism and solar rays Somerville was able to publish her findings in the prestigious scientific journal *Proceedings of the Royal Society of London* (1826). Somerville sought to uphold an existing hypothesis and set forth a new argument in this first paper. As this paper and subsequent work would prove her most influential writing came when her findings were engaged with the original arguments of others and used in supportive positions.

The English interest, or perhaps even obsession, with magnetic communication originated not in England but in Denmark. In 1819, Danish philosopher Hans Christian Oersted (1777 – 1851) discovered a causal relationship between electricity and magnetism.[23] Oersted's experiments resulted in a four page tract, "Experimenta circa Effectum Conflictus Electrici in acum Magneticam" (1820). "Effectum" outlined the procedure for generating magnetic communication by way of electro rotation.[24] The implications were monumental because there now seemed to be a relationship between two major forces of nature. To add to the fascination, electro rotation was a circular

[23] Bern Dibner, *Oersted and the Discovery of Electromagnetism* (New York: Blaisdell Publishing Company, 1962), 24.

[24] David Gooding, "Magnetic Curves and the Magnetic Field: Experimentation and Representation in the History of a Theory," in *The Uses of Experimentation: Studies in the Natural Sciences*, eds. David Gooding, Trevor Pinch and Simon Schaffer (Cambridge: Cambridge University Press, 1993), 184. Dibner, *Oersted and the Discovery of Electromagnetism,* 26.

motion that was now thought to affect the linear movement of magnetic energy. Members of the Royal Society including Humphry Davy, Michael Faraday, and William Wollaston immediately set out to validate Oersted's claim. Wollaston was a good friend of William and Mary Somerville during the 1810s. Importantly for Somerville, Wollaston's innovative ways of thinking about magnetic generation, and his interest in prismatic analysis, were shared with her.

Magnetism provided a venue for Faraday and the Royal Institution to engage the public in science. Faraday, by the early the 1820s, was already giving sporadic lectures on electro-magnetism. These lectures were successful partly because of Faraday's showmanship and because electro-magnetic rotation literally made sparks fly for the audience.[25] As a scientific hostess living in close proximity to the Royal Institution Somerville would have been aware of this exciting venue.

Throughout the 1820s, marked experimental and observational research was continually conducted on magnetism, and this work branched into finding areas of magnetic concentration around the globe and in the atmosphere above the earth. The Somervilles socialized with both experienced and amateur men of science who had refocused part of their research onto finding various spots in nature that could possibly hold magnetizing power. These social events expanded Somerville's inquisitive mind in regards to magnetic study and experimentation. Somerville was an avid reader of Laplace and since Laplacian astronomy involved hands on calculations,[26] it can be argued that Somerville's shift into an area of science that invited participatory work was not unusual.

---

[25] Iwan Rhys Morus, *Frankenstein's Children: Electricity, Exhibition, and Experiment in Early-Nineteenth-Century London* (Princeton: Princeton University Press, 1998), 20 – 21.

[26] Somerville stated that she spent many hours working on "higher algebra," which was inherent in Laplacian astronomy. Martha Somerville, *Recollections*, 141.

Calculating theorems and equations in mechanical astronomy was a form of experimenting with probabilities. It was theoretical experimentation on the page, and Somerville's move to hands-on magnetic work was an expansion of her desire to test the laws of nature.

In addition, a major portion of Laplace's mechanical astronomy involved theories about the interconnectedness of the forces of nature. According to Laplace, if universal gravitation kept the planets in motion, held worlds in their orbits, and maintained the earth's gravitation field, then other forces in the universe must be at work preserving cosmic harmony. Laplace's *Mecanique Celeste* was a complex piece that discussed this "body of forces" or as Somerville stated in *Mechanism*, "the laws by which force acts on matter." [27] Somerville, in *Connexion,* incorporated the study of terrestrial and celestial magnetism into the text and demonstrated her ability to captivate the English reading public with her wide range of knowledge as a scientific author.[28]

The likelihood that solar rays held magnetic influence was a theory originally put forth in 1812 by Italian experimenter Domenico Morichini (1773 – 1836). An unseasonably hot British summer in 1825 provided the necessary climatic conditions for Somerville, and Christie, to test Morichini's findings. Christie had already suspected that solar rays held magnetic communication, and his goal was to replicate Morichini's results. In "Magnetizing Power" (1826), Somerville published her outcome, which supported Morichini's theory and Christie's observations. The three participants, Somerville, Christie, and Morichini, continued to communicate their findings and results by citing each other in their papers. Additional published works in the mid and late 1820s

[27] See Mary Somerville, *On the Mechanism of the Heavens* (London, Murray, 1831), 150.
[28] Somerville, *Mechanism*, IX., 150.

were used specifically to verify each other's analyses with the hopes of proving, conclusively, that solar rays held magnetizing powers. An important feature of this work was that both Somerville and Christie used prismatic analysis to reach their conclusions.

In Chapter One I will begin by analyzing the published papers of key men of science at the Royal Institution to show how members such as Davy, Faraday, and Wollaston shifted their interest to magnetic research after 1819. I will demonstrate that aside from articulating findings and proposing hypotheses papers were sites for regulating proper procedures, for debating outcomes, for introducing new practitioners, for teaching new methodologies, and for spurring adjacent areas of research. This unfolding will help to interpret Somerville's own entry into the discussion. The movement towards magnetism contoured Somerville's experimental interest and she was fortunate enough to be socially connected with members of the Royal Institution, and the Paris Observatory, who exposed possible areas of exploration to her at a time when both facilities were making scientific knowledge accessible to the public. My goal is to present how Somerville was able to create an authorial voice as she engaged with and supported credible hypotheses introduced by well-established researchers in 1825. In the late 1820s Somerville used her reputation in magnetic science to establish a correspondence with John Herschel, who was instrumental in the production of *Mechanism* (1830). In the 1830s and the 1840s Somerville collaborated, again, with key scientific figures to re-enter experimentation and publication.

Davy, Faraday, and the Royal Institution

Michel Foucault's concept of heterotopias or spaces of privilege,[29] and in this case the space of the privileged construction of scientific knowledge that is "Other," applies to the building of places such as the Royal Institution. This exemplary space of experimentation housed a state of the art laboratory, which was often opened for public display. Jack Meadows points out in *Victorian Scientist: The Growth of a Profession* that the Royal Institution's first objective was to set up a laboratory with an adjoining lecture hall so that members, and non-members, could view experiments in progress.[30] The Royal Institution saw practical hands-on procedures as the only credible way of obtaining natural knowledge, and this emphasis was evident with the many experimenters who engaged in the study of magnetism.

Oersted's set of experiments drew excitement at the Royal Institution and by focusing on the papers centred on electro-magnetic rotation after 1819, we can assess the various openings for research generated by this interest. For example, Davy published a steady stream of papers from 1810 – 1820 and although his experiments touched on a variety of theoretical approaches, his work mainly centered on chemistry. Davy looked at the outcome of combining an assortment of chemicals and substances,[31] as well as chemicals with other chemicals,[32] and outlined the possible combustibility of various solutions.[33] Yet, after 1820, Davy's focus was electromagnetic rotation.

---

[29] Michel Foucault, "Des Espace Autres," *Architecture/Movement/Continuite,* (1984).

[30] Jack Meadows, *Victorian Scientist: The Growth of a Profession* (London: British Library, 2004), 59.

[31] Humphry Davy, "An Account of Some New Experiments on the Fluroic Compounds; With Some Observations on Other Objects of Chemical Inquiry," *Philosophical Transactions of the Royal Society of London* 105 (1815): 62 – 73.

[32] Humphry Davy, "New Experiments on Some of the Combinations of Phosphorus," *Philosophical Transactions of the Royal Society of London* 108 (1818): 316 – 337.

[33] Humphry Davy, "Some New Experiments and observations on the Combustion of Gaseous Mixtures, with an Account of a Method of Preserving a Continued light in mixtures of Inflammable Gases and Air without Flame," *Philosophical Transactions of the Royal Society of London* 107 (1817): 77 – 85.

Davy's first paper on electro-magnetic interaction titled "On the Magnetic Phenomena Produced by Electricity" was read before the Royal Society in 1820. His enthusiasm can be detected as Davy predicted magnetism would spur a strong interest in the scientific world:

> [...] from its [magnetism] importance and unexpected nature, [magnetism] cannot fail to awaken a strong interest in the scientific world; and it opens a new field of enquiry, into which many experimenters will undoubtedly enter: and where there are so many objects of research obvious, it is scarcely possible that similar facts should not be observed by different persons.[34]

As Davy assessed, the Royal Society was to see an awakening from well-seasoned experimenters and novice practitioners alike and numerous papers on magnetism were read in the early 1820s. However, rather than establishing "similar facts," the papers were showing contradictions. One such contradiction was the questionable claim that solar rays generated magnetic influence. Davy and Faraday had witnessed this experiment in Morichini's laboratory in 1813, and Morichini's failure to produce influence had already left both men cynical about the claim.

By 1822 there was continual appeal, chiefly from Davy and Faraday, for more diligent experimental work on magnetism and a greater focus on repetitive procedure. Davy, Faraday, and Wollaston had trouble obtaining similar swings on their needles when they performed Orested's experiments individually using the same apparatus at the Royal Institution. This irregularity, in turn, prompted constant work on magnetism between 1822 and 1826 and kept experimental activities on-going in this area of study.

Faraday utilized the sophisticated rotation device acquired by the Royal Institution, and his findings on magnetism and electric currents led him to write his first

[34] Humphry Davy, "On the Magnetic Phenomena Produced by Electricity," *Philosophical Transactions of the Royal Society of London* 111 (1821): 8.

scientific paper.[35] Faraday's "A Historical Sketch of Electromagnetism," published anonymously at the Royal Institution, gave a portrait of the ongoing tensions that transpired between acceptable procedure and the excitement of a science grounded in an almost mystical area of nature.[36] Much work has been done on Faraday's "Historical Sketch" and the unwritten processes or thought paths that led to Faraday's results.[37] Gooding and Steinle demonstrated that Faraday's mode of writing achieved transparency because every action, with the ensuring outcome, was noted. An author using this method of writing enabled the reader to dissect the experiment as if present at the time of the event. The reader could, "by virtual witnessing, that is, the construction of narratives that allow vicarious witnessing by lay observers," [38] repeat the procedure. Faraday spelt out the markers of science, experimentation, and proper research in "Sketch":

- It is not scientifically proper to make up states or entities for which no experimental evidence exists.
- Hypotheses cannot be freely invented, but must have some experimentally verifiable aspect.
- Hypotheses must be clear and unambiguous, and they must serve to explain, in a mechanical way, the phenomena for which they were invented. [39]

Faraday's definition of experimentation included keeping a meticulous notebook and writing papers that showed "discovery paths" while constructing a narrative history that "could be translated into repeatable observations."[40] As we will see in the next section, it

[35] Faraday published "A Historical Sketch of Electromagnetism" anonymously in 1821.
[36] Magnetism had recently gone through a history of questionability particularly after the claims of Anton Mesmer (1734-1815), which were dismissed before the scientific community by Benjamin Franklin in 1784.
[37] David Gooding, "Mapping Experiment as a Learning Process: How the First Electromagnetic Motor was Invented," *Science, Technology & Human Value* 15, no. 2 (Spring, 1990). Friedrich Steinle, "Looking for a 'Simple Case': Faraday and Electromagnetic Rotation," *History of Science* 33, no.2 (June, 1995).
[38] Gooding, "Mapping," 176.
[39] Michael Faraday "A Historical Sketch of Electromagnetism" in Gerrit L. Verschuur, *Hidden Attraction: The History and Mystery of Magnetism* (New York: Oxford University Press, 1993), 85.
[40] Gooding, "Mapping," 171.

was Margaret Huggins' ability to record "discovery paths" that distinguished her narration in the Hugginses' Notebooks.

Davy, in a later paper, was to reiterate Faraday's definition of proper procedure by noting the need for repetition.[41] Davy's and Faraday's influence on Somerville was evident. Realizing nature through a scientific process of fact finding was already part of Somerville's mindset and complemented her ambitions to join the field of practitioners working at the Royal Institution. As indicated by her maiden paper, "Magnetizing Power," Somerville was not oblivious to the need for experimental repetition and transparency. The "virtual witnessing" Somerville achieved in "Magnetizing Power" allowed other scientists to both substantiate and, ironically, debunk her work. Somerville's inclusion in the solar rays and magnetism debate, however unstable, marked her authorial presence as a serious contributor to science.

In 1823 the Royal Society's readings and subsequent publication in *Philosophical Transactions* of papers dealing with magnetism increased to five.[42] The papers were similar in that the research focused on locating the causal markers of this force, and yet

---

[41] Davy, "Magnetic Phenomena," 8. In the paper Davy outlined his procedure: "I found, in repeating the experiments of M. Oersted with a voltaic apparatus of one hundred pair of plates of four inches, that the south pole of a common magnetic needle (suspended in the usual way) placed under the communicating wire of platinum, (the positive end of the apparatus being on the right hand) was strongly attracted by the wire, and remained in contact with it, so as entirely to alter the direction of the needle, and to overcome the magnetism of the earth."

[42] Pepys' paper on the construction of an apparatus for experimentation was read on April 10th. W. H. Pepys, "An Account of an Apparatus on a Peculiar Construction for performing Electro-magnetic Experiments," *Philosophical Transactions of the Royal Society of London* 113 (1823): 187 -188. Readings on July 12th included Barlow's paper on terrestrial magnetism. Peter Barlow, "Observations and Experiments on the Daily Variation of the Horizontal and Dipping Needles under a Reduced Directive Power," *Philosophical Transactions of the Royal Society of London* 113 (1823): 326 – 341. Readings on July 19th included papers by Wollaston, Davy and Christie. William Hyde Wollaston, "On Metallic Titanium," *Philosophical Transactions of the Royal Society* 113 (1823): 17 – 22. William Hyde Wollaston, "On the Apparent Magnetism of Metallic Titanium," *Philosophical Transactions of the Royal Society* 113 (1823): 400 – 401. Samuel Hunter Christie, "On the Diurnal Deviations of the Horizontal Needle when under the Influence of Magnets", *Philosophical Transactions of the Royal Society* 113 (1823): 342 – 392. Humphry Davy, "On a New Phenomenon of Electro-Magnetism," *Philosophical Transactions of the Royal Society of London* 113 (1823): 153 – 159.

the papers were vastly different in that their suggestions of possible origins ranged from terrestrial spots, to atmospheric locations, certain elements, and a mixture of fluids. A brief examination of Davy's 1823 paper "On a New Phenomenon of Electro-Magnetism" will further contextualize the expansion of magnetic science during this year. At the same time, this close reading will reveal the tensions within the Royal Institution as a facility on the exploratory frontier of a new science. Unlike the 1821 paper, "Magnetic Phenomenon," which invited more work to be done on magnetism, "Electro-Magnetism" began on a cautionary note as Davy reminded the community of practitioners that the science of magnetism was still in the exploratory stage:

> On a subject so obscure as electro-magnetism, and connected by analogies more or less distinct with the doctrines of heat, light, electricity, and chemical attraction, it is not difficult to frame *hypotheses*; but the science is in a state too near its infancy to expect the development of any satisfactory *theory*; and its progress can only be ensured by new facts and experiments, which may prepare the way for extensive and general reasonings [sic] upon its principles.[43]

The above statement demonstrated Davy's wariness of the numerous findings surrounding magnetic communication. As well, retractions began to appear to rectify faulty assertions such as the one Wollaston published in 1822.[44]

Davy's "Electro-Magnetism" reminded fellow experimenters to remain diligent in claiming theoretical knowledge about this force because the reported results were extensive and often spectacular.[45] As Davy stated, at this point one could only make preliminary hypotheses about the power of magnetism. In the concluding paragraph of

---

[43] Davy, "Electro-Magnetism," 153. [emphasized in original]

[44] William Wollaston, "On the Apparent Magnetism of Metallic Titanium," *Philosophical Transactions of the Royal Society of London* 113 (1823).

[45] One such claim was that solar rays held magnetic influence. Both Davy and Faraday doubted this hypothesis.

"Electro-Magnetism" Davy again emphasized that he would not enter into conjecture because the science was still in its infancy.[46]

As the tensions mounted within the walls of the Royal Institution for scientists to stake out recognition in magnetic studies, the excitement was felt on the periphery of the inner circle of researchers. Wollaston disclosed to Somerville the type of work that he was involved in at the Royal Institution and even the conflict he experienced with Faraday over the use of the electro-magnetic rotation device.[47] Somerville was frequently exposed to the happenings within this circle of scientific practitioners with regards to what was thought of as acceptable behaviour and proper conventions. This information was valuable for a woman looking for an entrance into practice. Her shrewdness regarding proper social conduct, her ability to converse, and the fact that she made the Somerville home an inviting place was part of her strategy to have contact with significant scientific figures. Yet, this home for Somerville was not a gendered space. Indeed, Somerville had many male visitors and they were more than willing to discuss fashionable topics with her just as they would with her husband. As Charles Caldwell noted, he was completely at ease conversing with Somerville in her home even out of the company of William Somerville.[48] As well Somerville was to rely heavily on Wollaston, Edward Sabine (1788 – 1883), and John Herschel in her experimental work. Wollaston would go on to conduct his important prismatic experiments in her home, and Somerville would visit Herschel's home in Slough to test out her magnetism/solar rays hypothesis in his presence.

[46] Davy, "Electro-Magnetism," 158.

[47] Martha Somerville, *Recollection*, 128.

[48] James Secord, "How Scientific Conversation Became Shop Talk," in *Science in the Marketplace: Nineteenth-Century Sites and Experiences*, eds. Aileen Fyfe and Bernard Lightman (Chicago: University of Chicago Press, 2007.

Beyond Sociability

Using Somerville as a probe, one can access the penetrability of scientific circles at the Royal Institution, which relied on personal contacts and social networking. This strategy proved successful for Somerville in her younger years. In Edinburgh, Somerville had written letters to William Wallace (1768 – 1843), Professor of Mathematics at the Military College in Marlow, in answer to mathematical questions, which were published for public enjoyment. After initial introductions were made, Somerville energetically maintained contact with Wallace by pursuing common academic interests.[49] Wallace went on to introduce Somerville to John Playfair (1748 – 1819),[50] and Somerville again sustained a long friendship with this Scottish geologist and mathematician through the study of both these domains.

For a hospitable woman from Edinburgh, close proximity to the Royal Institution and to working scientists provided a geographic setting that allowed this strategy to blossom. [51] At the same time, this technique introduced Somerville to numerous women who were actively engaged in the production of scientific knowledge and the opportunities that were opened to her. Armed with letters of introductions in 1816,

[49] Martha Somerville, *Recollections*, 78 – 79. It was Wallace who later secured the small library of mathematical astronomy text for Somerville.

[50] John Playfair wrote a review of Laplace's *Mecanique Celeste* in 1808. See John Playfair, "Review of Laplace *Mecanique Celeste*," *Edinburgh Review* XI (1808).

[51] Somerville's own account of her life during the early 1820s was recorded in a detailed manuscript, edited by her daughters Martha and Mary, and first published after her death. Martha Somerville, *Personal Recollections from Early Life to Old Age of Mary Somerville* (London: Elibron Classic, 2005). The initial biography was first published by John Murray in 1873. In 2001 another version of the biography, with additions that were omitted by Martha Somerville, was published by Canongate Classics. Dorothy McMillan, *Queen of Science: Personal Recollections of Mary Somerville* (Edinburgh, Canongate Classic, 2001). McMillan points out that Mary Somerville began noting down events of her life from 1859 onwards with the intention of writing an autobiography. Somerville had wanted to publish her accounts in 1869 after sending the manuscript to John Herschel for editing. Herschel advised Somerville not to publish the manuscript until after her death believing it would make a greater impression on the public. I am not claiming that (auto)biographies are completely reliable; however, they do offer insight into the way a historical actor can best narrate or depict how things possibly happened.

Somerville was able to call on the already prominent Jane Marcet (1769 – 1858). Marcet was instrumental in helping Somerville further establish connections with Wollaston. In addition, Marcet was a scientific elder, who had already established herself within the community as a hostess,[52] and she was also a noted popular science writer publishing *Conversations in Chemistry* in 1806. Somerville was greatly impressed with Marcet and came to emulate her in the coming years by assuming the role of scientific hostess. Like Marcet, Somerville established a career in writing popular science books and textbooks.

The introduction to various arenas for female participation in science was not to end with Marcet. Somerville realized that many spouses of doctors or scientific men, aside from holding dinner parties and playing the role of an amiable wife, took an active part in the production of knowledge. Henry Kater's wife, Mary Frances Kater, assisted her husband with astronomical calculations. Mary Buckland, wife of William Buckland, became Somerville's close friend and Mary was actively involved in geology. Aside from being an avid collector of fossils Mary was also a talented artist. Both William Conybeare and George Cuvier employed her illustration skills. The careers these women were carving for themselves often began as a result of spousal collaboration. William Somerville was a government doctor at Chelsea Hospital, and this post did not require an artistic spouse.

William Somerville has been cited in scholarship as being without ambition. His medical career was said to be more in tune with nursing than doctoring and had shone "dim" in comparison to his contemporaries such as Charles Bell or Richard Bright.[53] He had refused to publish about his adventures in Canada or write about medicine. Rather, he

---

[52] Paterson, *Cultivations*, 13.
[53] Patterson, *Mary Somerville*, 32.

opted to be a promoter of his wife's work. In addition, William did not seek a career as a fashionable London doctor, which would have increased the family income substantially. Yet, William was simply living the life of contentment similar to which Wollaston, Somerville's most willing tutor, enjoyed. William Somerville already had, by the time he met Somerville, served his country. If William was seen as without ambition or in any other way ungentlemanly, the Somervilles would not have been accepted seamlessly into the company of Wollaston, Herschel, Kater, and Sir Walter Scott not to mention Arago and Laplace. In addition, it must be noted that William Somerville did present a paper before the Royal Society in 1816, and he was elected a member of the Society in 1817. [54] These attributes established the Somervilles as "high gentry," [55] which laid the foundation for Somerville to gain a way into science through a congenial meal, interesting conversation, and scholarly pursuits with practitioners.

The strategies Somerville employed to enter the scientific world were similar for male practitioners looking to make associations in science.[56] A significant change was occurring in Somerville's maturation as her world expanded to include women who produced knowledge rather than solely absorbing it by reading. Europe would expand her vantage point even more. In 1817, shortly after arriving in London, the Somervilles embarked on a continental tour and Somerville met the wife of the French astronomer Jean Baptiste Biot. Madame Biot was actively involved in translating scientific works from French to English, German, and Italian. Earlier in the year Madame Biot had

---

[54] Secord, "Shop Talk," 32.
[55] Secord, "Shop Talk," 32.
[56] See Allan Chapman, *The Victorian Amateur Astronomer: Independent Astronomical Research in Britain, 1820-1920* (Chichester: Praxis Publishing,1996). Chapman devotes a chapter to the "astronomical house-party" frequented by astronomers who shared similar interest.

translated E. G. Fischer's *Lehrbuch der Mecanischen Maturlehre,*[57] and Biot's success gave Somerville insight into yet another field for possible work.

Martha Somerville's *Recollection* gives a glimpse of how important the continental visit was to Somerville as it allowed her to assert her presence into French astronomical circles. In addition, this excerpt demonstrated that Somerville conscientiously promoted her own knowledge of *Mecanique Celeste*:

> M. Arago had told M. de la Place that I had read the "*Mecanique Celeste*," so we had a great deal of conversation about astronomy and the calculus, and he gave me a copy of his "*Systeme du Monde*", with his inscription, which pleased me exceedingly [...] The dinner party consisted of MM. Biot, Arago, Bouvard and Poisson. I sat next to M. de la Place, who was exceedingly kind and attentive. [58]

The dinner table scene described above forces a reinterpretation of the home as being a purely domestic, non-scientific space. Both males and females were present and no doubt Biot, Arago, Bouvard, Poisson, and Laplace used this setting to forge alliances and scientific bonds.

In 1819, in addition to Laplace and Biot, Somerville met Dominique Francois Arago. Arago would play a pivotal role in her scientific career in the 1840s. Arago was not only an astronomer, but he also observed magnetic communication in the skies between 1823 and 1826. Importantly Arago, similar to Herschel, began to take an interest in spectrum analysis and starlight. It is not surprising that Arago would agree to meet a scientific hostess from England and to promote her knowledge of Laplacian astronomy to Laplace himself. Arago believed in an educated public and gave free lessons in science

[57] Patterson, *Cultivations,* 21.

[58] Martha Somerville, *Recollections,* 109. McMillan, *Queen of Science,* 89,

and astronomy at the Paris Observatory as early as the revolutionary days of 1795.[59] To Arago, Somerville epitomized the idea that a lay person could learn independently. Arago went on to provide free weekly lectures in astronomy at the Paris Observatory from 1813 to 1848. These sessions were legendary and authors such as Victor Hugo learnt about the "polarization of light" from the astronomer.[60] Hugo's reference to the "polarization of light" indicated that Arago was already working with prismatic analysis during this period, and indeed, Arago was studying the light of a candle and its separation by a prism as early as 1817.[61]

Edward Sabine and Atmospheric Magnetism

An important addition to Somerville's social circle was Edward Sabine. Sabine spent his career searching for magnetic pockets in various terrestrial zones in the Americas and the North Pole. As his work continued, Sabine's interest diversified and he began to seek a relationship between the forces of magnetism and certain natural occurrences, most notably the Aurora Borealis. Sabine's papers on magnetism proved to be valuable working notes for Somerville when she began her own observational procedures in the summer of 1825.

Somerville developed an amiable relationship with Sabine after providing a crate of marmalade for the Sabine/Ross expedition.[62] Somerville had again utilized the domestic space to forge connections with a man of science, and as with scientific acquaintances in the past, Somerville maintained a long friendship with Sabine based on

---

[59] Teresa Levitt, "'I thought this might be of interest …: The Observatory as Public Enterprise," in *The Heavens on Earth: Observatories and Astronomy in Nineteenth-Century Science and Culture*., eds. David Aubin, Charlotte Bigg, and H. Otto Sibum (Durham: Duke University Press, 2010), 287.

[60] Victor Hugo in Teresa Levitt, "Public Enterprise," 287.

[61] Klaus Hentschel, *Mapping the Spectrum: Technique of Visual Representation in Research and Technology* (Oxford: Oxford University Press, 2002), 38 & 97.

[62] Martha Somerville, *Recollections*, 137.

a common research interest. As Somerville's later reminiscences indicated Sabine had left an impression on her scientific ambitions because of his speculations on a relationship between the Aurora Borealis and magnetism, which importantly for Somerville, was theorized as being causal in nature. If the Borealis could produce magnetic influence then Morichini's proposal that solar rays held the same communicative possibilities was becoming more and more feasible.

Unlike many magnetic investigators, Sabine was experienced in detecting magnetic influence, having invested a lifetime to a career in sourcing locations of magnetic variations on the globe prior to Oersted's discovery. Since Sabine had already established a reputation in research that involved magnetism he, more so than others, found the need to uphold the status of this science. Similar to Davy and Faraday, Sabine stressed the need for greater accuracy in determining readings before publication particularly by scientists who were new to magnetic research. It was clear that the study of magnetism was leading to speculation and problems were arising because magnetic variances were detected in an abundance of sources.[63] Sabine encouraged greater respect for experimental procedures: "The increased attention which has been given of late years by several philosophers to the subject of magnetism, and the consequent advance which has been made in this branch of natural knowledge, render it desirable, that a greater degree of accuracy should be obtained in all respects, in observing its various terrestrial phenomena, than hitherto." [64] As "increased attention" was paid to terrestrial magnetism the need to be the first to claim theories became more and more urgent. Debatable papers

[63] Edward Sabine, "The Bakerian Lecture. An Account of Experiments to determine the amount of the Dip of the Magnetic Needle in London, in August 1821; with Remarks on the Instruments which are usually employed in such determinations," *Philosophical Transactions of the Royal Society of London* 112 (1821): 1 – 21.
[64] Ibid., 1.

were sites for further work to be done by disputing scientists setting out to locate dilemmas or to debunk evidence. In addition to providing data other papers, such as Sabine's, acted as a means to call for the cleansing of scientific practice. Finding a method to determine the presence of chemicals in celestial bodies may have already been on Sabine's mind during the early 1820s.[65]

It can be surmised that Somerville demonstrated an enthusiastic interest in terrestrial and atmospheric magnetism to Sabine during the time she was living at Hanover Square. After the Parry expedition, Sabine made a generous scientific contribution to Somerville's study of magnetic fluids. As Somerville stated, "He [Sabine] had uniformly sent me copies of all his works; to them I chiefly owe what I know on the subject."[66] The papers were substantial and included the "observations made during the series of Arctic voyages on the magnetism of the earth."[67] Sabine travelled to Africa, America, and to the Arctic between 1821 and 1823 to take magnetic readings. The experimental data that Sabine gave to Somerville provided observational results and mapped the pockets on earth where the detecting needle exhibited magnetic influence. As well, the papers outlined a basic methodology on how to conduct experimental work on magnetism and atmospheric phenomena. As a woman who was self-taught in the difficult science of mathematical astronomy, Somerville would have been able to comprehend Sabine's experiments and by "virtual witnessing" learn how to conduct observational research.

---

[65]Sabine was very excited about William Huggins' 1863 work on the nebular spectra, and William's efforts to "examine the chemical constitution of stars and planets." Edward Sabine, "President's Address," *Proceedings of the Royal Society* 13 (1864): 500.

[66] Martha *Somerville, Recollections*, 138.

[67] Ibid., 138.

By the mid-1820s the number of scientists studying magnetism had dwindled and only hard core investigators remained. The papers that were published in *Philosophical Transactions* in 1825 focusing on this area of science came mostly from Barlow, Davy, Christie, Faraday, and Wollaston. Those experimenters working continually on magnetism outside of the Royal Institution were Sturgeon, Marsh, and Pepys. Like many early researchers who gave up magnetism after initial prospects proved difficult, impossible to replicate, or even false, Somerville turned to an area of investigation that originally intersected with her magnetic interest.

William Scoresby and Quick Entry into Magnetic Research

In the early 1820s Sabine introduced Somerville to William Scoresby (1789 – 1857) who had developed an enthusiasm for magnetic study. Scoresby's seemingly spontaneous emergence as a magnetic scientist was another indication to Somerville that individuals who had no previous practice working with magnetism could quickly initiate promising lines of inquiry. Scoresby was one of the many opportunists who began to investigate the causal relationship between magnetism and various metals.[68] In 1824, Scoresby submitted a paper that focused on the possibility of magnetic attraction in various metallic elements.[69] Scoresby's keenness for the new science was clear as his work was thorough and detailed, and his experiments were regimentally carried out over several days in order to determine the degree of magnetic energy caused by percussion upon rods of iron.

---

[68] Scoresby first paper appeared in 1822. William Scoresby, "Experiments and Observations on the Development of Magnetical [sic] Properties in Steel and Iron by Percussion," *Philosophical Transactions of the Royal Society of London* 112 (1822): 141 - 152.

[69] William Scoresby's paper "Experiments and Observations on the Development of Magnetical [sic] Properties in Steel and Iron by Percussion" was read by Davy in the 1824 January reading of the Royal Society.

Scoresby's paper, "Percussions" noted the size of each rod and every specimen was cut exactly to Scoresby's specifications. The weight of each rod was recorded and the slight variations between the two ends of the rod were carefully noted. The weight of every nail was also measured as the goal of the experiment was to use the magnetized iron to lift nails of various weights. The modifications made to each rod by drilling or hammering were recorded to the inch, and a diagram of the apparatus was included in the paper. The paper finished with a simple acknowledgement of Davy for his continual conversations and suggestions on how to proceed with the process. The paper, twenty-four pages in length, was indicative of the investments researchers were willing to make, in terms of equipment and materials in order to begin their research. Despite some questionable findings and publications magnetism was to be a serious science for nascent researchers. Many opportunists sought authorial possibilities in magnetic research, and Somerville aimed to carve a notable reputation from writing about its potential.

William Wollaston and Prismatic Analysis

No other scientist contributed more to Somerville's expertise in prismatic research than Wollaston. After their initial introductions Wollaston developed a close friendship with the Somervilles and spent many hours at the Somerville home at Hanover Square.[70] Wollaston's trajectory into magnetic investigation was key as this natural philosopher not only influenced Somerville's work with the prism, but Wollaston was noted as a defining contributor in the development of spectrum analysis.[71] Wollaston produced numerous

[70] The fact that Wollaston was not married and could afford to live the life of a gentleman can account for the considerable amount of free time he devoted to the Royal Institution and to scientific endeavours.

[71] See Hentschel, *Mapping the Spectrum*, 32. Myles W. Jackson, *Spectrum of Belief: Joseph von Fraunhofer and the Craft of Precision Optics* (Cambridge: MIT Press, 2000), 99. Colin A. Ronan, *Their Majesty's Astronomers: A Survey of Astronomy in Britain Between the Two Elizabeths* (London: The Bodley Head, 1967), 170. Pierre Rouseau, *Man's Conquest of the Stars* (London: Jarrods Publishers, 1957),

papers in *Philosophical Transactions* on a variety of subjects from 1810 onwards, which highlighted his polymath abilities.[72] After 1816 Wollaston seemed to have hit a dry spell and did not publish another paper until his work on magnetic rotation. Oersted's claim of magnetic communication and electro rotation reignited Wollaston's passion for practical work and publication.

By investigating Wollaston's contributions to *Philosophical Transactions* it can be determined that while he did work on electromagnetic rotation after Oersted's discovery, Wollaston remained true to the polymath tradition throughout the 1820s by writing on other subjects. What can help explain the exceptional friendship between Wollaston and Somerville was the fact that he was also interested in the vastness of celestial space, whose study composed a substantial portion of the research of celestial mechanics. In 1822 Wollaston produced a paper, "On the Finite Extent of the Atmosphere," for *Philosophical Transactions,* which investigated celestial bodies and accounted for his future work with solar rays.[73] "Finite Extent" examined, "whether any appearance of a solar atmosphere could be discerned," [74] and the thickness of such a stratum. Even in this early paper Wollaston was beginning to think about looking at the "apparent refraction" of the sun, or the "reflection from vapours that are suspended in

---

294. H.C. King, *Exploration of the Universe: The Story of Astronomy* (London: Secker & Warburg, 1964), 184.

[72] Topics ranged from cystic oxide (1810), to diabetes (1811), to diamond cutting (1816), and to calculating the mass of iron from Brasil [sic] (1816). William Wollaston, "On Cystic Oxide, a New Species of Urinary Calculus," *Philosophical Transactions of the Royal Society of London* 100 (1810): 223 – 230. William Wollaston, "On the Non-Existence of Sugar in the Blood of Persons Labouring under Diabetes Mellitus," *Philosophical Transactions of the Royal Society of London* 101 (1811): 96 – 109. William Wollaston, "A Synoptic Scale of Chemical Equivalent," *Philosophical Transactions of the Royal Society of London* 104 (1815): 1 – 22. William Wollaston, "On Cutting Diamonds," *Philosophical Transactions of the Royal Society of London* 106 (1816): 265 – 269. William Wollaston, "Observations and Experiments on the Mass of Native Iron Found in Brasil [sic]," *Philosophical Transactions of the Royal Society* 106 (1816): 281 – 285.

[73] William Wollaston, "On the Finite Extent of the Atmosphere," *Philosophical Transactions of the Royal Society of London* 112 (1822): 89-98.

[74] Wollaston, "Finite Extent," 89.

it,"[75] in order to study the depth of its atmosphere. It was from this branch of solar astronomy that Wollaston began to employ an object-glass to direct light through a slit onto a screen to study the characteristics of the rays. From understanding the density of the chemical compound Wollaston deduced that he would be able to establish the thickness of the atmospheric strata. Wollaston was insightful in that he knew "Finite Extent" was only a preliminary paper, and, rather than a solid conclusion, the paper set forth to encourage others to consider this science "worthy of farther investigation"[76] in the future. Wollaston's contribution to spectrum analysis was methodological as he was accredited with noticing the "refractive and dispersive powers" of a glass prism.[77] This practical use of the prism was a technique that he shared with Somerville.

Wollaston's challenge in "Finite Extent" was not only to determine the chemical analysis of solar rays but to discuss the atmosphere of the sun. Somerville's self-education on Laplace and *Mecanique Celeste* fell squarely within Wollaston's line of inquiry, and it is conceivable that Somerville's knowledge helped Wollaston calculate the numerical figures he proposed in the paper. It was Somerville's good fortune that Wollaston approached science with eclecticism. By analyzing Wollaston's contributions to *Philosophical Transactions* it can be determined that Wollaston often dived into fashionable topics to produce preliminary papers after which he progressed to other areas of nature. "Finite Extent" was Wollaston's only paper on solar rays as he moved onto the possible magnetic attraction of titanium crystals in 1823. It can be surmised that what seemed to be easy transitions between research agendas for Wollaston had an impact on Somerville as she set out to work on the rays in Chelsea. Her haste to publish

[75] Ibid., 89.
[76] Ibid., 96.
[77] Hentschel, *Mapping the Spectrum*, 32.

"Magnetizing Power" after only one summer of research was an indication that Somerville was led to believe that science provided quick answers for practitioners who could then freely move on to other subject areas.

To have an ongoing friendship with Wollaston that centered on atmospheric studies during this time was crucial to Somerville's understanding of the relationship between solar rays, refracted colours, and prismatic analysis. An account of these instructions was noted in the manuscript for the original autobiography and in Somerville's biography edited by Martha Somerville.[78] What Wollaston did in 1823 was introduce Somerville to a prismatic procedure for detecting the various properties of solar rays:

> One bright morning Dr. Wollaston came to pay us a visit in Hanover Square, saying, 'I have discovered seven dark lines crossing the solar spectrum, which I wish to show you', then, closing the window shutters so as to leave only a narrow line of light he put a small glass prism into my hand, telling me how to hold it. I saw them distinctly.[79]

Wollaston was practicing what became the science of spectrum astronomy and even at this early stage Somerville was able to understand that she was looking at a way to detect the matters that made up the cosmos:

> I was among the first, if not the very first, to whom he showed these lines, which were the origin of the most wonderful series of cosmical [sic] discoveries, and have proved that many of the substances of our globe are also constituents of the sun, the stars and even of the nebulae.[80]

Although Somerville was wrong in assuming that she "was among the first, if not the very first,"[81] to whom Wollaston showed this experiment to, the event was, for Somerville, formative. Somerville considered this amiable morning of science a central

---

[78] Martha Somerville, *Recollections*, 135, McMillan, *Queen*, 109.
[79] Martha Somerville, *Recollection*, 133.
[80] Ibid., 133 – 4.
[81] Ibid.,

scientific event in her life and dedicated a section in *Recollections* to this happening titling the important passage "The First Spectrum Analysis."

The Somervilles moved to Chelsea in 1825; yet, despite the distance, Somerville still relied heavily on Wollaston to conduct her experiments. During the summer of 1825 Wollaston had encouraged Somerville's research by lending her a specialized lens to separate the refracted rays.[82] The large lens was one Wollaston had used in his own astronomical research[83] and was meant to focus the rays more intensely than a prism. In an undated letter Wollaston gave instructions and praise:

> [...] the appearance of the transmitted light, that the red, the orange & other less refrangible rays are also intercepted. Your experiments on the effect of coloured lights are so conclusive that I certainly would not couple with them any more doubtful matters or even name Hygrometer Damps or fogs.[84]

Wollaston was Somerville's mentor and no doubt his encouraging words that her experiments were "conclusive" gave Somerville the confidence to produce a paper. Somerville was no stranger to receiving instructions via letters as she had done so with Playfair and Wallace on mathematical questions in the past. Her success with long distance tutoring in Edinburgh, which won Somerville recognition and a mathematical award, gave her tenacious character the assurance that such a form of coaching was adequate.[85] In addition, Somerville had received hands-on lessons in prismatic analysis from Wollaston at Hanover Square only three years earlier.

Despite Wollaston's knowledge of Somerville's experiments it was unlikely that he thought Somerville was about to produce a paper noting her results on the rays' magnetic influence. Somerville was by no means a practicing scientist at this time and

[82] Somerville, "Magnetizing Power," 135.
[83] Ibid., 135.
[84] Wollaston in Paterson, *Cultivations*, 46.
[85] Martha Somerville, *Recollections*, 79.

had never actively investigated magnetic properties before. Had Wollaston thought that Somerville meant to publish her results, which included citing him as a contributor, it is doubtful that he would have been so casual about lending her equipment and discussing her experiments. It can be surmised that by borrowing the large lens Wollaston thought that Somerville was engaging in a leisurely activity by repeating spectrum analysis experiments in Chelsea because the summer was very bright and hot. Somerville had borrowed an assortment of expensive crystals from Wollaston before to conduct science in her free time and no paper came from these occasions. With his reputation at stake, Wollaston would have made a trip to Chelsea, a distance of approximately three miles from the Royal Institution, to see the experiment before a paper was produced. Wollaston was in the practice of visiting practitioners as far as Geneva to observe experimental work.[86] On the other hand, for Somerville to have a paper read at the Royal Society in which she named Wollaston as a contributor marked her entrance into magnetic science as one who was well-connected with fellow solar ray experimenters and was, by way of association, affiliated with the Royal Institution. Her approach was common practice as other investigators used the same technique to show their own involvement in the various spaces of scientific work.[87]

There was no suggestion Somerville knew that Morichini could not replicate the solar ray experiments for Davy and Faraday in 1813. This fact alone indicated that Somerville was, by 1825, more an outsider of science than perhaps she believed herself to be. Yet, Somerville was not the only person in England attempting to generate magnetic

---

[86] See Wollaston's paper, "On the Apparent Magnetism of Metallic Titanium," *Philosophical Transactions of the Royal Society* 113 (1823): 400. Wollaston went to Geneva to see Peschier conduct experiments on crystals and magnetism. After seeing Peschier's experiment Wollaston issued a retraction of his own work.

[87] Christie began "Magnetic Influence" by listing his numerous affiliations.

communication from a heat source. Even more established scientific practitioners such as Christie repeated the experiment in the summers of 1824 and 1825. Christie's work was crucial because his research verified Somerville's findings, and this acknowledgement by a noted scientist was the key to Somerville's entry as a credible magnetic practitioner and authorial voice into a network of already well-established magnetic experimenters.

The Magnetic Network, Samuel Christie, and Experimental Verification

Six years after Oersted's theory connected magnetism with electro rotation a core of magnetic investigators had been established in London. Defining this "network" in terms of the expanding parameters of this science in 1825 will establish the circumstances that Somerville used to carve a beginning into the opportunistic solar rays and magnetic influence debate. Major contributors to magnetic study came from notable scientific and teaching institutions in London and its surrounding areas forming this tight "network."[88] The "network" was a space of shared concepts incorporating mutual ideas, information, knowledge, and technique that were articulated in unifying practices.

David Gooding in "Magnetic Curve and the Magnetic Field: Experimentation and Representation in the History of a Theory" (1989) points out that in the early days of magnetism, during the 1820s, a site did not exist where the practices of experimentation could be centralized. However, there was a connectedness about the practice:

> Their [magnetic researchers] common interest in electromagnetism was never institutionalised in a way that led all of them to meet regularly or work together. I refer to them collectively as a 'network' to indicate that most were acquainted through associations with other institutions or interest groups and that all knew of the others' work. [89]

[88] David Gooding, "Magnetic Curve", 199. Gooding points out that over one third of the core investigators were affiliated with the Royal Institution or the London Institution. Others were involved with the Royal Military Academy or other naval institutions.
[89] Ibid., 195.

The networking that Gooding refers to was supplemental to physical contact that was reinforced by language and the daily uses of common terms, vocabulary, linguistic expressions, and the important gossips that distinguished the magnetic experimenter from others. This practice formed new methods of thinking about magnetism and fostered innovative ways of writing about this phenomenon to interested audiences. This ideological space can only be reinforced by interacting professionally and socially, contexts that were so tightly interwoven as to be inseparable, with fellow scientists in order to observe practices and customs in motion.

Christie became a valuable ally to Somerville after the publication of "Magnetizing Power." During this period Christie was teaching at the Royal Observatory at Greenwich, well-connected with members of the Royal Society, a Fellow of the Cambridge Philosophical Society, and a member of the Royal Military Academy.[90] By 1825 Christie was part of the core group of magnetic investigators who had extensive knowledge about magnetism in various areas of nature. Christie was an inventor who could custom cut his own instruments to size for his experiments, and his emphasis on proper material was a factor for his high reputation. As a practitioner entering into scientific practice a mention in a paper written by Christie was of significant scientific recognition. Somerville was to receive such a mention in 1828.

There was no evidence to suggest that either practitioner, Somerville or Christie, knew of each other's work in 1825. Christie's findings were published in a paper, "On Magnetic Influence in the Solar Rays," in *Philosophical Transactions.* The experiments outlined were similar to Somerville's research in that Christie also manipulated the rays of the sun to generate magnetic influence; a section of his work centered on temperature

[90] Ibid., 199.

analysis or "*the effects of temperature on the intensity of magnetic forces*."[91] Christie stated that his findings showed that a needle heated by solar rays vibrated to a lesser degree than a needle that was positioned in the shade.[92] A reduced rate of vibration indicated that the magnetized needle had polarized to swing to a lesser degree than a non-magnetized needle.

Christie's prior work was in terrestrial magnetism and he, like Sabine, noted magnetic variations on different spots on earth. His polymath abilities were highlighted in the previous year when Christie submitted two papers, which focused on magnetism and iron, to *Philosophical Transactions* for publication.[93] The hot summer of 1825 allowed Christie to further consider the theory that concentrated areas of magnetism on earth were generated by solar rays rather than terrestrial conditions such as extensive deposits of iron ore. With this outcome in mind Christie moved his experiments into a controlled indoor environment. Christie employed a magnetized needle, a hair to dangle the needle from, and a thermometer. Although a seasoned experimenter Christie never questioned the proper functioning of his eclectic assortment of domestic materials, nor did he specify whether he tested the equipment before he commenced with the investigation. Christie's unease concerning laboratory-based work can be noted as he indicated apprehension that the room may be contaminated by other elements, possessing magnetic properties. Christie's only attempt to compensate for these variables, and to maintain some

[91] Christie, "Magnetic Influence" (1826): 219. [emphasized in original]
[92] Ibid., 219.
[93] Samuel Christie, "On the Magnetism of Iron Arising from its Rotation," in *Philosophical Transactions of the Royal Society of London* 115 (1825): 347 – 417. Samuel Christie, "On the Magnetism Developed in Copper and Other Substances During Rotation," in *Philosophical Transactions of the Royal Society of London* 115 (1825): 497 – 509.

consistency, was to utilize a wooden shutter outside the window for shaded experiments and to remove the shutter for the solar heat experiments.

"Magnetic Influence" recorded the findings from two sets of experiments conducted in the summer of 1824 and 1825. In both blocks of research Christie recorded arc variation readings. The paper was organized with observatory comments and charts to separate the different modes of inquiry. In 1824 Christie proceeded to count, with the naked eye, the vibrations of the needle under conditions of heat and conditions of shade. "When the shutter was up, so that the needle vibrated in the shade, I could very distinctly note the 100th vibration; but when it was removed and the needle vibrated exposed to the sun's rays, I could not distinctly mark the 75th."[94]

Like Somerville, Christie continued his experiments in 1825 because of the "very favourable circumstances, the sun shining clear and strong the whole time."[95] Encouraged by his 1824 observations Christie, by 1825, was attempting to prove conclusively that solar rays and magnetism were two unifying forces. Christie believed he had demonstrated this fact by measuring the diminished arc of vibration of the needle under the rays' exposure:

> The observations which I have detailed are, I think, quite conclusive as establishing the fact, that the rays of the sun had a tendency to check the vibrations of the needle, particularly those in the last table; since here, on the needle being exposed to the sun, the terminal arc was reduced from nearly 14 [degree] to 8 ½ [degree].[96]

Importantly, Christie went on to refine his analysis and his concluding statements corroborated Somerville's findings and claims. Christie stated that he questioned his own heat centered theory and retried the experiments with a compass and fire until "its heat

[94] Ibid., 220.
[95] Ibid., 223.
[96] Ibid., 225.

was barely supportable to the hand."[97] Christie found the opposite to be true and from this result Christie concluded that it was not the heat that generated magnetic energy but solar rays in particular. This premise verified what Somerville was to publish in "Magnetizing Power" and what Morichini had theorized. London now had two scientists who had conducted these set of experiments independently and reached the same conclusion.

In addition, Christie stated that he was aware of Morichini's failure to repeat his 1813 experiment. The experiments in "Magnetic Influence" were conducted, in fact, to remove any doubt that Morichini's theory was erroneous:

> The repeated failures of Morichini's experiments of magnetising a needle by violet ray, even under the most favourable circumstances, and in the ablest hands, have led many to doubt whether the effects, which were in some cases observed, were to be attributed to the influence of the ray; but as the experiments which I have detailed indicate magnetic influence in the compound solar rays, and are besides easily repeated, they will, I think, tend considerably to remove these doubts.[98]

The fact that Morichini could not repeat his experiments was what stimulated Christie to act as Christie theorized that the correlation was true. The inconsistency in findings gave the debate currency and at the same time provided entry points for inquiry, which Somerville utilized to publish her observations. Somerville's results was prestigiously verified by Christie's claim that "solar rays possess sensible magnetic properties, which [were] observable in the vibrations of a magnetised needle exposed to those rays, independently of the effects produced by the heat which they impart."[99]

Although Somerville's entry point into science was accompanied by some independent affirmation of her findings, immediately after "Magnetizing Power" was

---

[97] Ibid., 226.
[98] Christie, "Magnetic Influence," (1826): 232.
[99] Ibid., 219.

presented before the Royal Society, Somerville had doubts as to the validity of her conclusions. After the paper's reading in 1825 John Herschel and Somerville both tried individually to repeat the results on numerous occasions but they were unsuccessful. Nonetheless, despite the uncertainty, Somerville and her husband aggressively promoted the experimental outcomes. In April 1826, the couple sent copies of the paper to Joseph Louis Gay-Lussac who was researching atmospheric conditions in Paris. Gay-Lussac, upon receiving "Magnetising Power," forwarded the paper to Laplace. Laplace wrote a personal note of appreciation to Somerville for the paper. If Laplace knew Somerville's paper and theories were flawed, he made no mention of it in the letter. "Magnetizing Power" went on to achieve more notice in France receiving mention in the April 1826 edition of *Bulletin des sciences mathematiques, astonomiques, physiques et chimiques.* William Somerville encouraged the distribution of the findings in Italy by sending a copy to Morichini who in turn thanked Somerville for her work. Morichini stated that the paper shed light on the science of magnetism and his own research.[100]

However, by the summer of 1828 Somerville was so concerned about her claims that she made a visit to Slough to conduct the experiment with John Herschel. It is not surprising that Herschel would help Somerville as Herschel was accustomed to receiving scientists in his home to work out experimental results.[101] As well, during his days at Cambridge Herschel was a wrangler or head tutor accustomed to helping others with different research.[102] It was the inability to verify findings that created a solid working relationship between Somerville and Herschel. Somerville had, yet again, used a common

---

[100] Patterson, *Cultivations,* 47.

[101] Jackson, *Spectrum of Belief,* 127. Babbage was another frequent visitor at Slough.

[102] Jackson, *Spectrum of Belief,* 126. Jackson argues that being a "senior wrangler" was synonymous with being the class tutor and that Herschel, by nature, was accustomed to helping others with difficult research.

area of science to maintain correspondence with a leading scientific practitioner. The two experimenters pursued solar rays research throughout the 1820s and 1830s, which resulted in a joint paper in 1838.

Christie was insistent that solar rays held magnetic influence and in 1828 published an additional paper with the same title, "On Magnetic Influences in the Solar Rays,"[103] to further solidify the connection:

> In the conclusion of my former paper I stated, that as magnetic influence in the compound solar rays was indicated by the effects which I had described, this would tend to remove the doubts which had been entertained respecting the results obtained by Morichini, by means of the violet rays, and Mrs. Somerville's paper, read almost immediately after mine, describing the effects which that lady had observed to produce under different circumstances by the more Refrangible rays, appeared completely to verify Morichini's results, and to corroborate my opinion.[104]

This reference was central for Somerville because it included her as an insider to the solar rays and magnetism debate and accredited her as a practising scientist who validated a hypothesis. Christie went on to substantiate Somerville's findings and further defend her work:

> Although the experiments of Mrs. Somerville have, on repetition, in many instances failed, we cannot, seeing the precautions that were taken, suppose that the effects described were due to other causes than the influence of the rays, but must rather infer that were not aware of all the circumstances which may interfere with the success of the experiment. It cannot, however, be denied that the subject is at present involved in much mystery, and that it is therefore very desirable that the circumstances on which the success of Mrs. Somerville's experiment depends should be clearly ascertained and that effects which I have invariably found to be produced by compound rays should be traced to some known principle of action.[105]

---

[103] Samuel Christie, "On Magnetic Influences in the Solar Rays," *Philosophical Transactions of the Royal Society of London* 118 (1828): 379 – 396.

[104] Ibid., 395 – 6.

[105] Ibid., 396.

The work Somerville outlined in "Magnetizing Power" was not only praised by Christie and Morichini, but later, by M. Baumgartner and David Brewster.

The theory that solar rays held magnetic communication was later debunked by Peter Reiss and Ludwig Moser in 1829. Reiss' and Moser's results were published in a paper, "Ueber die magnetisirende Eigenschaft des Sonnenlichts," and proved conclusively that solar rays held no magnetic influence.[106] Somerville was personally shaken by this rebuttal and "committed all the copies to the flames"[107] of "Magnetizing Power." No notebook detailing the experimental process as conducted in 1825 survived, and Somerville was not to work in the magnetic sciences again. Indeed, one reason for Somerville's later lack of interest in magnetism was surely the eventual negative outcome of her paper.

However, Somerville was to continue working on solar astronomy and corresponded with Herschel regarding the effect of the rays on paper soaked with vegetable juice. Martha Somerville was to state in an editorial footnote of *Recollections* that Herschel was Somerville's "truest and best friend." This alliance was a valuable asset for Somerville who relied on Herschel's knowledge of both mathematical astronomy and spectrum analysis to edit *Mechanism.* As well, by 1828 Herschel became the most pronounced and fruitful link Somerville had with the inner circles of science in England because Wollaston had died this same year.

Somerville was at her most active in scientific society when Oersted's tract sparked a "eureka" moment in science. The impact of this exceptional claim on practitioners at the Royal Institution opened new avenues of inquiry. Somerville's

[106] Peter Reiss and Ludwig Moser, "Ueber die magnetisirende Eigenschaft des Sonnenlichts," *Poggendorff's Annalen* XVII (1829): 563 – 592.
[107] Somerville in Patterson, *Cultivations*, 48.

willingness to make her home a place of lively scientific conversation invited the sharing of scientific knowledge at the site. Investigating these experiences demonstrate that the home, in the Somerville story, is not a space which excludes male participation. This social arena played a pivotal role in shaping Somerville's research aspirations as Wollaston shared his enlightening prismatic discovery with her. In turn, the practical knowledge gained from these sets of experiments gave Somerville the confidence to conduct solar rays research in order to engage with Morchini's existing hypothesis. Although Somerville did propose new causal possibilities for magnetic communication in her first paper, she was most influential as a collaborative author and her findings were cited by fellow experimenters to validate the shaky claim. Such recognition demonstrates that supportive voices hold solid positions when conclusive results were yet to be made at the embryonic stage of a specialization. In chapter two I will conduct a close reading of Somerville's research papers in order to assess Somerville's transition from scientific hostess to scientific practitioner. I will demonstrate that Somerville's research papers illustrate similar experimental processes as her contemporaries, which added to the paper's credibility.

CHAPTER TWO

MARY SOMERVILLE: THE RESEARCH PAPERS

*****

Spectrum Analysis

In the previous chapter we saw the "configurations of power" that were in play at the time Somerville was living at Hanover Square. The influence her scientific friends had on her was evident as Somerville demonstrated a greater interest in broadening her scientific activities over this period. Somerville began to conduct experiments on solar rays and narrated the results of her experimental findings with her four works of original research, which centred on spectrum analysis. Although the initial paper, "Magnetizing Power," was written independently, Somerville was engaging with a hypothesis initiated by Morchini. Subsequent papers were collaborative pieces and Somerville's findings were used to shed light on the certain focus of particular experiments and to advance an untried hypothesis. The later papers came over a span of ten years and appeared as follows:" Experiences sur la transmission des rayons chimiques du spectre Solarie, a travers, differents milieux" (1836),[108] "On the Action of the Rays of the Spectrum on Vegetable Juices" (1845),[109] and "On the Action of the Rays of the Spectrum on Vegetable Juices" (1846).[110] A close reading will give insight into the various voices

[108] Mary Somerville, "Experiences sur la transmission des rays chimiques du spectre Solarie, a travers, differents milieu. Extrait d'une letter de Mme Somerville a M. Arago, Comptes rendus hebdomadaires des séances de L'Academie des Sciences 3 (1836): 473 – 476.

[109] Mary Somerville, "On the Action of the Rays of the Spectrum on Vegetables Juices: Being an extract from a letter by Mrs. M. Somerville to Sir John F. W. Herschel, Bart., dated Rome, September 20, 1845." Communicated by Sir John F. W. Herschel, Bart. F.R.S., *Abstracts of the Papers Communicated to the Royal Society of London* 5 (1845): 569 – 70.

[110] Mary Somerville, "On the Action of the Rays of the Spectrum on Vegetable Juices. Extract of a letter from Mrs. M. Somerville to Sir J.F.W. Herschel, Bart., F.R.S. dated Rome, 1845," *Philosophical Transactions of the Royal Society of London* 136 (1846): 111 – 20.

Somerville established in these papers and in one case we will see how Somerville's amateur status was used aggressively to try out a theory.

In Chapter Two I will investigate Somerville's scientific papers in order to assess her research in synchrony with other practitioners who were investigating the properties of solar rays in the 1820s, 1830s, and 1840s. My case study approach to Somerville's initial paper, "Magnetizing Power," will demonstrate that with her start into solar analysis Somerville was attempting to achieve two branches of experimental outcome while establishing an authorial presence in *Philosophical Transactions*. First, Somerville used her work to support Morichini's already viable theory. Second, Somerville set forth to establish new theories linking magnetic communication to an eclectic assortment of materials. I will conduct a textual analysis of Somerville's scientific papers in order to reveal her experimental processes, and I will argue that Somerville's approach to experimentation was modelled after her experiences in social scientific endeavours. As well, I will use Somerville's published papers to explore how scientific publications were a space where reputations were upheld, sustained, and re-established. I will demonstrate that Somerville, in subsequent papers, was primarily a collaborating author and these works were published for the purpose of adding to the validity of Dominique François Arago's and John Herschel's on-going hypotheses.

Somerville's papers were written over a twenty year span and during this time Somerville had successfully cultivated a career as a popular writer. An analysis will reveal the impact that popular writing had on Somerville's authorial voice in scientific work over the years. I will demonstrate that although Somerville clearly defined a role of engagement, it was a technique that was strategically employed. It was also a trait visible in her books.

The Maiden Paper: "Magnetizing Power"

As Geoffrey Cantor states, an experimental paper is an argument that sets out to persuade an intended audience. "By the discourse of experiment the author tries to convince an audience – be it a specific scientist, a community of scientists, the lay public, the dispenser of research grants, etc. --- of the validity of the author's position (and perhaps the falsity of some opposing view)."[111] Somerville, no doubt, produced "Magnetizing Power" to be read, at some point, before the Royal Society and her specific intended audience was a community of magnetic scientists and astronomers. The language that "Magnetizing Power" employed was commonly seen in other scientific papers, which were submitted to the Royal Society and appeared in *Philosophical Transactions.* Standard phrases such as "I had the gratification to find,"[112] "depending on circumstances which I have not yet been able to detect,"[113] "I was desirous of ascertaining,"[114] and "from the results which have been stated"[115] were used throughout the paper. By employing a writing structure similar to other papers Somerville sought to establish affinity with fellow scientists and to indicate her familiarity with scientific writing as well as with experimentation.

The experiments outlined in "Magnetizing Power" were conducted during the months of July, August, and September of 1825. The findings indicated that solar rays

---

[111] Geoffrey Cantor, "The Rhetoric of Experiment," in *The Uses of Experiment: Studies in the Natural Sciences*, eds. David Gooding, Trevor Pinch, and Simon Schaffer (Cambridge: Cambridge University Press, 1989), 161.
[112] Somerville, "Magnetizing Power," 132.
[113] Ibid., 134.
[114] Ibid., 136.
[115] Ibid., 139.

refracted through a prism onto different objects caused these materials to be magnetized. In the paper, Somerville also noted specifically that the refracted violet rays held the most magnetic properties, while the blue and green refracted rays held some magnetizing properties. The exposure time differed from one to four hours and the greatest success was achieved between the hours of noon and 4 p.m:

> The sun was bright at the time, and in less than two hours I had the gratification to find that the end of the needle which had been exposed to the violet rays attracted the south pole of the magnetic needle, and repelled the north pole. It had been previously ascertained that there was no iron near to disturb the results. The experiment was also repeated on the same day, under precisely similar circumstances, with the view of detecting any source of error that might have escaped observation in a first attempt; but the result was the same as in the first.[116]

After the initial experiment Somerville was encouraged that attraction had occurred and magnetic properties had been detected.

David Gooding points out, "[r]epeating an experiment can bring out the uncertainty of observational situations, blurring the clarity of hindsight and so highlighting the creative possibilities available in situations of uncertainty."[117] In "Magnetizing Power" Somerville drew attention to the fact that she was aware that redoing the same procedure on the same day, or on subsequent occasions, was an important practice in science. Somerville, in 1826, was in possession of Sabine's arctic papers and it can be surmised that Somerville made note of Sabine's practice of repetition. In his work Sabine had made a point of stating that he was pleased with the Parry Expedition because he was able to conduct the same experiments, at the same location on subsequent days, to locate terrestrial magnetic buildup. Yet, Somerville's

---

[116] Ibid., 133.

[117] David Gooding, "Mapping Experiment as a Learning Process: How the First Electromagnetic Motor was Invented," *Science, Technology, & Human Values* 15 (1990): 165 – 201.

entry into the study of prismatic analysis was marked by methodological flaws, which included her inability to ensure a sanitized work space.

The system Somerville employed to detect magnetic influence was based on observing the minute swings of a sewing needle after exposure to colour rays. With such detailed analytical work experienced magnetic experimenters were attuned to the possibility that any workroom may inherently be exposed to slight vibrations, which in turn would alter the degree of swing a needle exhibited.[118] There is no indication in that paper that Somerville had accounted for this fact. In addition, even in the most sterile magnetic laboratories researchers were suspicious of results, which were often inconsistent. A solution was to retry processes and to employ a dedicated regiment of trial and error to facilitate possible exposure to other magnetic sources. To further ensure the purity of the work area the site of experimentation was continually under scrutiny. Somerville noted in "Magnetizing Power" that she often left her site of research, leaving the test objects unattended for hours, before returning to determine if magnetism had occurred.[119]

Further reading of "Magnetizing Power" illustrates that Somerville was insensitive to potential flaws with her equipment. In the paper Somerville said little regarding the routine she applied to check that her tools were in proper working order. Somerville made no note of questioning the possibility that the stone, a major testing apparatus, may be inadequate to distinguish precise variations under such refined conditions.

---

[118] Ibid., 159.
[119] Somerville, "Magnetizing Power," 133, 136.

One method Christie employed to test for proper equipment function was to repeat the experiment using different tools that performed the same function. Whether it was out of carelessness or because she was not aware of this standard course of action, the paper indicated that Somerville did not perform this crucial step. Somerville's lack of concern surrounding her experiments may be linked to the way in which Wollaston conducted the solar ray experiments at Hanover Square. Somerville's amiable morning of science was a teaching in experimentation and thus Somerville conducted her own experiments for "Magnetizing Power" in the same way. Consequently the tone of the paper reflected the casual manner of how these tests were carried out.

Christie was a terrestrial magnetic researcher who, by the early 1820s, had also turned his attention to solar rays. Because of his parallel findings, despite the notable difference in experimental procedure, a brief comparison of Christie's "Magnetic Influence" (1826) and "Magnetizing Power" will demonstrate that Somerville's acumen for research in 1826 was enthusiastic yet still dilettante. In "Magnetic Influence" Christie outlined the experimental process in meticulous detail and this feature became part of his idiosyncratic style. The exact time of exposure was recorded.[120] The magnetic readings were spelled out in paragraph form and translated to a chart for easy comparison.[121] The exact size of the needle used was noted.[122] The intensity of the arc of variation based on the temperature and the degree of variation were documented with precision. By the time Christie had ascertained the last of his findings he was calculating to the 6th digit:

> If we estimate the change of intensity by the difference in the times of vibration, calling the intensity at the temperature 60 degree, 1; we shall have,

[120] Christie, "Magnetic Influence" (1826), 223. For example Christie had stated that on the 19th of June, 1825. He made observations between 11 h 30 m and 12 h 40 m.
[121] See Christie, "Magnetic Influence" (1826), 221, 222, 224, 227, 229, 234.
[122] Christie, "Magnetic Influence" (1826), 220.

> Intensity at temperature 84 degree = (158.3)2/(158.9)2 = .992462
> We have therefore here a decrease of intensity .007538, in consequence of an increase of 24 degree in temperature.[123]

Christie was to list a further four such equations for intensity readings.[124]

Christie was aware of the sensitive nature of atmospheric conditions and in "Magnetic Influence" (1826) he addressed the issue of temperature variation. The paper charted his temperature settings precisely and recorded each finding. In addition to using a magnet, Christie used a compass to test for any external sources of magnetism.[125] Yet, despite Christie's detailed paper, and the precision he indicated in his methodological approach, his hypothesis was erroneous. Like Somerville, he was adamant that solar rays held magnetic influence. Whether or not Somerville would have achieved the same results under more stringent experimental procedures is uncertain.

"Magnetizing Influence" (1826) set out to uphold one thesis and Christie made this distinct fact known in the paper. The research engaged various methods and an assortment of tools were used in order to form the causal relationship between magnetic influence and solar rays. Somerville's work was not nearly as mundane or reserved. "Magnetizing Power," as will be shown by the numerous claims Somerville was to make, pointed to a speculative and impulsive practitioner. The 1826 document not only claimed episodic instances of magnetic communication but went on to bravely state that magnetic properties, once transferred, were sporadically re-emergent in certain items:

> On examining these needles [magnetized needles] the following day, they had lost their magnetism, a circumstance which had not before occurred, though it was observed sometimes to take place afterwards [...] and then the needles had not

[123] Ibid., 223.
[124] Ibid., 224.
[125] Ibid., 220, 234.

> only acquired very sensible magnetism, but still retain it, at the distance of nearly six months.[126]

The variation in the retaining power of the same set of needles, which seemingly made magnetism appear and disappear without explanation, should have raised suspicion but instead it egged Somerville on to expose other elements to solar rays. By doing so Somerville was to launch into a second area of experimental activity, which was to propose a new theory.

Under differently colored glass, and at times, covered by different color ribbons, Somerville exposed a diverse collection of household items to the rays. Somerville's findings were fantastic for a single experiment, and this outcome should have alerted Somerville to the likelihood that her equipment or her processes were flawed:

> Pieces of clock and watch spring were next tried, under the idea that they might, possibly from their blue colour, be more susceptible of magnetic influence, and it was the case; their greater extent of surface however, or their softness, may have contributed to this susceptibility. The pieces of spring were from two to three inches long, and from the eighth to half of an inch broad. It was difficult to procure watch and clock spring free from magnetism; it even happened on one occasion, that although the roll of spring was neutral, the pieces into which it was cut became magnetic.[127]

In error, Somerville believed that solar rays had successfully magnetized sewing needles varying in size from one inch to two inches, as well as clock springs, white steel, steel, and steel encased in blue and green ribbon.

As "Magnetizing Power" progressed Somerville's notation of specific tools and times became hazy and her keenness to establish magnetism as a far-reaching phenomenon was evident. The following passage was characteristic of her later entries and carried no record of how long the pieces of clock spring were exposed to the sun. The

---

[126] Somerville, "Magnetizing Powers," 135.
[127] Ibid., 135.

exact thickness of the glass, both blue and green, was not recorded and there was no indication if the glass pieces were tested for magnetic contamination prior to the experiment:

> On the 26th of August, the thermometer at noon being 66 [degrees], two neutral pieces of clock spring were exposed to the sun, one under a thicker piece of the same blue glass, as in the former experiment, and the other under green glass; both acquired polarity. [128]

The paper reveals that any flaws in the work spoke more of Somerville's lack of training and a rush to establish an authorial identity than any intentional deceit.

In this period, as we have seen in chapter one, magnetism was a science developed along many branches and instances of magnetic communication were noted on many fronts. Somerville may have been pressed into believing that magnetism can be generated from an array of sources because the phenomenon was considered widespread. The rush to try the solar experiments on numerous objects many have arisen because the hot summer days were quickly drawing to a close. Between August 26 and September 20' 1825, Somerville made six entries describing the successful magnetization of a number of items and each entry became less and less specific and more spectacular in its claims. In the final entries on September 2 and September 20, Somerville declared that clock spring pieces wrapped in green and blue ribbon were "fixed to the inside of a pane of glass in a window, where they were left exposed to the sun all day; in the evening both had become magnetic."[129] By the end of the summer Somerville's confidence that solar rays held magnetizing power was set in her mind.

[128] Somerville, "Magnetizing Power," 137.
[129] Ibid., 137.

"Magnetizing Power" in Context

The importance of "Magnetizing Power" at the time of its publication cannot be over-valued. Not only was the paper was successful in terms of its scientific contribution, but "Magnetizing Power" provided evidence that a woman with little formal education could develop a scientific mind. Somerville was exemplary of a rising concept, namely, that self-improvement was indeed possible by engaging in reading "for an hour or two every other day at least."[130]

Between 1827 and 1829, "Magnetizing Power" achieved steady mention in scientific papers from supporters who also saw a correlation between magnetic force and solar rays. In 1829, even after the rebuttal, "Magnetizing Power" and Somerville's name still enticed curiosity if not interest. Richard Taylor and Richard Phillips in *Annals of Chemistry, Mathematics, Astronomy, Natural History and General Science* (1830) included Somerville's paper as part of a seventeen year research investigation by a group of philosophers looking at magnetic communication. The article which was published in "Intelligence and Miscellaneous Articles" indicated that "Magnetizing Power" had "dissipated the doubts of many persons" and that Somerville's theory had given rise to numerous other theories concerning the magnetic variation on earth.[131] The reviewers further stated that Riess and Moser went on to prove conclusively that the "slight variation" observed was not due to magnetic communication.[132] Although cited as an erroneous work, "Magnetizing Power" was positioned by Taylor and Phillips to be of the

[130] Henry Brougham, *Practical Observations Upon the Education of the People: Addressed to the Working Classes and Their Employers* (Manchester: E.G. Morten, 1825), 1.

[131] Richard Taylor and Richard Phillips, "Magnetizing Power of the Solar Rays," in *The Philosophical Magazine or Annals of Chemistry, Mathematics, Astronomy, Natural History, and General Science* (1830): 155.

[132] Ibid., 155.

same calibre as papers by Morichini, Baumgartner, and Riess and Moser. Christie received no mention for his two papers, "Magnetic Influence" (1826) and "Magnetic Influence" (1828). Surprisingly, even as late as the twenty-first century, Somerville's spectrum analysis experiments still drew interest.[133]

Somerville and Dominique Francois Arago (1836)

Somerville continued to contribute to solar rays analysis over a ten year span and her presence on the page illustrated how she was able to shift and re-establish her authorial identity. Somerville added her findings to one research paper by Arago and two by Herschel and in these incidents Somerville claimed the role of a friend of science who dabbled in experimentation in order to complement the works of two giants in astronomy. It was apparent that Somerville now sought an auxiliary role allowing Herschel and Arago to take the lead, yet it was an influential position. In 1836, with Faraday's assistance, Somerville worked on the transmission of solar rays and her findings were sent to Arago. In 1838 Somerville and her husband moved to the Italian region and from this sunny and hot climate Somerville continued her research on the sun's rays sending her findings to Herschel in the mid-1840s.

The experiments Somerville conducted in 1835 were attempts to verify a hypothesis proposed by Italian philosopher, Macedonio Melloni (1798 – 1854). Melloni put forward the argument that the composition of the rays of the sun could be separated according to their various constitutions. Melloni's aim was to isolate the rays' illuminating qualities by filtering out the heat and chemical properties. Arago had heard of Melloni's claim and considered it to be credible. However, Arago was to remark that,

---

[133] In March 2001 a research assistant at Oxford attempted to replicate Somerville's experiment. No magnetism occurred under any condition that Somerville outlined. See Allan Chapman, *Mary Somerville and the World of Science* (Bristol: Canopus Publishing, 2004), 64.

as a courtesy, he would not undertake the actual experiment until he could determine if Melloni had wanted to conduct the research and be the first to establish this claim in writing. Somerville, apparently, did not have such concerns and Arago, in his letter to the Academy, surprisingly, supported her audacious approach:

> The motives which I had in 1835, said M. Arago, at the meeting of the Academy on the 17th of October 1836, not to interfere in researches which so directly conducted M. Melloni to these beautiful discoveries, still subsist. I shall, therefore, abstain from stating some results to which I have arrived concerning the absorption or interception of the chemical rays. Everyone, however, will understand that the same reserve cannot be imposed upon Mrs. Somerville; and I cannot, therefore, withhold the interesting experiments of this illustrious lady from the Academy, and the public.[134]

Arago, in the above passage, suggested that the porous position of being an independent researcher who was essentially unaffiliated with any scientific institution, in this case, excused Somerville and "the same reserve cannot be imposed"[135] on her as on him.

For this work, Somerville utilized the same circumstance that she had in the production of "Magnetizing Power." She chose an area of research that was still in the embryonic stage and open to new observations and claims. After ten years away from original research, Somerville's public status was again that of a dilettante of science. This position set her apart from those with serious scientific associations. Somerville did "milk" both worlds upon her re-admission into scientific experimentation and authorship. She used her ambiguous status as an outsider of science to engage in scientific practice without adhering to the polite decorum of an inside practitioner. At the same time, Somerville sent her results to Arago who endorsed her work, as a casual contributor, before a prestigious scientific society. Although Somerville lacked scientific membership

---

[134] "Extract of a Letter from Mrs. Somerville to M. Arago, Detailing some Experiments Concerning the Transmission of the Chemical Rays of the Solar Spectrum through Different Media," *Edinburgh New Philosophical Journal* 22 (April, 1837): 180 – 83.

[135] Ibid., 181.

in any institutions, she was quick to point out in the letter to Arago that she had important friends who helped her gather materials for the experiments. As "Magnetizing Power" utilized Wollaston's name,[136] her letter to Arago made mention of Faraday in the first sentence.[137]

In this series of experiments Somerville refracted solar rays through thin pieces of differently coloured glass onto paper soaked with chloride. The premise was that if the paper discoloured, then the illuminating properties of the rays had transported the chemical properties through the glass as well. Somerville was to state in her observations that she noticed the glass colour did influence the communication of the rays. Seemingly, the lighter the color of the glass the more noticeable was the occurrence of chemical transportation. The impact that the debunking of "Magnetizing Power" had on Somerville cannot be missed in this scientific letter. Somerville's narrative was full of doubt and her ambiguity was evident as she questioned the transparency of her apparatus. The paper did not possess the energy that "Magnetizing Power" exhibited, and the priority of her research was to observe for any signs of discolouration. Somerville clearly stated that she would not draw a conclusion from these initial observations:

> These experiments led me at first to suppose that all green substances possessed this property [being of an impenetrable nature]: but I very soon found that this would be drawing too hasty a conclusion; for, having shortly afterwards tried the experiment with a very large emerald [...] I found that it readily transmitted the chemical rays.[138]

As this passage indicates, the paper was unmistakably from a more weathered and cautious author.

---

136 Wollaston was no longer available to Somerville having died in 1828.

137 Somerville, "Letter to Arago," (1836), 181. Somerville stated that Faraday had prepared a concoction of "pure and white" chloride for her.

138 Somerville, "Letter to Arago," 182.

Using the same experimental techniques, Somerville exposed other materials to the rays. Her list included rock-salt, white glass, blue glass, and violet glass and she noted which of these items permitted more chemical rays to pass through and which allowed fewer. Analyzing the degree of discolouration produced on the chloride soaked paper, Somerville was able to establish the influence of the chemical rays. Somerville stated that her observations illustrated that violet and blue materials permitted greater penetrability while "garnet" shades were less permeable.

There was no question that in an informal letter to a friend Somerville could exercise less scientific rigidity in how she conducted her experiments and stated her observations. There was no mention of key factors such as exact exposure time, the intensity of the rays, and the level of discolouration. The observations were noted with breeziness and Somerville's method of record keeping was hazy:

> The white topaz, as well the blue, and the blue pale beryl, the cynatia [sic], the heavy spar, the amethyst, and various other substances, transmit the chemical rays with great facility; whilst the yellow beryl does not, so to speak, transmit them at all, and the brown tourmaline as well as the green, have the property to so light a degree.[139]

The letter was reminiscent of a day of casual science and far removed from the conformity of a scientific paper. The concluding sentence indicated that Somerville was aware of the amorphous observations that her research produced: "I may observe, that I purpose shortly to resume the prosecution of the subject."[140] It was apparent that Somerville would not again stake her reputation on questionable results.

Arago made the decision to present Somerville's observations at the October 17, 1836 reading of l'Academie des Sciences. "Experiences sur la transmission des rayons"

[139] Ibid., 182 – 3.
[140] Ibid., 183.

was published in *Comptes rendus* in the same year. Somerville's contribution to Melloni's pioneering theory gained her authorship into an alternate area of solar rays analysis in 1836. The extract was translated into English and published in 1837 in the *Edinburgh New Philosophical Journal.* The earnestness to reapply her familiarity with prismatic analysis to a new branch of solar research showed Somerville's determination to remain visible as an author in this domain. (Figure 1)

Figure 1
Portrait by of Mary Somerville by Samuel Lawrence (1836)
Girton College Library and Archive, Cambridge
Permission granted by the Mistress and Fellows, Girton College, Cambridge

Somerville and John Herschel (1845)

Somerville again forged an entry into the study of solar astronomy and spectrum analysis nine years later. John Herschel had developed an interest in photographic images and light. Somerville's observations of solar rays and their influence on vegetable juice were sent to him. Experiments for "On the Action of the Rays of the Spectrum on Vegetable Juice" were conducted in Rome and the results, totalling a brief two paragraphs, were published in *Philosophical Transactions* in December, 1845. Somerville had taken a break from science and her lack of contribution was aggravated by her isolation from scientific society in this southern country. She was to state in a letter to her son that she had not written because "[O]ne day [was] so precisely similar to the preceding, that there has been nothing worth writing about."[141] Somerville was, by 1845, geographically outside of scientific culture, and her only interaction with people of science was via intermittent holiday events and sporadic letters containing niceties and well wishes.

Somerville's decision to send the 1845 sets of experiments to Herschel was due to the fact that Herschel had been seduced by the photographic craze. He had diverted his attention to spectrum work and chemical analysis during the late 1830s and early 1840s. In the late 1840s John Herschel diverged into spectroscopy and attempted a set of experiments related to what we now know to be radiation wavelengths. [142] Of the three papers he published in *Philosophical Transaction* during this time span, two were

[141] McMillan, *Queen of Science*, 225.

[142] See John North, *The Norton History of Astronomy and Cosmology* (New York: W.W. Norton & Company, 1995), 445.

focused on the correlation between the colours of the spectrum and photography.[143] Herschel was much interested in Daguerre's observations pertaining to white light and refrangible rays on chemical agents and what this work could mean for photo imagery and its replication. The enormity of the task was to reproduce the same effect with chemical agents as seen in nature and transport that technology to generate "facsimiles of the original photograph."[144] Herschel found Somerville's work on acids and solar rays noteworthy enough to be published, and the results she had achieved were supportive of his own observations. As with Somerville, Herschel discovered that the redder rays produced different effects of discolouration on paper than did the violet or lavender rays. The suddenness of Somerville's re-admission into prismatic analysis indicated that Somerville must have heard about Herschel's photographic interests and immediately took it upon herself to conduct experiments in the favourable climate.

The tone of the first 1845 letter that Somerville sent to Herschel revealed the manner in which this episode of research was conducted. It was a letter that was setting the stage for a more permanent re-entry into scientific discourse. Considering the brevity of the piece, and the open question at the end of the concluding paragraph, there was a sense that Somerville was also testing Herschel's feedback to her work. Because of Somerville's continued experimental work, it can be surmised that Herschel's highly favourable response, which included the communication of her findings before the Royal Society was greatly treasured by Somerville.

[143] John Herschel, "On the Chemical Action of the Rays of the Solar Spectrum on Preparations of Silver and other Substances, both metallic and non-metallic; and on some Photographic Processes," *Philosophical Transactions of the Royal Society* 42 (1840): 205 – 210. John Herschel, "On the Actions of the Rays of the Solar Spectrum on Vegetable Colours," *Philosophical Transactions of the Royal Society of London* 55, (1842): 397 – 398.

[144] John Herschel, "On the Chemical Action of the Rays of the Solar Spectrum on Preparation of Silver and other Substances, Both Metallic and Non-Metallic; and on Some Photographic Processes," Abstract of the Papers Printed in the *Philosophical Transactions of the Royal Society of London* 4 (1837 – 1843): 206.

The experiments, similar to Somerville's work in 1836, investigated the chemical properties of the different colors of the solar spectrum. Somerville directed solar rays through a pin-hole onto paper soaked with vegetable juice and the results were scrutinized using blue spectacles.[145] The simplicity of the apparatus employed kept the character of a light afternoon of science and indicated an author who was only concerned with a supplemental, yet visible, role. Somerville's findings were that the differently coloured refracted rays did produce fluctuations in the intensity of discolouration on the paper. Somerville was to conclude that heat was not a factor. The letter, by its nebulous tone, left open the possibility for further research in spectrum analysis. "But altogether, as the author states, the action of the different parts of the spectrum seems to be very capricious, the changes of colour produced being exceedingly irregular and unaccountable."[146] This concluding sentence set the stage for more work to come from this author.

The still exploratory nature of the work in spectrum analysis and vegetable colouration was what permitted only a very loose hypothesis to be proposed, and Somerville's re-entry into experimentation made use of this opportunistic situation. The larger question, to which Somerville's work aimed to add knowledge, was to determine what accounted for the different shades and colouration of vegetables. Perhaps more important than the reading of the paper at the Royal Society was the encouraging letter Herschel sent to Italy. The letter was congratulatory in nature and even singled Somerville out for her pioneering spirit. According to Herschel, Somerville's work

[145] Somerville, "Letter to Herschel" (1845), 569.
[146] Somerville, "Letter to Herschel" (1845), 570.

showed the scientific community the numerous possibilities for spectrum analysis in astronomy, which lay in exploring the colours of solar light:

> I cannot express to you the pleasure I experienced from the receipt of your letter and the perusal of the elegant experiments it relates, which appear to me of the highest interest and show (what I always suspected), that there is a world of wonders awaiting disclosure in the solar spectrum, and the influences widely differing from either light, heat or colour are transmitted to us from our central luminary, which are mainly instrumental in evolving the maturing the splendid hues of the vegetable creation and elaborating the juices to which they owe their beauty and their vitality.[147]

Herschel felt Somerville's work did add to the early understanding of how the sun's rays influenced the colouration of vegetables

From the overall high spirited assessment of Somerville's experiments, Herschel made it known to Somerville that her letter would appear as "an extract of a letter to myself" before the Royal Society.[148] Herschel assured Somerville that he would not take such steps if he did not think well of her work:

> [...] Now I am going to take a liberty [...] and that is to communicate your results in the form of "an extract of a letter" to myself – to the Royal Society. You may be very sure that I would not do this if I thought that the experiments were not intrinsically quite deserving to be recorded in the pages of the Phil Trans. And if I were not sure that they will lead to a vast field of curious and beautiful research; and as you have already once contributed to the Society, (on a subject connected with the spectrum and the sunbeam) this will, I trust, not appear in your eyes in a formidable or repulsive light, and it will be a great matter of congratulation to us all to know that these subjects continue to engage your attention ...[149]

Herschel specifically invited Somerville to continue her work with solar rays and vegetable juice and his congenial comment to "Pray go on with these delightful experiments" was taken to heart by this investigative enthusiast.[150]

---

147 "Letter from Herschel to Somerville" (1845) in McMillan, *Queen of Science*, 226.
148 Ibid., 227.
149 Ibid., 227.
150 Ibid., 227.

However, Herschel must have been aware of Somerville's unease in making yet another contribution to *Philosophical Transactions* after "Magnetizing Power." Herschel made reference to the paper in the above paragraph, but he further alluded to the incident at the end of the correspondence by indicating to Somerville that a retraction of the experimental letter was inconceivable.[151] What motive Herschel had is uncertain but he was adamant that Somerville continue her work from her "residence in that sunny clime."[152] Herschel was attuned to Somerville's isolation and even tried to console her by suggesting that "I am here nearly as much out of the full steam of scientific matters as you at Rome."[153] With these prompting words Somerville was ready to again enter into sophisticated experimental practice, which, if successful, would retrieve her from obscurity.

Experiments from "that Sunny Clime"

From Italy emerged an impressive nine page experimental paper, which was sent to Herschel dated September 20, 1845 and received by the astronomer on November 6. The variety of the experiments indicated that Somerville was giving herself over to an in-depth study of the sun's rays, and her endlessly open days meant that she could commit herself whole-heartedly to analyzing the effect of an array of different refracted colours. The experimental program she engaged in was simply to collect a set of observations and findings. Somerville kept to a rigid experimentation platform that allowed her to make use of the afternoon sun.

Working with the different color rays on paper and black silk drenched with sulphuric acid, sulphate, and nitrate, Somerville noted the intensity of discoloration after

---

[151] Ibid., 227.
[152] Ibid., 227.
[153] Ibid., 227.

certain time spans. The observations indicated that when colours conjoined a different intensity occurred:

> There was reason to suspect that the action of the spectrum at the junction of the lavender with the violet rays, is in some cases different from what it is on either of these colours separately, a second dark image having appeared at the extremity of that which terminated with the violet, indicating a break in the continuity of action and giving the idea of a secondary spectrum.[154]

This finding was considered noteworthy by Herschel because much of his work was centred on the lavender and violet rays. Herschel's work, which now included Somerville's excerpt, was the only paper in *Philosophical Transactions* discussing the rays of the spectrum and colour analysis in 1846.

The fact that Somerville was diligent in these sets of experiments was apparent as she went to the length of providing a meticulous sketch of each outcome. The diagrams, twenty-one in total, illustrated the shape and size of each stain. Each discoloration was subsequently described in detail in the paper and referred to in the diagram. Much emphasis was given to the liquids used and the processes that went into obtaining the results. Clearly, Somerville's priority was to make sure that this submission to the Royal Society and *Philosophical Transactions* was done with scrupulous regard to detail. Yet, regardless of how much attention Somerville put into her observations the paper still indicated a lingering sense of caution. As the last sentence pointed out, "I fear I may have some mistakes, especially in the estimation of the action of the different coloured rays, the limits of which it was extremely difficult to determine in so small a spectrum as that with which I worked."[155] Somerville's re-entry into scientific practice exposed a guarded researcher and writer. Her acumen for writing had matured, and this fact was obvious not

[154] Somerville, "Rays of the Spectrum" (1846), 112.
[155] Ibid., 120.

only in the descriptive passages but also in how Somerville organized her observations. More importantly, the fact that Somerville understood that her observations had been achieved using tools that were restrictive indicated that she, at this stage in solar analysis, was a knowing practitioner. In addition, by 1845 Somerville had produced two successful popular books on mechanical astronomy and atmospheric conditions. Writing these works contoured Somerville's narrative abilities as both publications were based on Somerville's ability to engage with on-going theories and relay them to the public.

Between 1826 and 1845 Somerville produced four pieces of original research that expanded the breadth of spectrum analysis. Somerville's first paper was an independent work that supported a theory Morchini had outlined. Somerville's supportive voice in papers by Arago and Herschel demonstrated a shift in Somerville's narrative identity as she wrote as a secondary experimenter. In all four papers Somerville was influential because her results were used to collaborate with the work of others regarding theories in progress. The papers demonstrated the fluidity between an amateur practitioner and noted men of science and the mutually beneficial nature of this relationship. In chapter three I will demonstrate how Somerville again engaged with an established scientific document to gain recognition in the popular arena.

CHAPTER THREE

MARY SOMERVILLE AND WRITING FOR A PUBLIC AUDIENCE

*****

On the Mechanism of the Heavens

Mary Somerville was successful as an astronomical popularizer and her books reached the public market at intervals between her scientific publications. Somerville's contribution to both arenas highlights her narrative abilities. The dissertation will investigate Somerville's popular work, which requires back tracking in time, in order to discuss the relationship between Somerville the popularizer and Somerville the experimenter. In this comparative approach I will demonstrate that Somerville, in her popular writing, was most influential when she illuminated the theories of others to the public. As well, Somerville's association with various scientific circles introduced her to different ways that science and nature were discussed in polite conversation. These talks shaped Somerville's narrative format in her popular work. In addition, Somerville gained extensive knowledge in the area of magnetism through her experimental work and this force of nature was spiritedly brought out in her popular publications.

As with her scientific experiments and subsequent papers, Somerville was able to take advantage of her circumstances to enter into popularization. Somerville was commissioned to translate Laplace's work in 1827 because Laplace had suddenly died and numerous requests were being made in England and America for versions of his text. In translating and popularizing *Mecanique Celeste,* Somerville engaged with a popular French theory and reintroduced the work by adding dimensions that were sensitive to the

English reader. Somerville's English translation was subsequently titled *On the Mechanism of the Heavens* (1830). To make *Mechanism* more absorbing, Somerville added a "Preliminary Dissertation" and in this section she experimented with a style of writing similar to "chatter," which was less formal than the "sisterly" dialogue or the maternal tradition under which many women popularized the natural world.[156] This inclusion outlined the contributions of English scientists and how their theories set the universe in motion,[157] placed the heavenly bodies within a Godly context, and included the sublime to convey the great distances embodied within the celestial sphere.

In 1834 Somerville again engaged with the theories of astronomers and scientists and published *On the Connexion of the Physical Sciences*. This text was more sophisticated than *Mechanism* and an analysis will demonstrate that Somerville's writing method had changed. Departing from an informal "chatter" style, Somerville became a conversationalist as she organized and clearly articulated the relationship between the theory and the theorist to a popular audience.

In Chapter Three I will perform a textual analysis of *Mechanism.* I will argue that Somerville introduced a new narrative format, "chatter," to popular writing styles of the 1830s and her goal was to cultivate familiarity with the reader. It was the "Preliminary Dissertation" which drew most praise from reviewers rather than the body of the work itself. In order to contextualize the work within the wave of translations of *Mecanique Celeste* appearing in the marketplace after Laplace's death, I will assess the reviews and comments that *Mechanism* received upon publication.

---

[156] See Bernard Lightman, *Victorian Popularizers of Science: Designing Nature for New Audiences* (Chicago: University of Chicago Press, 2007), 129. Lightman points out that by the 1820s and 1830s, popularizers were already looking to other narrative formats and by 1850 had abandoned the maternal or sisterly tradition altogether.

[157] Neeley, *Illuminations*, 105.

In addition, I will provide a close reading of Somerville's other work on atmospheric conditions, *Connexion.* The text was not simply an extension or enlarged version of the "Preliminary Dissertation" as previously argued in past scholarship. An analysis of the reviews pertaining to *Connexion* is crucial to understanding the definition of the term "scientist" in the mid-1830s because William Whewell, in his praise of *Connexion*, created the word to refer to the work produced by writers and practitioners such as Somerville.[158] The successes of *Mechanism* and *Connexion* were fundamental to Somerville receiving a contentious Civil List Pension, which allowed her to continue her original research on solar rays and vegetable juice as well as write other science books for the popular marketplace.[159]

The Society for the Diffusion of Useful Knowledge

The request to popularize Laplace for the Society for the Diffusion of Useful Knowledge (SDUK) came to Somerville in 1827.[160] The main goal, under the direction of Lord Henry Brougham, was to publish inexpensive reading material for popular distribution. A large portion of the material commissioned was scientific in nature and the objective was to make such knowledge more accessible to the working classes.[161] The manuscript for *Mechanism*, which took two years to complete, was sent to Herschel, "our greatest astronomer," to ensure its accuracy. It was with Herschel's editorial assistance and under his assurance of the book's mark on "posterity" that the manuscript was sent to print:

---

[158] William Whewell, "Review of On the Connexion of the Physical Sciences," *Quarterly Review* 51 (1834): 54 – 58

[159] Somerville wrote *Physical Geography* in 1850 and *On Molecular and Microscopic Science* in 1869.

[160] The Society for the Diffusion of Useful Knowledge was founded in 1826.

[161] See Alan Rauch, *Useful Knowledge: The Victorians, Morality, and the March of Intellect* (Durham NC: Duke University Press, 2011).

> I [John Herschel] have read your manuscript with the greatest pleasure, and will not hesitate to add, (because I am sure you will believe it sincere,) with the highest admiration. Go on thus, and you will leave a memorial of no common kind to posterity; and, what you will value far more than fame, you will have accomplished a most useful work. [...] Will you look at this point again? I have made a trifling remark in page 6, but it is a mere matter of metaphysical nicety ...[162]

Herschel made minor corrections throughout the manuscript and later promoted the sale of the book as a textbook at Cambridge.

The "Preliminary Dissertation" in Context

The study of the exchange of scientific information between distinct cultures has a long tradition in Science and the Humanities. Maurice Crosland and Crosbie Smith stated in their paper, "The Transmission of Physics from France to Britain: 1800 – 1840" (1978), that the process involved more than translation.[163] What can be called the networking of scientific knowledge goes through alterations at every encounter whether the information is transmitted at a personal or an institutional level. The processes of transmission mirrors how individual actors engaged treatises and how participants in a particular area of science intertwined translations, reviews, counter-arguments, assessments, and how they popularized works into their own popular, academic, or scientific culture:

> Transmission may take place at two levels. At the first and simple level, someone sees a treatise of printed memoir, for example, and becomes aware of the physical existence of the work. At the second and more complex level, he responds to the work in the light of his own views. [...] In the latter situation, he may review, popularize, each, if necessary translate, debate, or develop the work to the extent that it integrates with, adds to, modifies, or replaces his views. [...] The process of transmission is a dynamic one of continual change and debate, involving frequent

[162] Letter from Herschel to Somerville in McMillan, *Queen of Science*, 135 –36.
[163] Maurice Crosland and Crosbie Smith, "The Transmission of Physics from France to Britain: 1800 – 1840," *Historical Studies in the Physical Sciences* 9 (1978): 2.

> interaction among men of science through verbal exchanges or letters or through treatises, texts, or papers.[164]

Somerville's entry into the popular marketplace incorporated multiple facets of Crosland's and Smith's definition of transmission.

The most noticeable characteristic of the work was Somerville's addition of the "Preliminary Dissertation." This section resembled an independent, small novella and indeed fifty copies, without the ensuing work of Laplace's mechanical philosophy, were published for Somerville to distribute to her friends.[165] The Dissertation had gathered numerous positive responses from Somerville's contemporaries. "With great good sense, therefore, and no small kindness, Mrs. Somerville has given all that we could have desired, in a preliminary dissertation, which, independently of its own intrinsic excellence, cannot fail to stimulate many readers to pursue for themselves the investigation of the phenomena it describes."[166] The above praise, for example, was awarded by the *Literary Gazette.*

The *Literary Gazette* was so impressed with Somerville's piece that the paper suggested Somerville publish the "Preliminary Dissertation" as a separate item, which could be made available to the common reader:

> Is it asking too much of Mrs. Somerville to express a hope that she will allow this beautiful preliminary dissertation to be printed separately, for the delight and instruction of thousands of readers, young and old, who cannot understand, or who are too indolent to apply themselves to the more elaborate parts of the world? If she will do this, we hereby promise to exert our best endeavours to make its merits known.[167]

---

[164] Crosland and Smith, "Transmission," 2.

[165] James Secord, "Introduction," *Mary Somerville: Mechanism of the Heavens*, (Bristol: Thoemmes Continuum, 2004), X.

[166] "Review of *Mechanism of the Heavens*, *Literary Gazette* (17 Dec. 1831): 806-7," in *Mary Somerville: Scientific Papers and Reviews,* ed. James Secord, (Bristol: Thoemmes Continuum, 2004).

[167] Ibid., 6.

Why Somerville, or Murray, her publisher, chose not to distribute the Dissertation on its own could be attributed to the fact that *Mechanism* was doing very poorly in sales when it was first published and neither the author or the publisher was willing to risk additional production costs. The "Preliminary Dissertation" was in fact published separately without Somerville or Murray's knowledge in subsequent years. Carey and Lea, publishers based in Philadelphia, issued the "pirated" "Preliminary Dissertation."[168] The sale numbers are not known and Somerville never received any monies for it. James Secord argues that the Dissertation was not a work that can be considered independently and must be analyzed as part of *Mechanism.*[169] I will analyze the "Preliminary Dissertation" in context with *Mechanism.*

A Creator and *Mechanism*

In *Mecanique Celeste* (1799 and 1825) Pierre-Simon Laplace revitalized Newtonian theoretical astronomy by reformulating Isaac Newton's equations into a more applicable series of formulas. With Laplace's contribution, French mechanical astronomy was able to better predict the paths of planets, the position of the stars in the universe and, to the delight of popular audiences, the return of comets. *Mecanique Celeste* was Laplace's majestic five volume work, which introduced the parabola to Newtonian astronomy.

Gravitational and physical astronomy relied heavily on observation and by using this ancient tradition mechanical astronomers could verify the accuracy of their calculations. Newtonian astronomy was highly regarded in the scientific world, and was popular in culture, because astronomers, using Newton's *Principia,* were able to predict

---

[168] Secord, *Mechanism*, XIV.
[169] Ibid., X.

to the half-year the return of Halley's Comet in 1759.[170] The occurrence did, in fact, solidify the theory.

A key difference between British Newtonian mechanical astronomy and the work of French mecanique astronomers, dominated by Joseph Louis Lagrange (1736 – 1813) and Laplace, was that with the French system the role of a Creator was eliminated. The French had provided the equations for a cosmos that never needed to be reset and hence did not require the hand of God to function perpetually. What distressed natural theologians more was the fact that neither Lagrange nor Laplace alluded to the fact that the flawlessness of the system was proof of Design. Laplace's *Mecanique Celeste* had stayed away from any debate surrounding the origin of the universe or what set the universe in motion in the first place. The preface Laplace provided expressed his desire to keep the work strictly within the context of mathematics, and only to use the application of formulas and equations in determining the force and gravitational fields, which established the movement of celestial objects:

> My [Laplace's] object is to present a connected view of these theories [by Newton], which are now scattered in a great number of works. The whole of the results of gravitation, upon the equilibrium and motions of the fluid and solid bodies, which compose the solar system, and the similar systems, existing in the immensity of space, constitute the object of *Celestial Mechanics* or the application of the principles of mechanics to the motions and figures of the heavenly bodies. [171]

---

[170] Michael Hoskin, "Newton and Newtonianism," in *The Cambridge Concise History of Astronomy*, ed. Michael Hoskin (Cambridge: Cambridge University Press, 1999), 148.

[171] Nathanial Bowditch, *Celestial Mechanics by the Marquis de La Place* (New York: Chelsea Publishing Company, Inc. , 1966), XXIII. [emphasized in original]

Laplace was adamant that the goal of his work was to put Newtonian equations in sequence and to develop a methodology that made it possible to calculate any celestial movement.[172]

It was clear that the Scottish Somerville did not want to mark her entry into popular astronomy with a work that did not include a Godly presence. The first goal of the weighty Dissertation was to reinforce the concept that the universe was God's design and the working system was one that He had instigated. The place of God was elevated beyond a hands-on position to a God of the highest order who ensured the movement of celestial objects by creating the fundamental laws of force and gravity. Somerville enforced this concept in the second paragraph by stating that, "[b]y such steps he [Newton] was led to the discovery of one of those powers with which the Creator has ordained that matter should reciprocally act upon matter."[173] These laws governed the universal processes, allowing for a self-sufficient system that only occasionally needed intervention.

In this first work of popular astronomy, Somerville linked the theme of elevation and immateriality with the innate abilities of man's mind. Man had the capacity to know the workings of God because man was endowed with the faculty of higher thought or "elevated mediation":

> The contemplation of the works of creation raises the mind to the admiration of whatever is great and noble, accomplishing the object of all study [...] By the love or delightful contemplation and pursuit of these transcendent aims for their own sake only, the mind of man is raised from low and perishable objects, and prepared for those high destinies which are appointed for all those who are capable of them.[174]

---

[172] Ibid., XXIV.
[173] Somerville, *Mechanism*, IV.
[174] Somerville, *Mechanism*, VI.

This correlation cunningly raised the astronomer to the highest position among the natural philosophers by making astronomy the uppermost order of scientific study. In Somerville's hands Laplace's formulas were slotted into a theological context and the reader was encouraged to engage in "contemplations of the works of creation"[175] and to reinforce the notion of First Cause.

The *Monthly Review* well appreciated Somerville's Godly rendition:

> It [astronomy] teaches him to look beyond the 'ignorant present', to raise his wishes, his hopes, his desires, far beyond any objects of gratification which are to be found in this perishable sphere; it imparts to his soul some knowledge of that all wise and all provident First Cause, which, assuredly, would never have implanted in his soul a thirst of immortality, without intending to gratify the appetite.[176]

As the *Review* points out, Somerville's Dissertation teaches astronomy as a science that reassures the audience of the validity of the concept of "First Cause." The *Monthly Review*, overall, gave Somerville positive comments, and the section that Somerville devoted to the English contribution to the sciences was highly praised. However, the *Review*, like many reviewers, criticized Somerville's translation of Laplace's work noting many of Somerville's theoretical short-comings. Somerville's diagrams, rather than assisting the reader to clear Laplace's mathematic labyrinth, "place[d] it [the algebra] out of [the reader's] power to pursue the course of reasoning or description, which she adopted."[177] The *Literary Gazette* positively noted Somerville's inclusion of religious references and went so far as to reiterate Somerville's view that the true calling of astronomical knowledge was to know the work of God:

---

[175] Ibid., VI.

[176] "Review of *Mechanism of the Heavens*, *Monthly Review*, n.s. vol. 1 (January 1832), pp. 133 - 41." in *Mary Somerville: Scientific Papers and Review*, ed. James Secord, (Bristol: Thoemmes Continuum, 2004), 141.

[177] "Ibid.," 137. Further analysis of the diagrams and the calculations will follow later on in this section.

> But we must not forget that it involves still higher and more important considerations, by teaching us at once the wisdom, the power, and the beneficence of God, the Creator of all these things. And it must go hard indeed with our hearts if they be not touched by these important proofs of the Divine goodness to the creatures he has placed on one of the smallest of the countless myriads of orbs he has set in motion.[178]

Aside from the overtly Christian references, the "Preliminary Dissertation" placed the planets within a hierarchical system reinforcing the notions that celestial objects, being of God's design, were created in an orderly manner and slotted to fill certain positions in the universe.

In Somerville's hands the solar system maintained a familiar patriarchal order reflective of the Christian theme, which dictated that males are the dominant figures. The larger planets such as Jupiter and Saturn, symbolic of the prevailing male, were referred to as "he."[179] The sun was masculine and possessed all the attributes of a stately prince with the planets placed as his attendants and rotating in one direction under his command.[180] This order supported the Creation story, which dictated that every being was created for a specific purpose and for eternity. The sun, as man, was in the central position to be adored by lesser beings. The parallel between the placement of the heavenly bodies to the Christian concept of order was so perfect that, according to Somerville, "a coincidence so remarkable cannot be accidental."[181] To further support the notion of order and a well- thought-out plan, Somerville went on to state that, "the revolutions of the planets and satellites are also from west to east, [thus], it is evident that both must have arisen from the primitive causes which have determined the planetary

[178] "Review of *On the Mechanism of the Heavens*," *Literary Gazette*, 5.
[179] Somerville, *Mechanism,* XIX,
[180] Ibid., XXXII.
[181] Ibid., XXXII

motions." [182] The relationship Somerville constructed between the sun and the moon was one of masculine and feminine. To reinforce the notion that the moon was feminine Somerville gave the pronoun "she" to this orb.

Somerville's enthusiasm to set *Mechanism* within a Christian patriarchal framework extended to citing a passage from "Book V" of John Milton's "Paradise Lost":

> Yonder starry sphere
> Of planets, and of fix'd, in all her wheels
> Resembles nearest, mazes intricate,
> Eccentric, intervolved, yet regular
> Then most, when most irregular they seem.[183]

A central theme in "Book V" was disobedience: In this seventeenth-century poem, God foreshadowed the disobedience of Adam and Eve and their expulsion from Eden. As the fallen angels before them had been cast out of heaven by God, the warning in this segment was that this fate would be inflicted upon Adam and Eve should they not, at all times, adhere to God's commands. Milton used this passage to illustrate that even on the horrendous day when the rogue angels were cast from the skies the starry orb continued in its movements. The planets and stars did not falter in their "regular" and "irregular" cycles. Somerville placed Milton's passage after her own argument, which stressed that the "rotation of the earth is uniform; therefore day and night, summer and winter, will continue their vicissitudes while the system endures, or is untroubled by foreign causes."[184] Somerville again assured her reader of eternal motion towards the end of the

---

[182] Ibid., XXXII.

[183] Somerville, *Mechanism*, XV. John Milton, "Paradise Lost," in *John Milton: The Complete Poems*, ed. John Leonard (London: Penguin Books, 1998), 235.

[184] Somerville, *Mechanism*, XV.

Dissertation by stating that, "the great laws of the universe are immutable like their Author."[185]

In this work, which marked her start into popular astronomy, Somerville's continual efforts to reconcile "facts" with religion found its way to the very last statement of the "Preliminary Dissertation." This section used both geology and religion to address what the calculations from practical astronomy showed. These calculations proved that the age of the universe, like the earth, was almost infinite. In order to fit the evidence into a pious agenda, Somerville cited the Book of Peter:

> The traces of extreme antiquity perpetually occurring to the geologist, give that information as to the origin of things which we in vain look for in the other parts of the universe. They date the beginning of time; since there is every reason to believe, that the formation of the earth was contemporaneous with that of the rest of the planets; but they show that creation is the work of Him with whom "a thousand years are as one day, and one day as a thousand years."[186]

Somerville paired scripture with science before embarking on Laplace's primary work. Bernard Lightman in *Victorian Popularizers of Science* states, "Somerville aimed to demonstrate that the higher analysis of the French could be used to enhance understanding of the manifestations of God's divine goodness and power."[187] Somerville, even in this first piece, was attuned to the conventions of popular writing. And Somerville, as with many of her contemporaries, was not about to popularize a theory that held no need for His intervention.

The Scottish Sublime

[185] Ibid., LXIX.
[186] Ibid., LXIX.
[187] Lightman, *Victorian Popularizers of Science*, 22.

Somerville marked her entry into popular astronomy with a "Preliminary Dissertation" that incorporated a sublime twist, which high-lighted a religious presence. Somerville's universe was one filled with awe, and her statement that, "the heavens afford the most sublime subject of study which can be derived from science,"[188] set the tone for the subsequent pages. Somerville invoked in her readers feelings of a majestic landscape familiar in the Romantic constructions of nature. "The magnitude and splendour of the objects, the inconceivable rapidity with which they move, and the enormous distances between them impress the mind with some notion of the energy that maintains them in their motions with a durability to which we can see no limits."[189] The previous passage's preoccupation with great distances and vast spaces reflected the sublime tendencies of Scottish landscape writers such as David Hume and Ossian.

Hume used space to suitably place large objects at a distance in order to appreciate their aesthetic value. As Andrew Ashfield and Peter de Bolla points out in *The Sublime: A Reader in British Eighteenth-Century Aesthetic Theory* (1998):

> The preoccupation with distance is a hallmark of eighteenth-century visual aesthetics, and can be found in writings on art as well as landscape. Within the analytic of the sublime distance is related to size so that far-off objects appear to be less threatening or terrifying. Hume, however, makes the opposite case in his invocation of esteem and admiration, thereby giving a greater value to distant objects. [190]

This aesthetic tool was also employed by Somerville as she used distance to ward off any fear of colliding globes. As the passage below will indicate, intersecting mathematics with images of marvel in the introduction to a body of work that later dealt with

---

[188] Somerville, *Mechanism*, VI.
[189] Ibid., VI.
[190] Andrew Ashfield and Peter de Bolla, *The Sublime: A Reader in British Eighteenth-Century Aesthetic Theory* (Cambridge: Cambridge University Press, 1996), 196.

mechanical astronomy may not have given clarity to the science but created a more buoyant text, which Somerville assumed was well-suited for a popular marketplace:

> Far as the earth seems to be from the sun, it is near to him when compared with Uranus; that planet is no less than 1843 millions [sic] of miles from the luminary that warms and enlivens the world; to it, situated on the verge of the system, the sun must appear not much larger than Venus does to us [...] Sublime as the idea is, this assumption proves ineffectual, for the apparent places of the fixed stars are not sensibly changed by the earth's annual revolution; and with the aid derived from the refinements of modern astronomy and the most perfect instruments, it is still a matter of doubt whether a sensible parallax has been detected, even in the nearest of these remote suns. [191]

Concepts of an explosive and particularly dangerous universe with scenarios of stellar spectacles were vigorously debated during the late eighteenth century with the introduction of the nebula hypotheses, which were most prominently proposed by Laplace and William Herschel (1738 – 1822). Both Laplace and Herschel enthusiastically stated that the heavens were not always harmonious and that new star systems came into being only after much force and fanfare. Somerville was not oblivious to the fact that popular readers of astronomy in the 1830s would not mind greater reassurance that catastrophes of this kind, in nature, would not occur near our solar system.

Somerville reinforced the sublime structure of the narrative with mathematical proof, which was embedded in Laplacian mechanical astronomy to assure her readers that the calculations derived from the laws of force and gravitation stabilized the stars near our sun:

> With the exception of these two elements, it appears, that all the bodies are in motion, and every orbit is in a state of perpetual change. Minute as these changes are, they might be supposed liable to accumulate in the course of ages, sufficiently to derange the whole order of nature, [...] and to bring about collisions, which would involve our whole system, not so harmonious, in chaotic confusion. The consequences being so dreadful, it is natural to inquire, what proof exists that creation will be preserved from such catastrophe? [...] The proof is

[191] Somerville, *Mechanism*, XXXI.

> simple and convincing. All the variations of the solar system, as well secular as periodic, are expressed analytically by the sines and cosines of circular arcs.[192]

Despite the motions and change within our solar system, it would be "preserved from such catastrophe" because of the laws of nature.

Somerville's use of the sublime may be attributed to her love of Ossian and from reading his poems during her youth: "I was a great admirer of Ossian's poems, and viewed the grand and beautiful scenery [of the Scottish Highlands] with awe."[193] Ossian's poems evoked what Dugald Buchanan, an eighteenth-century poet, called "the sublime sentiment."[194] Ossian's poems did use imagery from the celestial sphere to invoke a feeling of wonder and fearful admiration in the reader. A prominent example was the poem titled, "The Songs Selma," in which the sun, wind, and rain swept the Highlanders with their natural powers:

> The wind and rain are over, claim is the noon of day. The clouds are divided in heaven. Over the green hills flies the inconstant sun. Red through the stony vale comes the stream of the hill. [...] Thou were swift, O Morar! As a roe on the hill; terrible as a meteor of fire. Thy wrath was as the storm. Thy sword in battle as lightning in the field. Thy voice was like a stream after rain, like thunder on distant hills.[195]

In this work, Ossian summoned the celestial sublime to reflect the awe and terror of human conquest. The sun, wind, and rain may be recurring natural phenomena but in heaven and on earth cohesion was not always certain. The clouds separated that sphere, which, in turn, allowed meteors to shower on earth with a fury. When nature was divided so too were the Highlands. The wrath of man was felt as the heat of human battle played

---

[192] Somerville, *Mechanism*, XIV.

[193] Martha Somerville, *Recollections,* 66.

[194] Dugal Buchanan in Donald E. Meek, "The Sublime Gael: The Impact of Macpherson's Ossian on Literary Creativity and Cultural Perception in Gaelic Scotland," in *The Reception of Ossian in Europe*, ed. Howard Gaskill (London: Thoemmes Continum, 2004), 45.

[195] James Macpherson, *The Poems of Ossian* (New York: E. Kearny, 1846), 285. Meek, "Sublime Gael", 47.

out on an eerie landscape. Explosive forces of the natural world such as thunder and lightning further mirrored the fierce forces of human emotions. Ossian used the notion of atmospheric disharmony to express tremulous human happenings and to magnify historical occurrences in order to bring forth a feeling of breathlessness. Traces of Ossian's "sublime sentiment" can be found in Somerville's primary work particularly when she approached a "very great" scenario in the "splendid" celestial landscape in which the magnitude of the mathematical calculations was to be exorbitant.[196]

Somerville's inclusion of the sublime had its effect on the *Edinburgh Review* and the paper used this word in their description of Somerville's creative ability in bringing the dullness of mathematical astronomy to life: "Such was the sublime picture exhibited in that extraordinary production; but into none of the productions of the human intellect does time bring greater ameliorations than into those of the mathematician."[197] The use of the sublime in *Mechanism* may have gained an aesthetic marker for the text and produced a work that became an intersection of literature and science; however, it was a questionable intersection. What Somerville thought would contribute to a popular demand for the book, and give it more appeal than a dry translation of *Mecanique Celeste,* in fact fragmented the text. As Somerville moved from discussions of the moon, to the meridian, to the sun, to the parallax, to her acquaintances, and to God the Dissertation became unfocused and disorganized. Kathryn Neeley makes a far more generous assessment of the "Preliminary Dissertation" in *Mary Somerville: Science, Illumination and the Female Mind* (2001).[198] Neeley argues that what Somerville

[196] Somerville, *Mechanism*, XII., XIV.

[197] "*Mechanism of the Heavens* by Mrs. Somerville, *Edinburgh Review,* no. CIX, (April 1832)," in *Mary Somerville: Scientific Papers and Review*, ed. James Secord (Bristol: Thoemmes Continuum, 2004).

[198] See Neeley's *Illumination.*

produced was a rendering that moved the Dissertation from scientific literature to a piece of art. "There is yet another reason why the term "rendering" is appropriate. Somerville's text, especially the "Preliminary Dissertation" functions much as an artist's or architect's rendering does."[199] This portrayal of the "Preliminary Dissertation" has its merits, yet the work exhibited no unity or cohesion characteristic of carefully rendered literature. There were no subheadings in the "Preliminary Dissertation" and the work became a long paper that was essentially unravelling as it progressed.

Chatter and the English Scientific Hostess

The addition of religious themes and tidbit topics to the "Preliminary Dissertation" created a piece of writing closer to chatter than literature. Somerville wrote as if she was speaking at a dinner party and her style was characteristic of a conversation from a scientific hostess. It is not surprising that Somerville would employ this style. Somerville had never embarked on popular writing before, and her only reference to sharing natural knowledge was through conversation. In "How Scientific Conversation Became Shop Talk" James Secord states, "[o]ral performance, has been and remained at the heart of making knowledge,"[200] and even in the nineteenth century natural philosophers such as Charles Babbage and John Herschel were more famous for how they spoke about nature than their actual published papers. "Their [including Babbage and Herschel] position was signalled by their status as 'lions,' whose presence could give intellectual depth and sparkle to a social gathering."[201] As we have established, Somerville was often in the company of Babbage and Herschel for scientific purposes, and Somerville's chatting about science and other topics in the "Preliminary

---

[199] Neeley, *Illumination*, 94.
[200] James Secord, "How Scientific Conversation Became Shop Talk," 23.
[201] Ibid., 30.

Dissertation" was reminiscent of how such sharing of information through talk could have transpired in polite company. In the same manner as how these "lions" shared knowledge with her, Somerville employed the same methodology as she shared knowledge with her readers.[202] The lack of structure in the text is reflective of an easy-going conversation, whose direction is dictated by what comes to the speaker's mind.

Yet, chatter does not imply an exchange of nonsense but rather an interchange of tidbits important to the speaker and listener. As mentioned, chatter is used in English literature to suggest a sharing of information in a friendly setting. Emily Bronte in *Wuthering Heights* illustrated that chatter, unlike the malicious connotations with gossip, was an intimate form of talk that could be used to share knowledge. Even sickly Linton had "grown wiser" by Cathy's chatter in the novel.[203] The complex and vindictive Heathcliff mustered a smile in the company of friendly chatter.[204] And chatter is often heard in the warmest and most secured place at Wuthering Heights, the kitchen.[205] Somerville's chatter dialogue embodied these characteristics and worked well when used informally to introduce British astronomical and scientific figures into a complex text founded on mechanical astronomy. She spoke of these men with familiarity as if discussing friends with friends, and one can imagine a smile upon the face of the reader particularly if he/she is somewhat familiar with the names mentioned.

Somerville brought life to the work and created an amiable atmosphere in the "Preliminary Dissertation" with this style of writing. At the same time, *Mechanism* upheld national pride by recognizing that the text was intended for English audiences and

---

[202] Somerville discussed many occasions in which she in the company of noted scientist sharing scientific conversations in *Recollections*, 109, 122.

[203] Bronte, *Wuthering Heights*, 299.

[204] Ibid., 65.

[205] Ibid., 3.

welcoming a British-centric point of view.[206] This technique extended beyond introducing natural theology to Laplacian astronomy and incorporating a subliminal undertone, which added a distinctly Scottish flavour. Somerville continually reminded the reader that Laplace's formulas would not have been possible without the initial work of Newton and Newtonian physics. This fact was easy to substantiate in popular culture and scientific circles. As Crosland and Smith point out, "British natural philosophers were very loyal to their native Newtonian heritage."[207] Somerville credited Newton with deciphering the laws that made God's work understandable stating that Newton had introduced the laws of attraction and force, and that it was "[b]y such steps he was led to the discovery of one of those powers with which the Creator has ordained that matter should reciprocally act upon matter."[208] Reviewers were quick to appreciate Somerville's numerous mentions of Newton, and English pride also prevailed in the reviews. For example, the *Literary Gazette* was inclined to refer to their English astronomers by name and to Laplace only as the "great continental successor of Newton."[209]

Cambridge, the centre of Newtonian culture, had always seen Newton's work as the foundation of physical astronomy. Somerville's on-going references to Newton made *Mechanism* greatly popular at the university. Cambridge scholars were receptive to Laplace and especially *Mecanique Celeste* because they saw it as completing the Newtonian system. John Hershel's lengthy assessment on this work appeared in the *Quarterly Review* in July of 1832.[210] Herschel began by contextualizing Laplace's work

---

[206] Somerville maintained this technique in her biography, *Recollections*. This popular work also went to great lengths to acknowledge British contributions to science, literature, and exploration.
[207] Crosland and Smith, "Transmission," 3.
[208] Somerville, *Mechanism*, V.
[209] "Review of *On the Mechanism of the Heavens*," *Literary Gazette*, 1.
[210] John Herschel, "Review of *Mechanism of the Heavens*," *Quarterly Review* 4 (July 1832): 537 – 59.

within a Newtonian framework and repeated the concept that Laplace had complemented what Newton had begun. At the same time Herschel noted other astronomers such as Woodhouse, Lagrange and Babbage from England. Further, Herschel named Gregory, Napier, and Playfair from Scotland. Herschel cleverly included Somerville in the list of mathematicians and by association implied that her work was on equal footing with the noted men of calculations and astronomy. This affinity, no doubt, added to the reputation of the author and *Mechanism.* Herschel continued by promoting Somerville as a well-known and respected person in the "philosophical world by her experiments on the magnetising influence of the violet rays of the solar spectrum."[211] In the *Quarterly* Herschel took the opportunity to downplay Somerville's inaccurate findings in "Magnetizing Power," stating that the conditions were adversarial to accurate results and that the experimental process did, in fact, give Somerville expert knowledge in solar rays:

> A delicate and difficult subject of physical inquiry [solar rays], which the rarity of opportunities for its prosecution arising from the nature of our climate, will allow no one to study in this country except at a manifest disadvantage. It is not surprising, therefore, that the feeble, although unequivocal indications of magnetism which she undoubtedly obtained should have been regarded by many as insufficient to decide the question at issue.[212]

Herschel may have felt the need to reposition Somerville within the scientific world in order to promote the sale of *Mechanism.* It would have been difficult for Herschel to endorse Somerville if her status as an erroneous practitioner lingered. The circle of practitioners in astronomical research was tight and Herschel's reinstatement of Somerville's reputation was necessary for Somerville to continue further work on solar rays and in astronomy. Herschel was the leading astronomer in Britain at the time and his review was effective.

---

[211] Ibid., 547.
[212] Ibid., 547.

Since Somerville's style of writing mimicked that of chatter, her promotion of English scientists was not to end with Newton. This approach meant that in the "Preliminary Dissertation" Somerville often spoke freely of other English contributors in various disciplines of science. She acknowledged their work and involvement with ease, and her tone was that of conversing with friends about mutual acquaintances. In the Dissertation Somerville chatted about Thomas Young's work to determine the variation in the density of matter at the earth's centre.[213] A few pages later Somerville spoke of Young's work on a papyrus from Egypt and his enormous contribution to hieroglyphic research. Somerville stated that Young's "varied acquirements do honour not only to his country, but to the age in which he lived."[214] Young had also worked on Laplace's *Mecanique Celeste* in the early 1820s. Despite the numerous outlines of Young's scientific achievements Somerville did not mention Young's *Elementary Illustrations of the Celestial Mechanics of Laplace* (1821), which was initially published anonymously.[215]

Other friends also made it into print in the "Preliminary Dissertation," and Somerville's inclusions of these people were often without astronomical context. As with her scientific papers, Somerville may have mentioned her acquaintances in order to give herself credence and to show that she was an insider of science. She talked about their work and scientific interests as if at a dinner party sitting with friends. For example, Kater received mention for his work on the Fahrenheit system.[216] Babbage was mentioned for his observations on the velocity of fluids at different heights and distances

[213] Somerville, *Mechanism*, XI.
[214] Ibid., XLVII, LVII.
[215] Crosland and Smith, "Transmission," 16.
[216] Somerville, *Mechanism*, XLIX.

from the centre of the earth.[217] Parry was mentioned for his voyage in search of the Northwest Passage in 1819.[218] William Herschel, without surprise, was to receive numerous mentions and Caroline Herschel was also noted for her categorizing work of the star systems.[219] Wollaston's work on the light of the sun in ratio to Sirius was added in passing.[220] Playfair was cited as having expressed appreciation of Lagrange's work in physical astronomy.[221] Playfair was one of Somerville's early mentors; the two had corresponded when Somerville was residing in Edinburgh. In 1814, Playfair had stated in the introduction of his textbook, *Outlines of Natural Philosophy* (1814), that he was indebted to Laplace for reducing mathematical astronomy to one theory.[222]

Neeley, in *Illumination*, states that Somerville, in the "Preliminary Dissertation," created a "cosmic platform" or "a view from space where the reader was invited to contemplate the immensity, regularity, intricacy, and beauty of creation. The platform was intimately connected to life on earth through the law of gravitation."[223] Although there is no doubt that Somerville was dedicated to discussing gravitation, and would remain so in *Connexion*, the "Preliminary Dissertation" was far too fragmented to sustain a platform for the reader to gather a stable footing. The view the reader received was that of a British scientific depiction of nature and how British scientists, past and present, contributed to natural knowledge. The "cosmic platform" that Neeley spoke of was far more prevalent and steady in *Connexion.*

---

[217] Ibid., XXXVI.
[218] Ibid., LX.
[219] See Ibid., IXIII, IXV, IXVI.
[220] Ibid., IXIV.
[221] Ibid., XV.
[222] Crosland and Smith, "Transmission," 12.
[223] Neeley, *Illumination*, 105.

The Formulas, the Diagrams, and the Mathematics

Somerville's addition of formulas in an effort to explain Laplace's calculations emphasized the fact that she thought the theorems were too complex for the popular reader. Yet, these additions did not render *Mechanism* more accessible, but rather attracted negative responses from reviewers. In a brief introduction preceding the already long "Preliminary Dissertation," Somerville reiterated that understanding mechanical astronomy and Laplace's formulas were impossible "without having recourse to the higher branches of mathematics."[224] Somerville was so concerned that she included diagrams in addition to the formulas and stressed that, "[d]iagrams are not employed in La Place's works, being unnecessary to those versed in analysis; some, however, will be occasionally introduced for the convenience of the reader."[225] Somerville was not the only translator to include diagrams. H. Harte did the same in his *System of the World* and Harte's edition was used as a textbook in Dublin. Whether Somerville thought of promoting her book as a textbook when she was translating the work was unlikely. The sale of the work for the purpose of teaching at Cambridge came as a surprise to Somerville.

Somerville considered *Mechanism* not as a total or complete version of *Mecanique Celeste* but rather as an "endeavour." That is, an "endeavour to explain the methods by which these results [Laplace's formulas] are deduced from one general equation of the motion of matter."[226] Another word Somerville used to describe the work was "spirit." Somerville stated that her version did not attempt to translate Laplace's *Mecanique Celeste* verbatim but rather to capture the "spirit" of the text. As noted in this

[224] Somerville, *Mechanism*, 3.
[225] Ibid., 3.
[226] Ibid., 3.

comment by Crosland and Smith, *Mechanism* was consistently slotted in the popular arena as being a "relatively popular exposition of Laplace's *Mecanique Celeste*."[227]

A review in the *Athenaeum* stated that the text became a work that was essentially Somerville's own inadequate theory:

> We want his [Laplace] work as fresh from his intellect as it can be brought to us through the medium of a translation; and we like not the task which Mrs. Somerville has undertaken, of giving us his thoughts in language different from that which he thought best calculated to convey them. If her object was to simplify his reasonings [sic], we cannot but applaud the intention; but we have every excuse for not having observed it, inasmuch as the work itself laughs all simplicity to scorn.[228]

The *Athenaeum's* reviewer continued to give scathing comments about *Mechanism* and Somerville's translating and mathematical abilities. These included remarks such as "On the subject of force, Mrs. Somerville is singularly unintelligible,"[229] "We, for our parts, protest against Mrs. Somerville's comprehensive admission of ignorance,"[230] and lastly that Somerville's work was "rashly undertaken, and very imperfectly completed; and that, remarkable as Mrs. Somerville's powers undoubtedly are, she has here assigned to herself a task considerably beyond them."[231] The comments continued to be relentlessly severe and were often satirical.

The harsh words the *Athenaeum* provided can be attributed to the fact that the journal thought Somerville's extensive explanations to be condescending to the intellect of the working class:

> She [Somerville] talks of force *exerted by matter* – of matter *acting* upon matter – and much more in the same strain. At length, however, her mind grasps a

---

[227] Crosland and Smith, "Transmission," 19.
[228] "Review of *On the Mechanism of the Heavens*," *Athenaeum*, 3.
[229] Ibid., 3.
[230] Ibid., 4.
[231] Ibid., 6.

> definition; it is this 'analytically F = *dv/dt*, WHICH IS ALL WE KNOW ABOUT IT.
> Spirit of the working classes, here is a boon! How admirable is the arrangement of symbols which thus concisely developes [sic] to us all that may be known of force. This is in the very spirit of that compression, by which an octavo volume of mathematics is brought into the compass of a threepenny pamphlet, and, at the same time, simplified from the intellectual standard of the well-read student in physics to the mind of a mechanic.[232]

Even the *Literary Gazette*, which gave the "Preliminary Dissertation" excellent praise, commented that Somerville's mathematical footnotes, particularly the diagrams, were often unnecessary:

> The number of diagrams employed by Mrs. Somerville to assist the elucidation of her meaning, and the purely algebraical [sic] character of most of her explanations, place it altogether out of our power to pursue the course of reasoning or description which she has adopted. [233]

In addition, the *Literary Gazette* stated that the additions Somerville made to the work itself tended to confuse the reader and to impose even more complexity to a theory that was already difficult to comprehend.

The *Edinburgh Review* noted that, in general, Somerville's diagrams were in fact not of any use and at times could "by some readers [...] be regarded as an impediment"[234] because "in a mathematical investigation, it is obvious that whatever is not absolutely required to complete the chain of evidence serves only to fatigue and distract the attention."[235] The fact that Somerville did not endeavour to translate *Mecanique Celeste* in its entirety allowed the *Edinburgh Review* to call the work an "abridged" rendition of Laplace. However, surprisingly, the *Edinburgh Review* did give Somerville a favourable closing comment expressing gratitude for the work Somerville

---

[232] Ibid., 4. [emphasized in original]
[233] "Review of *On the Mechanism of the Heavens*," *Literary Gazette*, 137.
[234] "Review of *On the Mechanism of the Heavens*," *Edinburgh Review*, 5.
[235] Ibid., 5.

undertook and stating that *Mechanism* shed light on "sublime truths" that can be realized only by "mathematical analysis."[236]

The Culture of *Mecanique Celeste*

Somerville went to great lengths to add to Laplace's *Mecanique Celeste,* yet these efforts slotted the book as being less worthy, traditionally, in scholarship and even in the popular arena than other translations of the text. Michael Hoskin in "Newton and Newtonianism" lists Nathaniel Bowditch (1773 – 1838) as the only translator of *Mecanique Celeste.*[237] Bowditch's *Celestial Mechanics by Marquis de La Place* appeared in four large volumes.[238] In it Bowditch cited Toplis' and Young's work in England, and he also knew of another work in translation by H.H. Harte.[239] Bowditch made no mention of Somerville's work in progress. He either did not know of Somerville's intended publication or he thought it was a popular work that was not of the same calibre as *Celestial Mechanics* or the work of Young, Toplis, and Harte.[240]

Somerville's entry point into popular astronomy arose out of an opportune situation. Laplace's death in the late 1820s created a stir and demand for translations of his work. Her addition of the "Preliminary Dissertation" received mixed comments and reviews, yet Somerville was praised for her ability to engage with a broad spectrum of popular literary devices. Somerville offered a pious rendition of Laplace, added a sublime

[236] Ibid., 25.
[237] Hoskin, "Newton and Newtonianism," 156.
[238] Nathaniel Bowditch, *Celestial Mechanics by the Marquis de La Place*, (Bronx: Chelsea Publishing Company, Inc.: 1829). Bowditch's original translations were published in 1829, 1832, 1834 and 1839. The first volume (1829) was published a few months before Somerville's *Mechanism.*
[239] H. H. Harte, *The System of the World,* (Dublin: unknown publisher, 1830). Harte's translation of Laplace was meant for teaching and was used as a textbook.
[240] The last volume of Bowditch's translation appeared in 1839 after Bowditch's death. Bowditch's children included a biography in this volume that was to number 148 pages. The biography was a testament to the accomplishments, which their father had achieved during his lifetime. In the 1966 reprint version the editors decided to move the biography to the front of the first volume of *Celestial Mechanics*.

twist to the workings of the heavens, and she used the "chatter" format to claim her authorial presence in the popular marketplace.

On the Connexion of the Physical Sciences

It was Somerville's ability to "compare and identify" both the laws of heaven and earth that earned her recognition as a "scientist."[241] Published by John Murray, *On the Connexion of the Physical Sciences* (1834) was considered to be Somerville's most successful work. In the same year, Charles Lyell's *Principles of Geology* was also put out by Murray.[242] *Connexion* ran into ten editions with Arabella B. Buckley, Lyell's long-time assistant, revising the last edition in 1877.[243] In 1834 Somerville and Lyell had covered both the workings of the universe and the formation of the earth for the popular reading public.

Yet, in Somerville's eyes, this reading public was segmented. *Connexion* was dedicated to Queen Adelaide, and, as Somerville expressed, the book was written for the benefit of the female reader. The inscription read:

> To the Queen
> If I have succeeded in my endeavour to make the laws by which the material world is governed more familiar to my country women, I shall have the gratification of thinking, that the gracious permission to dedicate my book to your majesty has not been misplaced.[244]

Oddly, although Somerville slotted *Connexion* for her "countrywomen," she did not follow the "familiar format" or writing traditions of this gendered marketplace.[245] Somerville did not employ the maternal tradition opting, rather, for a "narrative of

---

[241] This argument will be demonstrated in this section.
[242] Ibid., XI.
[243] James Secord, "Introduction," in *On the Connexion of the Physical Sciences* edited by James Secord (Bristol: Thoemmes Continuum, 2004), XI.
[244] Mary Somerville, *Connexion*, XVVII.
[245] Lightman, *Victorian Popularizers of Science*, 22.

nature" exposition that was a staple in natural history writing throughout the century and generally adopted by male writers. This narrative style "structures popular accounts of nature that are diverting, full of anecdotes, and nontheoretical [...] Here the plant, the animals, and the fascinations of the natural world, not the activity of the scientist, are the focus."[246] As well, Somerville's omission of formulas and mathematical calculations clearly released the text from the grasp of the "narrative of science" type of publication to a piece that focused on interconnecting mathematical principles within nature.[247] Somerville's emphasis on nature and its wonders also extended to *Connexion,* where she abandoned the repetitive naming of prominent British countrymen, which had been prevalent in her "Preliminary Dissertation" in *Mechanism.*

Somerville scholar Katherine Neeley argues that Somerville wrote *Connexion* to complement her first popular work in astronomy; however, an analysis will reveal that *Connexion* was substantially different from the "Preliminary Dissertation" as well as the Laplacian portion of *Mechanism.* The chatter that was characteristic in the Dissertation gave way to more mature conversation as Somerville patiently articulated, in a well-thought-out manner, the "connexion of the physical sciences"[248] in a stable authorial voice.

Physical Astronomy

In *Connexion,* similar to the "Preliminary Dissertation," Somerville began by describing science as a study that furnished facts through experience.[249] From this point on *Connexion* differed and steered away from being an overtly British text by by-passing

---

[246] Lightman, *Victorian Popularizers of Science*, 35-6.
[247] "Narrative of science" refers to a text that is written primarily to "establish the credibility of the scientist." See Lightman, *Victorian Popularizers of Science*, 35.
[248] Somerville, *Connexion*, XIX.
[249] Ibid., 1.

a reference to Newton and, rather, focusing on a definition of physical astronomy. According to Somerville, this specialization in astronomy was a science that compared the laws that governed the earth with the laws that governed the heavens. This definition was reminiscent of Somerville's solar rays experiments because the studies investigated how a force from the celestial domain, magnetism, imposed the same characteristics on earth. From this terrain Somerville moved from gravitation to velocity,[250] and investigated how these two phenomena influenced the moon, planets, and the solar system.[251] This format imposed a mathematical understanding of the laws that govern the spheres without relying on formulas or calculations in the text.

Somerville showed her sophistication by discussing in detail the works of French astronomers such as Laplace,[252] Louis Poinsot,[253] Dominique Francois Arago,[254] and Joseph Louis La Gange.[255] In addition, Somerville introduced Chinese and Arabic astronomy. Unlike *Mechanism,* which only noted the findings of Chinese astronomers observing in the city of Layang 1100 before the birth of Christ,[256] Somerville refocused her thoughts and discussed how Chinese astronomers contributed to the outcome of Western astronomical observations.[257] To further demonstrate her vast knowledge Somerville dived into classical astronomy with points on Ptolemy[258] as well as the astronomy of the Moderns by noting Johannes Kepler's contribution of the elliptical

---

250 Somerville, *Connexion,* 8 -9.
251 Ibid., 8 – 9.
252 Ibid., 22.
253 Ibid., 21, 23.
254 Ibid., 341.
255 Ibid., 21.
256 Somerville, *Mechanism*, XLVII.
257 Somerville, *Connexion*, 24.
258 Ibid., 18.

orbit.[259] These inclusions were also linked to its contribution to current or rising astronomical ideas.

Somerville devoted a large section, numbering eighty-nine pages, to the study of magnetism. Somerville began by outlining Oersted's discovery that "a current of voltaic electricity exerts a powerful influence on a magnetised needle"[260] and noted that magnetism was "the most interesting science of modern times."[261] An analysis of this section show that it mirrors Somerville's writing format throughout the text. The section was clearly laid out in a progressive order. Somerville began with a scientific discovery and stated how this new knowledge opened other areas of inquiry. This commonsensical narrative voice allowed the reader to formulate an understanding of the universe by noting first the discovery of each particular theory, law, or heavenly body:

> It was long known by observation that five times the mean motion of Saturn is nearly equal to twice that of Jupiter; a relation which the sagacity of La Place perceived to be cause of a periodic irregularity in the mean motion of each of these planets, which completes its period in nearly 929 years, the one being retarded which the other is accelerated; both the magnitudes and period of these quantities vary, in consequence of the secular variations in the elements of the orbits.[262]

The above passage was preceded by a general reference regarding how similar observations had been made by Western, Chinese, and Arabic astronomers about the motion of Saturn and Jupiter. The passage noted Laplace's work on motion and provided specifics regarding the velocity of the planets. Somerville intertwined astronomical observations with key mathematical calculations in order to discuss acceleration and these two planetary orbits. The explanation was well articulated as the reader was able to

---

[259] Ibid., 7.
[260] Ibid., 323.
[261] Ibid., 323.
[262] Ibid., 24.

draw a connection between the observation, the theory, the astronomer, and certain celestial objects.

The final section again repeated the interdependencies between the laws that governed the celestial sphere with the laws that dominated in terrestrial space.[263] Because the same laws governed both realms celestial phenomena could be studied on earth. As this dissertation will discuss in the next section, this concept premised the "New Astronomy" and governed the rise of astrophysics. Margaret Huggins would spend a lifetime pairing celestial light bands signatures with chemical markers created in a laboratory.

Tensions

The tension to maintain a more secular text coupled with the need to include the concept of a Creator before the reading public was evident. To solidify the presence of a Creator, Somerville, again, included a short passage from Milton's "Paradise Lost."[264] As well, in the final passages of *Connexion* Somerville relied on the well-worn idea of Design to reinforce this point. Somerville began the last paragraphs by stating that the laws of the universe are as "immutable" as its Author,[265] which assured the reader that physical science is within the grasp of human understanding because of its logical order:

> These formulae, emblematic of Omniscience, condense into a few symbols the immutable laws of the universe. This mighty instrument of human power itself originates in the primitive constitution of the human mind, and rests upon a few fundamental axioms which have eternally existed in Him who implanted them in the breast of man when He created him after His own image.[266]

[263] Ibid., 412.
[264] Ibid., 21. "Yonder starry sphere/ Of planets, and of fixed, in all her wheels/Resembles nearest mazes intricate/Eccentric, intervolved, yet regular/Then most, when most irregular they seem," Milton, *Paradise Lost,* 620.
[265] Ibid., 410.
[266] Ibid., 414.

This final passage placed the foundation of knowledge as a form of deliverance from a purposeful God, yet directed agency to man to follow through.

Praises All Around

Somerville drew praise from all reviewers for *Connexion* because the text was seen as comprehensive. The *Literary Gazette* stated that "[w]ith her usual skill, Mrs. Somerville has succeeded in exhibiting the concatenation of phenomena, and the universality of the laws by which they are governed."[267] David Brewster, in similar manner, praised Somerville because she was able to treat all topics "with much sagacity and precision."[268] *Mechanic's Magazine* listed the numerous topics Somerville addressed in detail declaring that *Connexion* should be placed alongside John Herschel *Study of Natural Philosophy* as both can be accredited with "no common order."[269] The final spirited sentences, "We do not, however, advise its being placed on the shelf. Instead of that we say – read it! read it!,"[270] reiterated *Mechanic's Magazine's* endorsement.

Somerville's dedication to Queen Adelaide and her countrywomen was quickly embraced by *The Printing Machine: Or, Companion to the Library. Printing Machine* pointed out that Somerville had, in *Connexion,* brought science in a polite manner to a gendered audience:

> It was a great point gained when a lady might write a poem or a novel; and the whole sex is indebted to Mrs. Somerville for proving – not that the most profound branches of science were attainable by a woman, for that has been demonstrated before – but that the knowledge might be shown and brought before the English

---

[267] "Review of *On the Connexion of the Physical Sciences,*" *Literary Gazette* (8 March 1834): 173.

[268] David Brewster, "Review of *On the Connexion of the Physical Sciences,*" *Edinburgh Review* 59 (April 1834): 159. Brewster lists, with other topics, "mutual actions of the primary and secondary plants," "theory of the tides, acquisition of standards of weights and measures," and "the rectification of chronological epochs."

[269] "Review of On the *Connexion of the Physical Science,*" *Mechanics' Magazine* 20 (29 March 1834): 427.

[270] Ibid., 427.

> public, without provoking a single sneer, even in what we termed fashionable newspapers, and gazettes miscalled literary.[271]

The journal went on to note Somerville's great breadth and her acumen for relating the various areas of science into a comprehensive text.[272] In like fashion, William Taylor of the *Athenaeum* also appreciated Somerville's linking of the sciences stating that to investigate "one science independently of another" would bring "hazard" to the study of the physical sciences.[273] The final assessment from the *Athenaeum* was that the volume was "an honour to our age and country."[274] These comments indicate that the polymath was still well-regarded in science. Despite the high praise that Somerville received from the above reviewers, the most generous review was to come from William Whewell.

Person of Real Science

It is well-known that Whewell first coined the word "scientist" at a meeting of the British Association for the Advancement of Science in 1833. In a review of Somerville's *Connexion* Whewell further argued for the common usage of the term and at the same time referred to Somerville's work, in relation to the skills she demonstrated before the production of *Connexion*, as the work of "persons of real science." The criterion that Whewell laid out will aid in situating Somerville within the many engagements of science production in which she was involved and show that her work in the publication of "Magnetizing Power," *Mechanism*, and *Connexion* made her equal to other practitioners.

---

[271] "Review of On the Connexion of the Physical Sciences," *The Printing Machine: Or, Companion to the Library* (19 April 1834): 79.
[272] Ibid., 80 – 81.
[273] William Crooke Taylor, "Review of *On the Connexion of the Physical Sciences*," *Athenaeum* (15 March 1834): 202 – 3.
[274] Ibid., 3.

In the review, Whewell began by pointing out that Somerville was a scientific person who took on the lower task of writing for a popular audience. "We may observe that the alarm of which Mrs. Somerville here speaks, affords an example of the confusion of ideas, which popular views of scientific matters often involve; and thus shows us how valuable a boon it is to the mass of readers, when persons of real science, like Mrs. Somerville, condescend to write for the wider public, as in this work she does.[275] Whewell accredited Somerville with understanding the interconnectedness of various disciplines in order to produce *Connexions*, which dealt with the paths and motion of celestial objects. Whewell stated that a term needed to be agreed upon to describe a person who studied the "material world collectively" rather than one of the specialized branches of knowledge. Since there were terms such as "artist" and "economist," by analogy, the term "scientist" should, for sensible reasons, apply to such persons.

Whewell, rather than designate the term according to specific practice, suggested the usage be applied to all those working in the sciences. In addition, Whewell well appreciated the span of study that a person was able to engage in. Towards the end of the review, Whewell made the argument that by the execution of the breadth of her popular work, Somerville demonstrated the unity of the sciences:

> The inconveniences of this division of the soil of science, into infinitely small allotments have been often felt and complained of. It was one object, we believe, of the British Association, to remedy these inconveniences by bringing together the cultivators of different departments. To remove the evil in another is one object of Mrs. Somerville's book. If we apprehend her purpose rightly, this is to be done by showing how detached branches have, in the history of science, united by the discovery of general principles. [276]

[275] Whewell, "Review of On the Connexion," 54 – 58.
[276] Ibid., 60.

The writing of *Connexions* further revealed Somerville's narrative abilities to engage the "departments" of science for her reader. Whewell, in the review, would go on to say that Somerville's accomplishments parallel those of the famed Ancient Greek female mathematician Hypatia,[277] which in its generosity reinforced the embellished tone of the evaluation.

The Civil List Pension

The award of a Civil List Pension of 200 pounds a year to Somerville in 1835 was controversial. The Civil List was awarded to those exhibiting "eminence in science and literature." In a letter from Robert Peel to Somerville Peel stated that Somerville should be given this money so that she could "pursue [her] labours with less anxiety, either as to the present or the future."[278] Somerville was awarded the pension based on the work that marked her entry point into still exploratory areas of prismatic analysis and popular writing. The pension was to allow Somerville to live "at least in public dignity"[279] as she was pursuing science in "service" to the country. To fuel the debate surrounding the worthiness of Somerville's contribution to astronomy Peel's original sum was raised to 300 pounds per annum by Lord Melbourne. It can be surmised that this amount, equivalent to what George Airy and Michael Faraday received, was the bone of contention rather than the actual grant. As Claire Brock points out in "The Public Worth of Mary Somerville," Charles Buller had considered the sum paid to Somerville a "waste

[277] Ibid., 67.
[278] Letter from Robert to Mary Somerville (1835), in McMillan, *Queen of Science*, 145.
[279] Claire Brock, "The Public Worth of Mary Somerville," *British Society for the History of Science* 39, (2006): 264.

of Money" because Somerville's work did not add "anything to the stock of human knowledge."[280]

It must be noted that, however Somerville's "public worth" was assessed this practitioner and popularizer never wavered at a chance to enter into science and popular science. Somerville was at the frontier of the solar rays/magnetism debate and her experimental processes and data were noted by fellow magnetic enthusiasts. Somerville's readmission into scientific practice in the 1830s and 1840s was prompted by two highly regarded astronomers, Arago and Herschel. Illuminating her experiences with experimentation demonstrate that Somerville was most prominent as a supportive figure using her findings to propel ongoing theories. The good-natured voice that Somerville established in the popular marketplace was one of engagement as she brought forth the theories of noted scientists to the reading public. Regardless of the comments Somerville received for her mathematical interpretation of a Laplacian universe, Somerville, in *Mechanism*, was well appreciated for her ability to bring to the page the contributions made by the British titans of science, astronomy, and exploration. In *Connexions* Somerville delivered a wide scope of scientific information to the popular reader and this breadth of work earned her much praise. As noted previous, Somerville wrote two additional works in popular science. Somerville remained a notable figure even into the twentieth century Somerville. A portrait bust of Somerville (Figure 2) was commissioned in 1922.

---

[280] Ibid., 255.

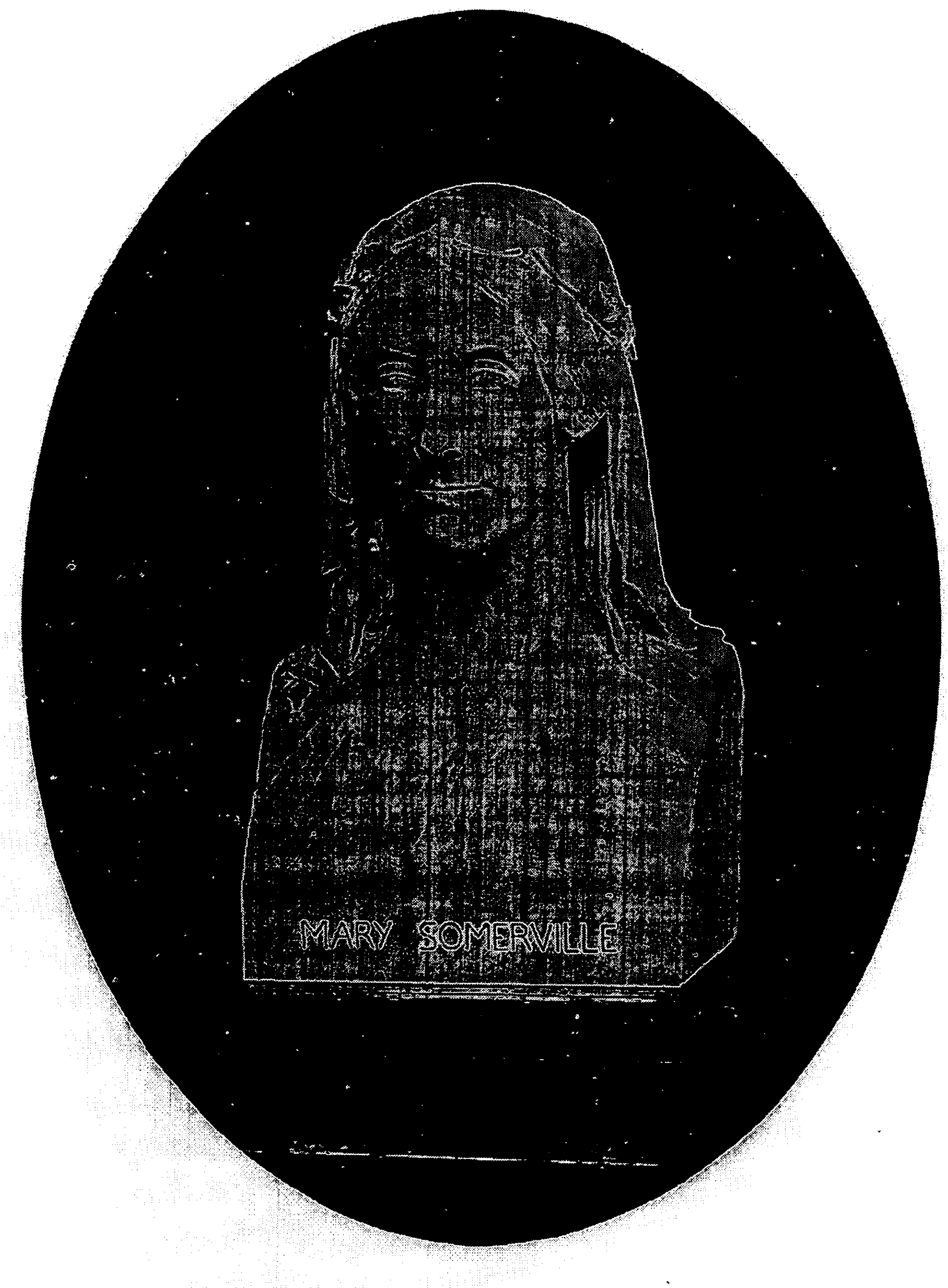


Figure 2
Portrait Bust of Mary Somerville by Lawrence MacDonald (1922)
Girton College Library and Archive, Cambridge
Permission granted by the Mistress and Fellows, Girton College, Cambridge

CHAPTER FOUR

EMERGING FIELDS OF INQUIRY

*****

Shifts and Developments

This comparative study of Mary Somerville and Margaret Huggins is concerned with collaborative voices at the embryonic stages of specialized areas of astronomical research. The processes, experiments, findings, results, and analyses these experimenters undertook, and consequently wrote about, were added to the larger creative ideas brought forth by prominent scientific minds. Because these two women were working and writing about a quarter of a century apart, Somerville's last paper was published in 1846 and Huggins' first Notebook entry was in 1876, this dissertation will investigate the shifts, developments, and emerging fields of inquiry that occurred under the umbrella of celestial studies over this time span.

An initial glance at how Somerville and Huggins entered into experimentation shows very different circumstances. Somerville was a "grand" scientific hostess who forged friendships with important scientific men to become involved in science. Huggins, on the other hand, married a "grand amateur astronomer." Yet, repositioning our vantage point divulges that both historical actors were in a position to dynamically engage with a rising area of astronomical study. Somerville was not an experimenter before she began work in spectrum analysis, and Huggins was not involved in astronomy before her start at Tulse Hill. Somerville and Huggins were present when opportune situations for inquiry were presented to them and both women made use of these opportunities to access rising specializations.

The prismatic study Somerville undertook with Wollaston, who is noted by twentieth century scholars of astronomical studies as a leading contributor to spectrum analysis, experimented with one of the first ways to separate white light.[281] By the time Huggins began her experimentation, the use of the spectrum to separate celestial light had been revolutionized. Joseph Fraunhofer's (1787 – 1826) design of the simple spectroscope coupled with Gustav Kirchhoff's identification of the sodium line focused experiments on the sun and several metals were identified in it.[282] William along with William Allen Miller expanded the use of the spectrum to other stars' light and nebulae, and Hugginses employed another nineteenth century obsession, photography, to record the findings.

Somerville used written narrations, in both scientific papers and popular works, to describe what she saw in nature. In addition, her last paper, a collaborative work with John Herschel, was submitted with hand-drawn images to illustrate the size and characteristic of the stains she observed from her experiments with solar rays and vegetable juice. Photography was only in its infancy when Somerville's *Connexion* came to print in 1834.[283] Somerville's intersection with the photographic process occurred in this last paper with Herschel and was part of his larger plan to make "facsimiles of the original photograph."[284] Though Huggins relied on written narrations and hand drawings in her scientific papers and her Notebook entries, her career was devoted to claiming a position of authority for the photographic image.

---

[281] David Dewhirst and Michael Hoskin, "The Message of Starlight: The Rise of Astrophysics," in *The Cambridge Concise History of Astronomy*, ed. Michael Hoskin (Cambridge: Cambridge University Press, 1999), 224. North, *Astronomy and Cosmology*, 423.

[282] Dewhirst and Hoskin, "Message of Starlight," 224 – 26.

[283] Tucker, *Nature Exposed*, 1.

[284] Herschel, "Chemical Action," 206.

The practice of integrating photography with spectrum analysis was perhaps inevitable as photography was quickly becoming a part of the scientific process. As will be discussed, striking photographic images of the moon by Warren de la Rue secured the method's place in observational astronomy.[285] Capturing an image with a mechanical instrument was often seen as less tiresome than having to tediously draw images by hand. As well, by mid-century machines were being seen as accurate and enduring "paragons" in science. Peter Galison and Lorraine Datson point out:

> It was a nineteenth-century commonplace that machines were paragons of certain human virtues. Chief among these virtues were those associated with work: patient, indefatigable, ever alert machines would relieve human workers whose attention wandered, whose pace slackened, whose hand trembled. Scientists praised automatic recording devices and instruments in much the same terms. As the photograph promised to replace the meddling, weary artist, so the self-recording instruments promised to replace the meddling weary observer. It was not simply that these devices saved the labor of human observers; they surpassed human observers in the laboring virtues; they produced not just more observations, but better observations.[286]

An investigation of the Hugginses' Notebooks and their published papers will reveal just how strenuous a process it was to get those "better observations" and to legitimize the photographic narrative included in their work.

Somerville's magnetizing experiments were performed in her home, which is traditionally noted as a gendered space. However, many male practitioners including Wollaston, Herschel, and Christie performed experimental work at home. Huggins and William also performed all their astronomical work at a facility attached to their place of residence, which not only highlights the perseverance of the amateur tradition in astronomy well into the late nineteenth century but again questions whether the house is a gendered space in astronomical research. As Allan Chapman notes there were no fewer

---

[285] Tucker, *Nature Exposed*, 195 - 97.

[286] Peter Galison and Lorraine Datson, "The Image of Objectivity," *Representations 40* (1992): 83.

than 50 private observatories in Britain in 1884, which had been operational for over one hundred years, and the British amateur tradition was expanding to the rest of the Empire.[287] These sites were part of the domestic frontier rather than any institutionalized space.

As we have seen, aside from scientific work, Somerville was a "towering figure" as a popularizer.[288] The maternal tradition was a format commonly used by female writers, such as Jane Marcet, Somerville's good friend, in the early nineteenth century.[289] However, when Somerville entered into popularization this way of writing was seen as catering to women and child readers. Somerville did not employ this method. One reason was that she, along with other popularizers, was targeting a wider audience. For example, astronomical enthusiast, Mary Ward (1827 – 1869) wrote on the telescope, microscope, and entomology, and her aim was a wider audience.[290] Rosina Zornlin (1795 – 1859), similar to Somerville, wrote about astronomy and physical geography. Her target audience was children as well as the adult reader.[291] Somerville aimed at reaching the "adult male audience,"[292] and she had to demonstrate in her writing that she was at ease in the company of men and could converse in a way that held their attention, if not igniting their intellectual curiosity. Noteworthy is the fact that the inscription in *Mechanism* specifically stated that it was a work "undertaken at His Lordship's [Lord Brougham's] request" [293] gearing the text away from a solely female readership. Rather than focusing on being stern and didactic, Somerville concentrated on being familiar and

---

[287] Chapman, *Victorian Amateur Astronomer*, 27
[288] Lightman, "*Victorian Popularizers*," 97.
[289] Ibid., 99.
[290] Ibid., 104.
[291] Ibid., 108.
[292] Ibid., 100.
[293] Somerville, *Mechanism*, b1.

conversational. The success of *Mechanism* and the even greater success of *Connexion* indicate that this conversationalist format was appealing and aided in Somerville's popularity well into the 1870s.

The Somerville/Huggins study illuminates the rise of the institutionalized observatory, and later, the observatory/laboratory for astrophysical studies. From Somerville's period to the end of the Hugginses' careers the number of observatories set on investigating both heaven and earth had risen from less than three dozen to greater than two hundred.[294] The facilities utilized by astrophysicists were changing as modern observatories, built to carry out a "range of activities," came into being.[295] As we will see in the next four chapters, Huggins and William were familiar with many institutionalized sites and often worked together with these facilities to prolong viewing times and confirm results. The accessibility to larger facilities and their findings throughout the Hugginses' careers points to the porous relationship between large institutional sites and the amateur astronomers at Tulse Hill.

At Tulse Hill, Huggins made substantial contributions to the Hugginses Notebooks, and these documents were viewed by both William and herself. Her style of writing was similar to the technique Faraday employed in "Sketch." As with Faraday, Huggins noted down every action and outcome, even if the results were inconclusive. Consequently, a reader, either herself or William at a later date, could by "virtual witnessing" watch the experiments unfold, again, as if they were present. This

---

[294] Ibid., 2.

[295] David Aubin, Charlotte Bigg, and H. Otto Sibum, "Introduction: Observatory Techniques in Nineteenth Century Science and Society," in *The Heaves on Earth: Observatories and Astronomy in Nineteenth Century Science and Culture*, ed David Aubin, Charlotte Bigg, and H. Otto Sibum (Duke University Press, 2010), 2.

contribution was significant, and Huggins became the main narrator of the Notebooks after 1876.

Huggins, similar to Somerville, was influential as a supporting author in scientific papers, and this was a role that brought her prominence. Scrutinizing Huggins' slow emergence and guarded visibility in published papers demonstrates Huggins gentle entry into the inner core of astronomers. The Hugginses were aware that a specific authorial space was required for Huggins in scientific journals and their placement of her contribution demonstrates their initial unease about her presence.

Spectrum Analysis and Cosmic Matter

A condensed exploration of William Huggins' practices at Tulse Hill in the years leading up to Huggins' entry into research will allow for a fuller understanding of her impact at the observatory. This contextualization sets the frame in which to paint a comparative study of Somerville's and Huggins' entry into science and publication. Similar to the shift in focus at the Royal Institution to magnetism, the field of research where Huggins entered into astronomical studies was also undergoing changes. Singling out William's key project prior to Huggins' involvement will outline the ever evolving parameters in which Huggins set to work in the mid-1870s.

In 1875, when Margaret Lindsay Murray married William Huggins and began life at Tulse Hill, William was already well immersed in astronomical research and well respected within the inner circle of astronomers in London and abroad. William was elected a member of the Royal Society in 1865 and in 1866 was awarded the Society's Royal Medal. This honour meant that William's astronomical work was as esteemed as past winners like John Herschel (honoured with the Royal Society medal in 1833, 1836, and 1840), George Airy (honoured with the Royal Society medal in 1845), William Parsons (honoured with the Royal Society medal in 1851), and Warren De La Rue (honoured with the Royal Society medal in 1864).

William, as indicated by his earlier entries in the Hugginses' Notebooks, had for many years, relied on a detailed eye and a meticulous hand to record what he saw. Depictions of celestial surfaces were sketched into the Notebooks with the first grouping of entries made in 1856. These sketches showed the transition of Mars on three days in April, one in May, and one in June.[296] The entries in these early years of his research were observations as William recorded the appearance of planets in the most accurate way possible.

[296] Notebook One, The Huggins Collection in the Special Collections, Wellesley College.

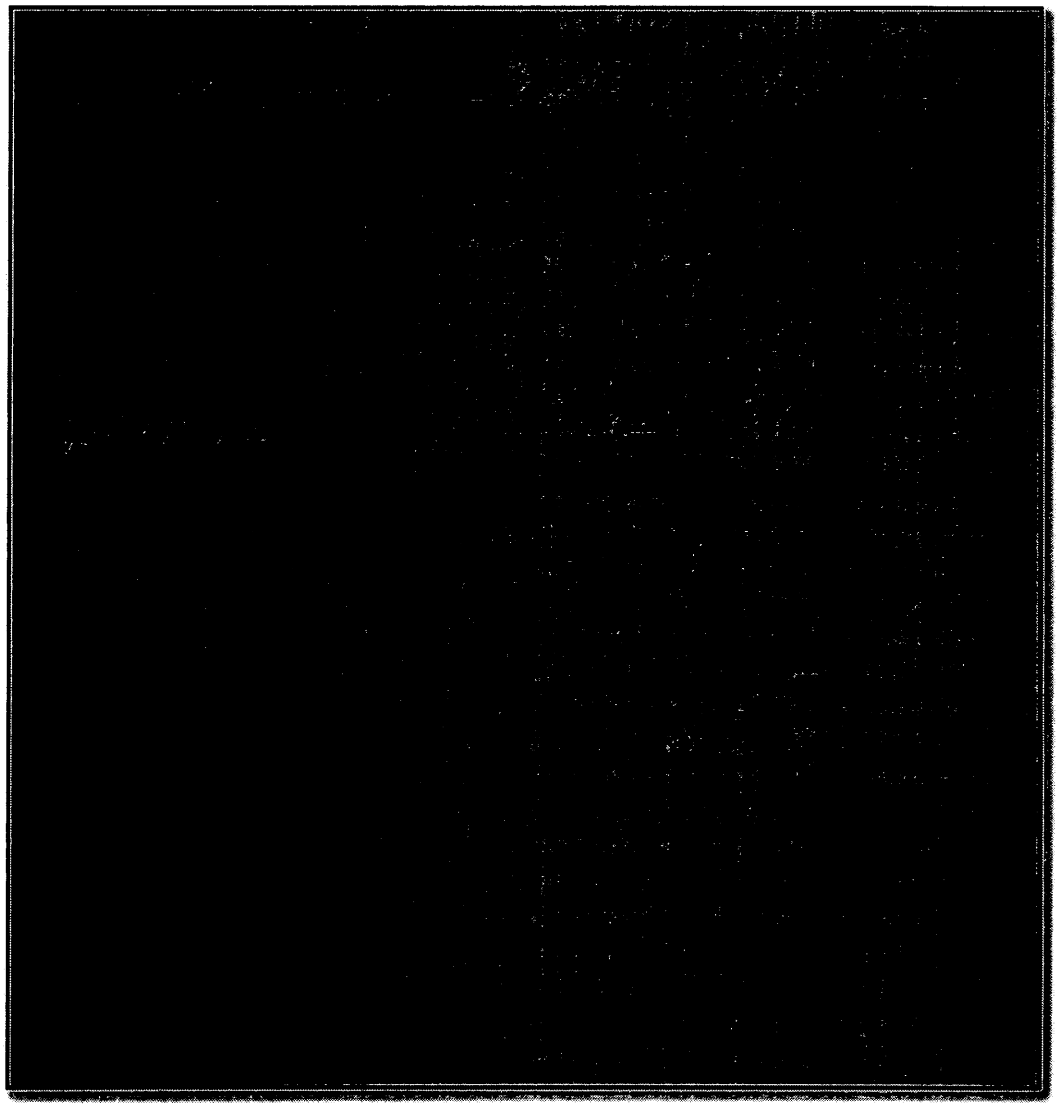


Figure 3
Observations of Mars, 1856
Notebook One
Wellesley College Library/Special Collection

Sometime in the early 1860s, William became interested in the composition of starlight. Although no record of his initial work can be found in any of the six Notebooks at Wellesley, William did produce a seminal paper on the spectroscopic observations of a number of fixed stars for the Royal Society. His neighbour and friend, William Allen

Miller, assisted in this work and in the writing of the paper.[297] The lengthy contribution was titled "On the Lines in the Spectra of Some of the Fixed Stars."[298] This paper was highly regarded at the Royal Society particularly by Edward Sabine. The Miller/William act of collaboration proved rewarding for William and reinforced his need for an assistant. This first paper of William's for the Royal Society illustrates that he employed a collaborative voice. Miller was a well-respected chemist and the addition of his name demonstrated not only his involvement but gave the paper greater credibility. This inclusion would mark another important paper with the addition of Huggins' name in 1889.

William was to gain greater prestige in 1868 when the Royal Society officially awarded him the responsibility of a Grubb Telescope, which would be housed at Tulse Hill but paid for by the Society. William had an obligation to use the telescope productively; however, the instrument did not function properly on many occasions, and William stated that "I fear I shall not be able to do all that the Society might reasonably expect."[299] William, although still a "grand amateur astronomer," now had institutional ties and commitments.

In Chapter Four I will map William's rapid rise in the "New Astronomy," which he achieved by determining key chemical signatures in a large array of celestial bodies. I will demonstrate that William's early papers in spectrum analysis were collaborative pieces. Even after his partnership with Miller ended the papers William produced were not the voice of a "solitary observer" as Hugginses scholar Barbara Becker has argued.

---

[297] Author corresponded with Barbara Becker on this matter and confirmed that no records of these experiments were found with the Miller papers at King's College or Cambridge.

[298] William Huggins and William Allen Miller, "On the Lines in the Spectra of Some of the Fixed Stars," *Philosophical Transactions of the Royal Society of London* 154 (1864): 413 – 35.

[299] William Huggins to Robinson in Becker, *Unravelling Starlight*, 128.

William was aware that astronomy may call for individual observations but collective theses produced the most influential results. This set the foundation for Huggins' entry at Tulse Hill after which William relied on Huggins' experiments and data recording abilities to substantiate his arguments.

The New Astronomy and William Huggins

William was born in 1824 in London where during his youth his father prospered with a mercer and drapery business. In 1856 William sold the business and built an observatory next to his house on Tulse Hill. He later stated in *An Atlas of Representative Stellar Spectra*:

> In 1856 I built a convenient Observatory, opening up a passage from the house, and raised so as to command an uninterrupted view of the sky except on the north side. It consisted of a dome 12 feet in diameter and a transit room. There was erected in it an equatorially mounted telescope by Dollond of 5 inches aperture, at that time looked upon as a larger rather than a small instrument.[300]

In addition, William, even at a very early stage in his research, was willing to invest a considerable amount of money in acquiring expensive equipment. Jack Meadows in "The Origin of Astrophysics" points out that both Father Angelo Secchi at the Pontifical Observatory, and William at Tulse Hill, attempted to detect the Doppler shift in Sirius. It was William who saw a red shift in Sirius' spectrum in 1868, and William claimed that his equipment allowed him to prove the Doppler Effect can be applied to celestial objects.[301]

William, in 1858, first became aware of spectrum analysis and the success Bunsen/Kirchhoff had with light analysis and solar rays. Forty years later William

[300] William in Joseph S. Tenn, "The Huggineses, the Drapers, and the Rise of Astrophysics," *Griffith Observer* (1986): 3.
[301] See Jack Meadow, "The Origin of Astrophysics," in *Astrophysics and Twentieth-Century Astronomy to 1950* ed. Owen Gingerich (Cambridge: Cambridge University Press, 1984), 10.

reminisced that hearing of the discovery was like "coming upon a spring of water in a dry and thirsty land. Here at last presented the very order of work for which in an indefinite way I was looking – namely to extend [Kirchhoff's] novel methods of research upon the Sun to the other heavenly bodies."[302]

The Bunsen/Kirchhoff breakthrough was a major event not only for William but for many in astronomy and science. For example, John Gassiot, amateur scientist, noted in *Proceedings* (1862-1863) that Bunsen/Kirchhoff had shown "the importance of spectrum analysis" in spectroscopic research and telescope use.[303] William was so influenced by the Bunsen/Kirchhoff technique that he went on to note Kirchhoff's success in the first "prismatic analysis" paper he submitted to the Royal Society:

> The recent discovery by KIRCHHOFF of the connexion between the dark lines of the solar spectrum and the bright lines of terrestrial flames, so remarkable for the wide range of its application, has placed in the hands of the experimentalist a method of analysis which is not rendered less certain by the distance of the objects the light of which is to be subjected to examination. The great success of this method of analysis as applied by KIRCHHOFF to the determination of the nature of some of the constituents of the sun, rendered it obvious that it would be an investigation of the highest interest, in its relations to our knowledge of the general plan and structure of the visible universe, to endeavour to apply this new method of analysis to the light which reaches the earth from fixed stars.[304]

After learning of Kirchhoff's discovery, William refocused the resources at Tulse Hill onto spectrum research.

William enlisted the aid and expertise of his friend and neighbour

[302] William Huggins in Ian Elliott, "The Huggins Sesquicentenary," *Irish Astronomical Journal* 26 (1999): 65.
[303] John Gassiot, "On Spectrum Analysis: With a Description of a Large Sectroscope [sic] Having Nine Prisms, and Achromatic Telescopes of Two-Feet Focal Power [Abstract]," *Proceedings of the Royal Society of London* 12 (1862 – 1863): 536.
[304] Huggins and Miller, "Spectra of Some of the Fixed Stars," 413. [emphasized in original]

William Allen Miller, a practising chemist and chemistry teacher at King's College, and this partnership led to William's first spectrum paper. William was new to the science as Somerville had been to magnetic studies. In her earliest work, Somerville chose to confirm the theory of a long time practitioner, namely Morichini. William also chose not to work alone but to work with an expert in the field. As Dewhirst and Hoskin in "The Message in Starlight" note, Miller by 1859 had realized that "light emitted by electric arcs struck between two metal rods differed from metal to metal" and thus that these dissimilarities could be used to identify elements.[305] As we have seen, the collaborative route into a specialized area of study and a scientific network was a tool used by Somerville, Faraday, and now William. Later, this dissertation will demonstrate that it was also employed by Huggins.

The Miller/William projects illustrated William's success in working with a partner. As Agnes Clarke noted in *A Popular History of Astronomy During the Nineteenth Century*, "the work [of] each [William and Miller] was happily directed so as to supplement that of the other."[306] With William's beginning in spectrum analysis, the Observatory which was initially an observational site became an experimental space. William later stated in *Atlas*:

> Then it was that an astronomical observatory began, for the first time, to take on the appearance of a laboratory. Primary batteries, giving forth noxious gases, were arranged outside one of the windows; a large induction coil stood mounted on a stand on wheels, so as to follow the positions of the eye-end of the telescope, together with a battery of several Leyden jars; shelves with Bunsen burners, vacuum tubes, and bottles of chemicals, especially of specimens of pure metals,

[305] Dewhurst and Hoskin, "Message in Starlight," 225.
[306] Clerke, *History of Astronomy*, 373

> lined its walls. The observatory became a meeting-place where terrestrial chemistry was bought into direct touch with celestial chemistry. [307]

William's and Miller's strategy for research was "the comparison of the dark lines of the stellar spectra with the bright lines of terrestrial matter."[308]

At this initial stage the independent and still unaffiliated amateur astronomer was selective about the stars and planets that he investigated. The collaborative paper, "Spectra of Some of the Fixed Stars," studied approximately 50 bright stars such as Aldebaran, Sirius, and Capella, and a small array of popular planets such as Jupiter, Venus, Mars, and Saturn. The paper was a record of findings gathered over two years and demonstrated knowledge in chemistry, which Miller no doubt had contributed. When the partnership dissolved upon Miller's death William had acquired chemical know-how and laboratory equipment to outfit the site.

It was during the years in which William conducted research for "Spectra of Some of the Fixed Stars" that he, along with Miller, made their first attempt to photograph spectrum bands. Two bands of the spectrum of Sirius, outlining several chemical lines, were captured on wet plates;[309] however, the procedure was very messy and the men did not attempt this process in further collaborative works. It was Miller who had the photographic skill in this partnership and in 1862 – 63 Miller produced an experimental paper that dealt with the use of different metals, chemicals, and glasses, accounting for the rate of absorption over different exposure times.[310] The technique for

[307] William in Tenn. "Rise of Astrophysics," 4. William Huggins would make continual reference to the use of these chemical apparatuses in his papers particularly a paper titled, "Note on the Spectra of Erbia and Some other Earths," which he devoted to chemistry. This paper will be discussed further on in this section.
[308] William Huggins and Miller, "Spectra of Fixed Stars," 413.
[309] Ibid., 444.
[310] W. Allen Miller, "On the Photographic Transparency of Various Bodies, and on the Photographic Effects of metallic and other Spectra Obtained by Means of the Electric Spark [Abstract]," *Proceedings of the Royal Society of London,* 12 (1862 – 1863): 159 – 66.

photographing objects at this time was commonly referred to as the "wet plate" method, which had been newly invented in 1851 by Scott Archer and Peter W. Fry.[311] William and Miller did employ this awkward process at Tulse Hill, and it was this process that Miller attempted to improve upon in "Photographic Transparencies,"

"Spectra of Some of the Fixed Stars"

The importance of William's and Miller's paper cannot be overemphasized, as shortly after the publication of "Spectra of Some Fixed Stars" William was awarded custodianship of a Grubb telescope. The Royal Society was confident that Tulse Hill should house a Grubb because of William's extensive work in spectrum analysis over a very short span of time and because he was willing to spend money on equipment to upgrade the site. Another great sum that William was to spend at the Observatory was the purchase of the land lease for Tulse Hill for an additional 50 years and more.[312] This purchase ensured that once installed the giant telescope need not be moved for a half century. The honour of housing the Grubb was great,[313] yet William understood that it was not a telescope that he could operate easily on his own. Even before the Grubb arrived William indicated to Thomas Romney Robinson, the director of the Armagh Observatory in Ireland, that the telescope was large, heavy, and difficult to manoeuvre without help. The Grubb was an unwieldy and cumbersome instrument consisting of two interchangeable telescopes, one being an 18 inch refractor and the other being a 15 inch refractor. Although William was willing to continually spend money to upgrade Tulse Hill, hiring a helper was not a financial possibility; William had stated to Robinson that it

---

[311] B. E. C. Howarth-Loomers, *Victorian Photography: A Collector's Guide* (London: Ward Lock Limited, 1974), 52.

[312] Becker, *Unravelling Starlight*, 129.

[313] The cost of the Grubb was about 2,000 pounds paid for by the Royal Society. See Becker, *Unravelling Starlight*, for a full account of the purchase.

would "cripple me" to hire an assistant.[314] The fact that William eventually married a person who could assist him at the Observatory no doubt added to the harmony of the matrimonial relationship.

Between the year of the first spectrum paper with Miller (1864) and his marriage to Huggins (1875) William produced an astounding twenty papers. Apparatuses were continually added to Tulse Hill to keep the site up to date. Eyepieces,[315] a new spectroscope with "compound prism,"[316] a hand-held spectrum-telescope contrived by William in 1866 for observing "meteors and their trains,"[317] and a galvanometer to measure heat[318] were some of the major pieces of equipment that William acquired in the twelve year interval. By 1870 William was not only commissioning new tools, but had taken on the role of inventor. William, with the assistance of an optician, fashioned a pointer for an eye piece inside a spectroscope.[319] The purpose of this ingenious device was to allow the eye to remain on the telescope while the hand instantaneously recorded the readings. William noted that this tool lessened the eye's fatigue as one needed not refocus the eye from one instrument to the next.

Not a Solitary Site

What was apparent in "Spectra of Some of the Fixed Stars" and in future papers was William's continual complaint of fatigue. On more than one occasion the paper

---

[314] William Huggins in Becker, *Unravelling Starlight*, 172.

[315] William Huggins, "On the Spectra of the Nebula," *Philosophical Transaction of the Royal Society of London* 154 (1864): 438.

[316] William Huggins, "Further Observations on the Spectra of the Sun, and of Some of the Stars and Nebulae, with an Attempt to Determine Therefrom Whether These Bodies are Moving towards or from the Earth," *Proceedings of the Royal Society of London* 16 (1867 - 1868): 383.

[317] William Huggins, "Description of a Hand Spectrum – Telescope," *Proceedings of the Royal Society of London* 16 (1867 – 1868): 241 – 42.

[318] William Huggins, "Note on the Heat of the Stars," *Proceedings of the Royal Society of London* 17 (1868 – 1867): 310.

[319] William Huggins, "On a Registering Spectroscope," *Proceedings of the Royal Society of London* 19 (1870 – 1871): 317 – 18.

stated that "comparison[s] of this kind are extremely fatiguing to the eye" due to the faintness of the celestial objects coupled by the demand to view the lines of the spectrum for extended periods of time.[320] In this early stage there were already indications that this type of analysis was physically strenuous and required at least two or more observers at a time to do the work. William produced only three papers with Miller.

Despite the fact that William worked alone after 1868 he was not a solitary astronomer. The Tulse Hill Observatory had gained recognition locally, and as the "Visitor's Log" indicated, numerous people often visited the site.[321] William was always more than willing to proudly show his friends around the Observatory.[322] As well, the Observatory hosted several prominent astronomers in the spring of 1865, most notably being Lord Rosse of "the Leviathan" at Birr Castle, Rosse's son Lord Oxmantown, and John Robinson of Armagh Observatory.[323] Robinson was there looking to add spectroscopic research and photography to the Armagh in Northern Ireland.

In 1867, William proudly took John Herschel[324] on a tour of the Hill,[325] and Herschel went on to add spectroscopy to his Observatory in Colonial India. William was, by the mid-1860s, an authority on observatory conversions. The facility was an astronomical meeting place and the possibility of possessing "certain knowledge of a more intimate nature"[326] on celestial objects transformed the observatory into a small functioning physical laboratory. As the "New Astronomy" began to entice other

---

[320] William Huggins and Miller, "Spectra of Some of the Fixed Stars," 425, 432.
[321] "Visitor Log", Notebook Two, The Huggins Collection in the Special Collections, Wellesley College.
[322] Ibid.
[323] Ibid.
[324] John Herschel is the son of the John Herschel previously mentioned in the dissertation.
[325] Visitor Log", Notebook Two, The Huggins Collection in the Special Collections, Wellesley College.
[326] William Huggins, "On the Spectrum of Comet 1, 1866," *Proceedings of the Royal Society of London* 15 (1866 – 1867): 5.

astronomers, more and more telescopic sites became observatory/laboratories, and William's Tulse Hill was a model of such a progressive facility.

William Huggins' Research Agenda

Although William's research interests were vast, several key hypotheses from the ten years leading up to Huggins entering Tulse Hill will be outlined in order to establish the site's focus. The analysis will center on celestial groupings, which Huggins adopted and took on during her years of practice. The theories proposed and the best method to use was often questionable. Norman Lockyer was to become one of William's foes as the two men came to disagree about chemical compounds and methodology. To add to the debate that persisted as the specialization gathered momentum, astrophysicists questioned the work of observational astronomers and their need to build large and expensive telescopes. At the same time, the issue as to whether the refractor telescope, such as the one employed by William, or the reflector telescope, such as the one used by Lord Rosse at Birr Castle, was more accurate raised much controversy in this science. As Aubin, Bigg, and Sibum point out, "(a)t times [in the nineteenth century] physicists have seemed to pay more attention to their instruments than to the natural phenomena they purportedly studied."[327] William was vigorously, and vocally, visible in all these debates.

William's initial research on the nebulae was marked by his paper entitled, "On the Spectra of Some of the Nebulae" (1864). This paper deserves a close reading because it set the foundation for William's hypothesis arguing that distinct terrestrial chemical markers were also consistent in celestial entities. By finding the distinguishing physical characteristic, or the chemical signature of each object, one could use the dominant

---

[327] Aubin, Bigg, and Sibum, "Introduction," 11.

characteristics to group celestial bodies into specific families. This was a pivotal argument.

William further argued that finding the signature of stars and searching for these same markings in nebulae would help to determine if nebulae were indeed composed of stars:

> Some of the most enigmatical of these wondrous objects are those which present in the telescope small round or slightly oval disks. For this reason they were placed by SIR WILLIAM HERSCHEL in a class by themselves under the name of Planetary Nebulae. They present little indication of resolvability. The colour of their light, which in the case of several blue tinted with green, is remarkable, since this is a colour extremely rare amongst single stars. These nebulae, too, agree in showing no indication of central condensation. By these appearances the planetary nebulae are specially marked as objects which probably present phenomena of an order altogether different from those which characterize the sun and the fixed stars. On this account, as well as because of their brightness, I selected these nebulae as the most suitable for examination with the prism.[328]

William was in fact arguing that there were two types of nebulae. One type exhibited the same colouration as single stars and was composed of stars. The second was truly nebulous in nature. In the above passage, however, William stated that his work in prismatic analysis now pointed to this second type of Nebula, in which the colouration is much different or "extremely rare" from the starlight emanating from single stars. "Spectra" hypothesized that this nebula was showing "several blue tinted with green" lights suggesting true nebulosity.

William's two nebula theory added to the Nebular Hypothesis argument in the early nineteenth century. The term "Nebular Hypothesis" was coined by William Whewell in the Bridgewater Treatise of 1833.[329] The over-arching question was whether nebulae star clusters proved a nebulous origin to the universe. The argument stated that in

[328] William Huggins, "Spectra of some of the Nebulae," 437.
[329] Schaffer, "The Nebula Hypothesis," 135.

order for solar systems to form condensation of single stars must occur in the process, allowing materials to form planets. As Schaffer explains in "The Nebular Hypothesis":

> In its simpler versions, the nebular hypothesis was taken as giving an astronomically proper account of the origin of the Solar System through the action of natural law upon a condensing and rotating gaseous nebula of gravitating matter. It was claimed that as this cloud contracted, rings of matter would be precipitated into space at regular intervals. Each ring would then make a planet. The central condense cloud produced the Sun.[330]

William proposed that they were able to see line signatures that were different in colouration from suns and single stars. Thus, the material forming this type of nebula was not similar to that of the planetary nebula. Since there was a non-star or solely gaseous nebula, nebulosity did not always lead to the formation of solar systems. Edward Sabine, the President of the Royal Society, believed that William's and Miller's two nebula theory was worthy of consideration. In the Presidential Address of 1864 Sabine hailed William as bringing something "totally different" to astronomy.[331]

Celestial and Terrestrial Happenings

Throughout the 1860s and early 1870s William's techniques were continually polished as he gained more innovative and practical ways to obtain data. As Agnes Clerke was to note later in *History of Astronomy,* from a very early point, William's greatest contribution was not his findings but the way he had refined a research process in this fields. "The scope of Sir William Huggins' achievement was not, however, to provide definitive data, but to establish a practicable method of procuring them."[332] William was not a practitioner who centered on one type of celestial body; he enjoyed investigating the physical characteristics of numerous entities in the heavens. This

---

[330] Ibid., 132.
[331] Edward Sabine, "President's Address," *Proceedings of the Royal Society of London* 13 (1864): 502.
[332] Clarke, *History of Astronomy*, 387.

interest in various celestial matters in turn allowed William to continually expand his techniques and methods to include objects that were vastly different in make-up. Briefly focusing on William's other major projects will illuminate the diversity of his research agenda while demonstrating that William remained focused on prismatic analysis to determine his findings.

The year 1866 proved to be a busy one for William because of the appearance of a comet in our solar system and a nova in the Corona Borealis, in the Constellation of the Northern Crown. William, again, worked with Miller to study this natural occurrence. The observations, as indicated in the Notebook entries, were made on May 16 and the findings were sent to the Royal Society on May 17.[333] Both William and Miller were aggressively taking the lead on this new star.

The comet of 1866 provided William with his first opportunity to apply "prismatic analysis" to the "light of comets" on his own.[334] This astronomical event excited William because he had been unable to observe the comet of 1864 due to unfavourable weather. He soon published a short but important paper outlining the possibility that comets and nebulae were closely related in composition. William was extending his theory of the solely gaseous nebulae to comets. In the same year, William revisited the nebular hypothesis and published a short abstract titled, "Further Observations on the Spectra of Some of the Nebulae, with a Mode of Determining the Brightness of These Bodies."[335] What can be noted is that William was conducting

[333] William Huggins, Notebook Two, The Huggins Collection in the Special Collections, Wellesley College.
[334] William Huggins, "Comet 1, 1866," 5.
[335] William Huggins, "Further Observations on the Spectra of Some of the Nebulae, with a Mode of Determining the Brightness of These Bodies [Abstract]," *Proceedings of the Royal Society of London* 15 (1866 – 1867): 17 – 19.

experiments with candles and other heat sources at Tulse Hill to connect terrestrial chemical elements to celestial matter. In the remaining years of the 1860s William took his spectroscopic device and focused his attention on numerous celestial objects including a nova, stars, the Sun, the moon, and two additional comets.

William participated in the celestial life debate by looking at the enigmatic moon. In the early days, his work on this celestial body consisted mostly of recording the changes to the lunar surface over consecutive days.[336] On several pages of Notebook Two Huggins noted that he observed that some craters had a "hazy patch."[337] There were discussions during this period in Victorian astronomy, and in popular culture, of a possible lunar atmosphere. One popular essay published in 1861 (the year William was working on lunar research) made note of an atmospheric alterations that one could observe on the moon:

> At one time we are told that the absence of an atmosphere and water would render life on [the moon] impossible, at other another time astronomers suggest the possibility of vapour and atmosphere different, perhaps, from that to which we are accustomed, but by no means incapable of supporting a mooncalf.[338]

The essayist, in turn, implied the existence of lunar life. William was adamantly against such theories and did not see a lunar atmosphere as synonymous with life.

William, although greatly admiring John Herschel, would disagree with Herschel's hypothesis that the moon did not have an atmosphere.[339] William argued that an atmospheric layer enclosed the moon, and it was this sphere that caused the haze and

---

[336] William Huggins, Notebook One, The Huggins Collection in the Special Collections, Wellesley College.

[337] William Huggins, Notebook Two, The Huggins Collection in the Special Collections, Wellesley College.

[338] Anon. in David Clifford, "Repopulating Heaven: Victorian Lunar Studies and the Anxiety of Loneliness," in *Repositioning Victorian Sciences: Shifting Centres in Nineteenth – Century Scientific Thinking*, eds., David Clifford, Elisabeth Wadge, Alex Warwick and Martin Willis (London: Anthem Press, 2006), 175.

[339] John Herschel in William Huggins, "The Spectra of Some of the Fixed Stars," 419.

accounted for the reflectivity of the moon's surface. William did not publish any work on the lunar facade until 1874 and his prismatic research again indicated that the haziness was due to the reflective nature of the moon's surface.

Several comets came into view in the 1870s and William's voice added to conflicting theories as to their composition and illumination. Encke's Comet appeared in the fall of 1871; however, William was to note with disappointment, that "bad weather prevented me from making later observations of the comet, with the exception of one evening, December 5 …"[340] Yet William was able to produce two short papers on the comet discussing both its visible appearance and the spectral reading hinting that he believed the comet tail to be self-illuminating.[341] William made observations throughout the month of July on Coggia's Comet and continued to argue that the brightness of the comet was not due to the reflection from the sun but because these bodies did produce light.[342] William sketched the Coggia's Comet's spectrum on July 13 and 14. The self-illuminating tail theory was still contentious in astronomy in the late 1870s.

Chemistry

The late 1850s and early 1860s was a time when chemistry was "in a stage of rapid development."[343] The work that William did at Tulse Hill was progressive and his success relied on his maintaining steady correspondence with those working in chemical analysis as well as those in celestial research. By the early 1870s William had gained a level of familiarity with chemistry tools such as Bunsen burners, gas flames, oxy-

---

[340] William Huggins, "Note on the Telescopic Appearance of Encke's Comet," *Proceedings of the Royal Society of London* 20 (1871 – 1872): 87 – 89.

[341] William Huggins, "Note on the Spectrum of Encke's Comet," *Proceedings of the Royal Society of London* 20 (1871 – 1872): 45 – 47.

[342] William Huggins, "On the Spectrum of Coggia's Comet," *Proceedings of the Royal Society* of London 23 (1874 – 1875): 154 – 59.

[343] Meadows, "The Origin of Astrophysics," 4.

hydrogen blowpipes, and Leyden jars, which allowed him to write a paper on Erbia. "Notes on the Spectra of Erbia and Some other Earths" set out to determine the intensity of "bright lines" that erbium would emanate.[344] William subjected chemicals such as glucina, alumina, and zirconia to a heat source and noted the characteristic of their spectrum refracted as a result of exposure to high temperatures. "Spectra of Erbia" again demonstrated that William's reliance on a collaborative voice, as in it he cited findings by Roscoe and Clifton, scientists stationed in Manchester, along with the experiments conducted by leading chemists Bahr and Bunsen. By the early 1870s the community of research facilities that Tulse Hill associated with were no longer restricted to observatories but included many chemical labs outside of London.

As we have discovered, William's interests and work after 1864 were, on every account, focused on the chemical analysis of celestial objects. William's early papers in this new area of astronomy were works of collaboration. William aggressively took the lead by proposing several daring hypotheses regarding the make-up of heavenly bodies. These debates were linked to wider astronomical issues such as the formation of solar systems. As William shifted his interest to the "New Astronomy" he became better known for his methodology and technique than for his findings. In the next chapter we will see how Huggins had the responsibility of meticulously entering the data from the experiments in a set of Notebooks. She would also include details of their daily practices. At the same time Tulse Hill began to experiment with photography, and the notes on this new tool would prove to be greatly beneficial as processes were tried out and outcomes, both successful and flawed, were obtained.

[344] William Huggins, "Note on the Spectra of Erbia and Some other Earths," *Proceedings of the Royal Society of London* 18 (1869 – 1870): 546 – 53.

CHAPTER FIVE

MARGARET HUGGINS AND ENTERING A PRACTICE

*****

Notebooks and Narration

In the previous chapter we saw that before Huggins' arrival at Tulse Hill William already held a prominent place in spectrum analysis and celestial light studies making the Observatory a working laboratory. William had successfully identified numerous chemical line signatures in many objects in the heavens. He was known for his willingness to try new approaches to spectroscopy and he was innovative as he fine-tuned his methods. With Huggins' arrival William applied a well-seasoned tool from observational astronomy, photography, to the "New Astronomy." But, it was Huggins' aptitude for tediously narrating experimental outcomes and practices that proved to be her most influential role at the site. Her detailed authorship, which included noting down the procedures and outcome as the experiment occurred, was particularly important because astrophotography was in the early experimental stage when the Hugginses began collaborating.

Huggins' involvement as the recorder meant that even William's experiments, outlined in the Notebooks, were filtered through Huggins' ability to articulate the work. Because William transferred the responsibility of maintaining the Notebooks to Huggins, William appears as a "point of view" contributor in these unpublished documents. That is not to say that William was secondary to Huggins in science or astronomical research, but that the way the reader, including William, saw the practices at Tulse Hill was now seen through Huggins' words. As these Notebooks became more personal, the way Huggins wrote revealed her anxiety and frustration at certain junctions in their year of collective research as theories were put forth, argued, rebutted, and re-introduced.

Huggins' first entry in the Notebooks (March 31, 1876) referenced a photographic procedure and her presence became synonymous with this practice. Because Huggins wrote most of the entries on photography it was she, not William, who became an expert at writing about this process. The first paper coming from Tulse Hill after their marriage was a short note on the "photographic spectrum" of selected stars. In the paper William spent a few lines explaining his abstention from using photography in his work. Barbara Becker argues that it was clear that this respected astronomer felt the need to explain to the scientific community why he was not employing a technique that many in his field were using with proficiency. However, a detailed reading of the published papers in *Proceedings* will demonstrate that the appeal of photography in culture and the belief that this tool can assist in an accurate recording of spectra lines was a concept rather than an accepted practice throughout William's early years of astrophysical investigation.

In Chapter V I will demonstrate that Huggins' work at Tulse Hill focused on her ability to record the astronomical sightings and experimental findings acquired at the site. Becker has argued that Huggins was a crucial factor in William's willingness to integrate photography into spectrum research. No doubt that the tedious photographic process could best be achieved with two people and William's work with Miller in the early 1860s reveal that even with a second person, photography was not an easy tool to apply. This dissertation will demonstrate that Huggins' most important contribution to Tulse Hill was her ability to note down the data from experiments the couple performed, and to keep a meticulous record of the results whether successful or flawed. Huggins carved a specific authorial identity and Huggins sustained an influential position in scientific documents because of her ability to reveal the processes through her words.

The Early Years and a Telescopic Meeting

One can learn most about Margaret Lindsay Murray Huggins' early life from her obituary. The Murray family was originally from Scotland and moved to Cork when the Bank of Scotland transferred Robert Murray, Huggins' grandfather, to Ireland. Huggins was born in 1848 in Dublin. Her father, John Murray, was a solicitor. He married Helen Lindsay, the couple had two children, and the family of four lived in a spacious Georgian home six miles from town near the harbour of Dun Laoghaire.[345] Huggins' mother died when she was eight and her father remarried. Elizabeth (nee Pott) and John Murray had three more children. It was said that it was Robert Murray (Margaret Huggins' grandfather), who lived only three miles from Huggins' home, who taught her how to read the constellations. At an early age Huggins learned how to decipher a celestial atlas, and this curious child often used a telescope with which she enjoyed viewing sunspots.[346]

One piece of popular information, or perhaps legend, was that Huggins was in the habit of reading *Good Works*, an Evangelical family magazine, when she was young and had read in it an article on astronomical spectroscopy that was written by her future husband, William Huggins.[347] This fact cannot be substantiated; however, William had

[345] M. T. Bruck and I. Elliott, "The Family Background of Lady Huggins," *Irish Astronomical Journal* 20 (1992): 210. There is some question as to whether or not Huggins had an elder brother who may have died. What is known is that by the time the family moved into the Georgian house they were a family of four.

[346] I. Elliott, "The Huggins' Sesquicentenary," *Irish Astronomical Journal* 26 (1999): 65.

[347] Sarah Whiting, "Lady Huggins," *Science, New Series* 41 (1915): 854. Ian Elliott, Hugginses scholar, was adamant that Huggins had read William's work and was "an ardent admirer of her future husband" even before they had met. Barbara Becker, Hugginses scholar, argues that none of the anonymous articles

started work at Tulse Hill and was conducting spectroscopic observations in 1856 when Huggins was eight years old. William had indeed written for *Good Works,* using an anonymous pen, in the mid-nineteenth century. It was thus quite possible that Huggins read his articles during this time.

Huggins first met William in the home of Julia Montifiore in London in 1865. Later, in 1870, Huggins and William would meet again in Dublin at instrument maker Howard Grubb's facility. William was at the site to check on the progress of his refractor and Huggins was visiting the family. The fact that Huggins and William met at the location where a telescope was constructed with which for these two star searchers would share a lifetime of celestial research added a romantic element to the story. The word "romantic" figured in numerous pieces associated with this astronomical couple. In an obituary for Huggins the writer of *The Observatory* stated that, "Immediately upon entering the door [of Tulse Hill], one felt somewhat as if removed from the materialistic present into an age in which we are wont to think life was more romantic and sentimental."[348] Sarah Whiting, a good friend of Huggins, stated that, "it was the romance of her [Huggins'] life she should afterwards become the wife of the astronomer who wrote the papers [in *Good Works*], and with him made many discoveries with the magic instrument."[349] Although well meaning, the frequent application of terms like "romantic," "romance," "sentimental," and later "outpost" to the Hugginses' collaborative endeavours not only removed them from the "materialistic present into the

published in *Good Works* between 1860 and 1875 fit William's eclectic style or research interest. Becker argues that it was John Herschel who was writing the prismatic articles for the magazine.

[348] Anne J. Cannon, "Lady Huggins," *Observatory* 38 (1915): 323.

[349] Sarah Whiting, "Lady Huggins," 854.

age in which we are wont"[350] but created an aura of whimsy around the narrative presence of these two astronomers. As well, the use of the term "magic instrument" to describe the highly sophisticated spectroscope and camera the Hugginses used at Tulse Hill detracted from the credibility of their work. This term again added to the romantic aura of the site and, at the same time, renegotiated the authoritative voice that Huggins projected in her publications.

Huggins and William were married in Monkstown Parish Church on September 8, 1875. It was, by many accounts, a happy marriage strengthened by a common passion for knowing "intimately" the physical character of celestial objects. As Huggins was to state, using the word "romantic" herself, it was "a romantic marriage of the Browning order, quite as ideally happy for thirty-five years."[351]

The Culture of Astrophotography

It has been well documented that Warren De La Rue was one of the most important practitioners of astronomical photography in Victorian popular culture, and his famed pictures of the moon brought much delight to viewing audiences and brought him great respect amongst his fellow astronomers.[352] Yet, a photograph of the moon, eclipses, and other sensational celestial objects always held greater appeal than spectrum bands and chemical lines, which tended to be rather dull on the page. The acceptance of photography in determining the make-up of celestial bodies was not a phenomenon in the 1860s and early 1870s. There was, in fact, only one paper on photography and spectrum analysis in the interval between Miller's and William's first attempt at photographing star bands and the year that Tulse Hill's first astro-photographic paper was published in

[350] "Ibid.", 845.
[351] Margaret Huggins in Colin A. Ronan, *Their Majesties' Astronomers*, 177.
[352] See Tucker, *Nature Exposed*, 196 – 97.

Proceedings. The paper was by Captain J. Waterhouse, who was working in Calcutta, and it was sent to the Royal Society in 1875.[353] Waterhouse was able to produce three photographs of the solar spectrum using a dry collodion plate. Waterhouse's work investigated the effect of alternate colours of the spectrum on the dry plates, and the paper argued that this type of plate was a better photographic tool than the daguerreotype plate:

> As collodion has so many advantages over the daguerreotype, it seems probable that this new extension of an old principle may have an important practical application in spectroscopic photography, particularly for the mapping of a part of the spectrum in which eye-observations can only be made with difficulty and under favourable circumstances.[354]

Rather than writing an astronomical paper, Waterhouse was demonstrating a photographic concept employing the solar spectrum as an object of inquiry.

Outside of England two Americans had made some initial progress in photographing star spectrums. In 1872 Lewis M. Rutherfurd and Henry Draper produced a photograph of the spectrum of the Vega star in the constellation of Lyra. Rutherfurd and Draper were able to capture four distinct lines. This successful photograph of Vega was considered a major achievement in starlight analysis.

Astro-photographic Practice and Narration

Huggins' first entry in the Hugginses Notebooks was on March 31, 1876. The entry read:

> In March began to take photographs
> Friday, March 31st. 1876.
> Photographed Sirius. Wet Plate, 9 minutes exposure. Photograph on the edge of the plate in consequence of want of adjustment. 3 lines across refrangible end of spectrum.

---

[353] J. Waterhouse, "On the Reversed Photographs of the Solar Spectrum beyond the Red, obtained on a Collodion Plate," *Proceedings of the Royal Society of London* 24 (1875 - 1876): 186 – 89.

[354] Waterhouse, "Reversed Photographs," 187.

[image of spectrum enclosed][355]

Huggins' narration indicated at what stage the photographs were first taken, and the technique and materials used in March to secure a successful photograph on the 17 of this month.[356] The bulleted format suggests that Huggins was writing as the work took place and was impatient to get on with the observation. This method gives the reader the ability to "virtually witness" the process as if present. There was an absence of personal pronouns in this entry, yet in later entries personal pronouns, nouns and notations appeared. William was in the habit of writing in paragraph structure, which suggests that he completed the work first and wrote down the findings afterwards. From 1876 onwards, the Hugginses continued to investigate different photographic techniques and Huggins jotted down the results.[357] These entries became particularly important not only for understanding the make-up of the stars but also because it led to the questioning of the wet plate method throughout that summer. Huggins was keeping a tight methodological record in the Notebooks and she came to dominate its pages.

Although the wet plate method had already been adapted into mainstream photography, in the spring, Huggins attempted the dry method at the Observatory. Her entry on May 7 of the same year noted "that the dry plate gave best results" and continued by stating that the results were "so good" that "I might endeavour to photograph the spectrum of Venus using the same narrow slit I had from the Solar

---

[355] Margaret Huggins, March 31, 1876. Notebook Two, The Huggins Collection in the Special Collections, Wellesley College. Becker, *Unravelling Starlight*, 184.

[356] For an extensive example see William Huggins, Notebook One, The Huggins Collection in the Special Collections, Wellesley College. Another way to distinguish William's entry from Huggins was that William had better penmanship.

[357] Margaret Huggins, June 30 1881, Notebook Two, The Huggins Collection in the Special Collections, Wellesley College.

Spectrum."[358] As shown by this entry on May 7, by mid-spring Huggins was already confidently using the "I" pronoun. Huggins would do so again on May 9 by stating that she "took one or two photographs of Solar spectrum with a view to determining how wide I might open the slit and still obtain lines [...] I found that although otherwise desirable wet collodion processes are open to serious objection on account of oblique reflection."[359] By boldly referring to the work done at the Observatory as "'I' work" as she wrote in her own hand, Huggins had, in two short months, asserted herself in the Hugginses Notebooks. Huggins assumed the control of the narrative and the reader thus viewed the practice of science through her eyes.

The following entry demonstrates that it was customary for the couple to work together in the observatory and that William working alone was an oddity, which Huggins made note of. These narrations express the complexities of their working life with each partner taking the lead in the area where they felt most confident. The entry also demonstrates that Huggins, in this act of narration, was using the text to express her personal feelings. The Notebook assumes characteristics of a scientific autobiography:

> I was unable to be in the Observatory but W[illiam] insisted on working alone. [...] It [the image] is not however as strong as I should have liked & I regret much that W[illiam] would not take my counsel & have left the plate in so that it might have had continued exposure the next fine night.[360]

The above passage provides a solution on how to improve the intensity of the image and it was these small noted suggestions that advanced the accuracy of the photographic process.

---

[358] Margaret Huggins, May 7 1876, Notebook Two, The Huggins Collection in the Special Collections, Wellesley College.

[359] Margaret Huggins, May 9 1876, Notebook Two, The Huggins Collection in the Special Collections, Wellesley College.

[360] Margaret Huggins, November 12 1893. Notebook Five, The Huggins Collection in the Special Collections, Wellesley College.

The Hugginses' work on June 1876, along with the rest of the summer, focused on determining the best photographic method, wet or dry, for analysis using the solar spectrum as the test subject. Lighting was taken into account as the Hugginses determined whether to rely on reflected sunlight or diffused daylight. The Hugginses found that the wet collodion processes lead to reflection.[361] On the other hand, in a separate set of experiments the team found that "[a]fter this I [written in Huggins' hand] used in turn Emulsion, Gelatine, and Captain Abney's Beer plates and obtained some excellent photographs of the solar spectrum both by direct sunlight reflected by a Heliostat and by diffused daylight."[362] The last entry that recorded the use of a wet plate was on August 17, 1876.[363] From this date onwards the Hugginses employed only the dry plate method at Tulse Hill. Despite the fact that they phased out the wet plate method, Notebook Two held an extensive "Catalogue of Photographs of Stellar Spectrum," which indicated that this technique had successfully captured over fifty photographs of various stars.[364] The entries coupled with this log outlined the long and tedious journey that led to the adaptation of the dry plate method at Tulse Hill.

---

[361] Ibid., Notebook Two.

[362] Ibid.

[363] Margaret Huggins, August 17 1876, Notebook Two, The Huggins Collection in the Special Collections, Wellesley College.

[364] Margaret Huggins, Notebook Two, The Huggins Collection in the Special Collections, Wellesley College.

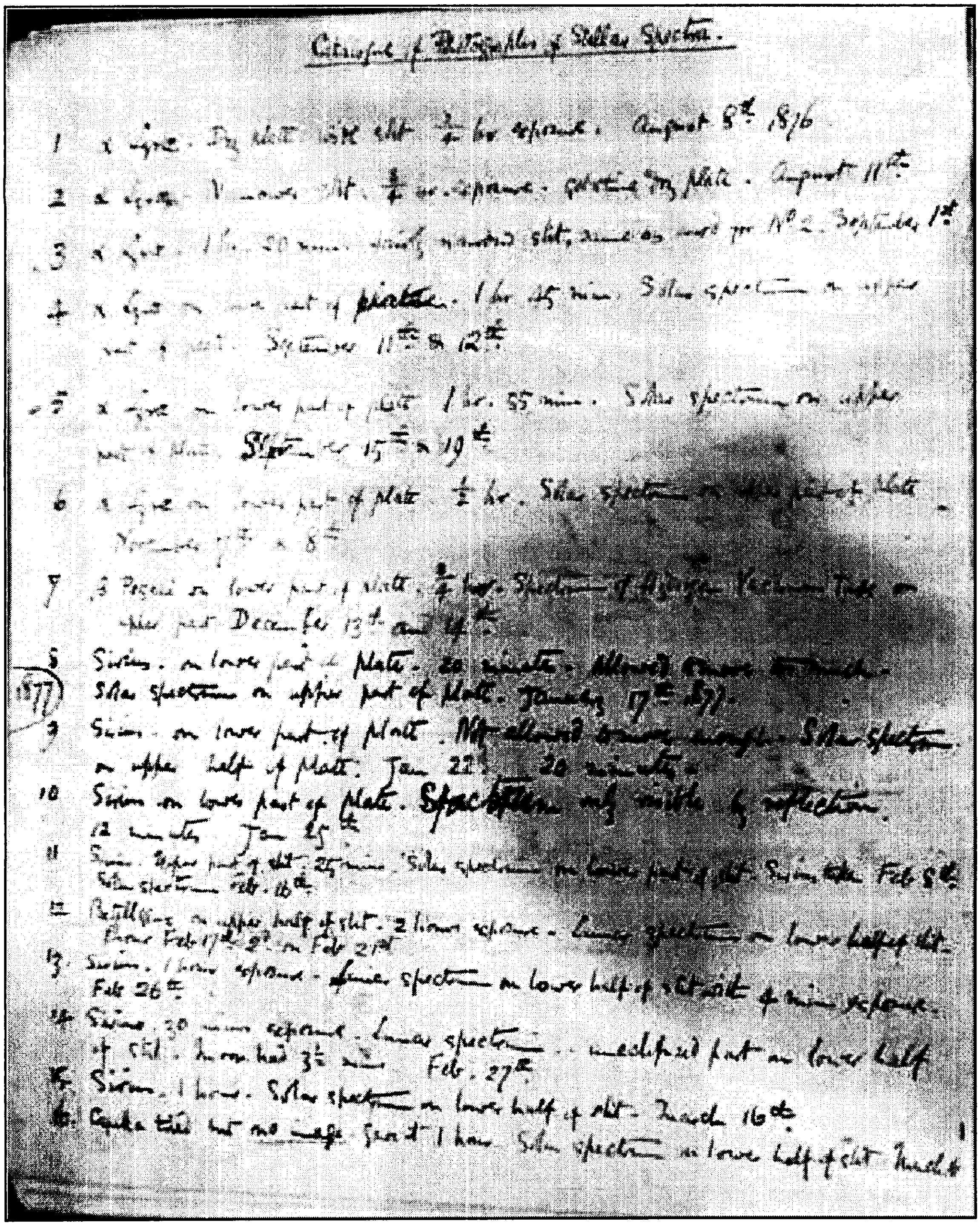
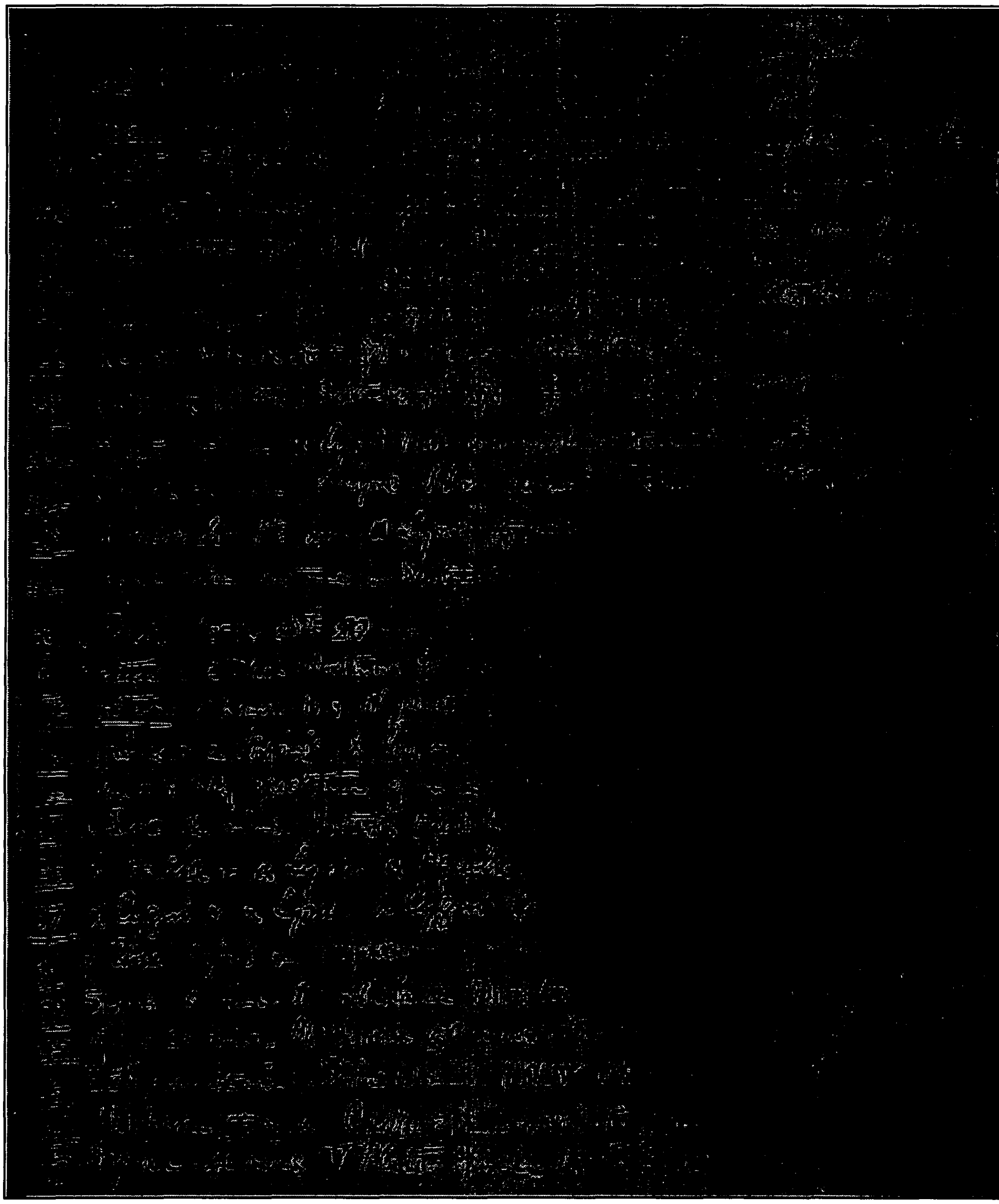

Catalogue of Photographs of Stellar Spectra.

Figure 4
Catalogue of Photographs of Stellar Spectrum (two pages)
<u>Notebook Two</u>
Wellesley College Library/Special Collection



The Hugginses were working at the embryonic stage of photographing the spectrum. The papers that were submitted to *Philosophical Transactions* by fellow practitioners investigating the spectra at this time, featured hand drawn-images accompanied by charts.[365] For example, Roscoe's and Thorpe's work, published in 1877, was a recording of the characteristics of absorption lines emitted by vapours of bromine after the substance was boiled at extreme heat. The individual hand-drawn images were referred to as a "map."[366] Schuster's "Spectra of Metalloids" (1879) also contained hand-drawn images and graphs along with his findings and experimental procedure:

> I have tried to represent in the spectrum in Plate 1, marked A the relative intensities of the oxygen lines. The intensities were carefully estimated, but cannot, of course, be greatly relied on except as far as the relative intensity of a group is concerned. It seems hardly possible to compare the intensity of a yellow and a blue line. [...] Photography will do the work much better in the extreme violet than I could have done.[367]

Tellingly, Schuster noted that the hand-drawn images and graphs in the paper were far from precise and stated that a photograph would provide more accurate data.

By the summer of 1876, some of the narrations in the Notebooks had lost much of their formality. Many comments were noted down without sentence structure and separated only by commas. For example, a June entry reads, "at the same time testing different photographic methods with a view to finding, relatively to different parts of the spectrum the most sensitive, and relatively to the whole spectrum the quickest method for star spectra."[368] In December 1876, Huggins began to use the first person plural, "we," in the entries.[369]

---

[365] See paper by H.E. Roscoe and T.E. Thrope. "On the Absorption-spectra of Bromine and of Iodine Monchloride," *Philosophical Transactions of the Royal Society of London* 167 (1877): 207 – 212. Arthur Schuster, "On the Spectra of Metalloids-Spectrum Oxygen," *Philosophical Transactions of the Royal Society of London* 170 (1879): 37 – 54.

[366] Ibid., 208.

[367] Schuster, "Spectra of Metalloids," 49.

[368] Margaret Huggins, June 1876, Notebook Two, The Huggins Collection in the Special Collections, Wellesley College.

[369] Margaret Huggins, December 1876, Notebook Two, The Huggins Collection in the Special Collections, Wellesley College.

In the Notebooks diagrams were still an integral part of data keeping and Huggins proved her talent for drawing. From looking at the personal items she donated to Wellesley College, one can conclude that Huggins was a person who enjoyed narrating the world in a pictorial way. Huggins included in her donation to the college, along with the six Notebooks, a small red Sketchbook of drawings. This artifact, similar to a personal diary, demonstrated how Huggins viewed the world, and her world was very much seen in illustrative form.[370] From a young age, Huggins was a visual author.

As the 1870s drew to a close, it was clear that the Observatory's ambitions of relying solely on astrophotography to collect data on spectrum bands would prove to be an arduous goal. Well into the 1880s the Hugginses, along with other astrophysicists, continually had problems photographing chemical signatures and determining the terrestrial and celestial chemical parallel for comets, stars and nebulae. Even at this late date the photograph was often more of a verification device to the naked eye. In many instances Huggins declared in frustration that "not even the faintest blurring" appeared on a photographic plate.[371]

In 1879 a further transformation occurred in the Notebooks' narration. After three years working along-side William, Huggins began to steadily differentiate her contributions from William's input. Huggins, in some entries after July 1879, used "W" to denote William's input while maintaining the first person singular "I" to define her own work. These notations were particularly visible when conflicting views occurred. "I persuaded W[illiam] to gently close the shutter and leave the plate in the camera to go on

---

[370]Margaret Huggins, Sketchbook, The Huggins Collection in the Special Collections, Wellesley College.

[371] Margaret Huggins, June 30, 1881, Notebook Two, The Huggins Collection in the Special Collections, Wellesley College.

with the next fine night."[372] Huggins showed her narrative authority as both a first-person and third-person narrator. This usage points to Huggins' self-awareness of her coming into being as an autonomous practitioner.

Recording Life at Tulse Hill

The life Huggins lived with William at the Observatory can be pieced together from a selection of personal entries that made their way into the Notebooks. From the start, her personal life intersected with her working hours and the Notebooks, at times, became an autobiography for Huggins. Her enthusiasm is clear in 1880 as Huggins started the year by stating "It is delightful to begin this year with work."[373]
The Notebooks show Huggins' dedication to research as it was she who, at times, was very much frustrated when work could not commence because the skies were "never clear."[374] A year later, in 1881, an entry indicated that she was very excited over claims made by Tulse Hill and went on to call the paper sent to the Royal Society "our," meaning both William's and her, submission.

Huggins was to have additional cause to be proud as in the same Notebook she stated that some diagrams, which were made "by me" with "extreme care," had been reproduced by the British Association. Huggins' research work was quietly yet surely gaining recognition in scientific circles. Just as Somerville had slowly promoted her knowledge of Laplace to gain familiarity with scientific practitioners, Huggins was gently penetrating scientific society with her artistic talents and knowledge. This technique of

[372] Margaret Huggins, December 5 1881, Notebook Two, The Huggins Collection in the Special Collections, Wellesley College.
[373] Margaret Huggins, Notebook Two, The Huggins Collection in the Special Collections, Wellesley College.
[374] Margaret Huggins, Notebook One, The Huggins Collection in the Special Collections, Wellesley College.

artistically contributing to the work of one's husband to gain entry into science production was frequently used by the wives of scientific men. For example, Mary Buckland illustrated for her husband, geologist William Buckland. Later, Mary went on to illustrate for George Cuvier.

The Hugginses hectic work schedule was compounded by the fact that astonishing celestial events did not always occur on "a most beautiful night, both clear and steady,"[375] and the forces of nature made for much anxiety at the Observatory. When "not a good night" happened the Hugginses were forced to do "what we could."[376] What is also revealing is that even into the 1880s the photographs the Hugginses took were often unreliable and spectrum bands were frequently drawn by hand in the Notebooks and in the papers published for *Proceedings.* The photograph was submitted only when a clear image could be obtained and in the early years, this image was not always attainable.

In 1881, the appearance of a comet created excitement in both scientific circles and popular culture as it was the first comet to be successfully photographed by Henry Draper in America and Jules Janssen in France. At Tulse Hill, the Hugginses attempted to photograph the chemical signature of Comet b 1881, which appeared on June 24, 1881. On the same day the Hugginses had been at a garden party:

> We were at a garden party at Kew in the afternoon, but hurried home from it as there was promise of a clear night. Had a hasty tea, got out of my "Sunday best", prestissimo [sic], and went at once with my husband to the observatory.[377]

---

[375] Margaret Huggins, May 23, 1890. Notebook One, The Huggins Collection in the Special Collections, Wellesley College.

[376] Margaret Huggins, Notebook One, The Huggins Collection in the Special Collections, Wellesley College.

[377] Margaret Huggins, Notebook Two, The Huggins Collection in the Special Collections, Wellesley College. [emphasized in original]

The addition of notes on social events and changes of clothing renegotiates the position of the narrator of the Notebooks. Huggins no longer solely used the text for scientific purposes. The books, instead, became a place to record a rich private life. Her ease with entering these personal events into the Notebooks suggests that these texts were for her, by this time, a very familiar space.

The work done on this night was important as the Hugginses were able to observe and clearly photograph a comet's signature. Their findings were published in a paper titled, "Preliminary Note on the Photographic Spectrum of Comet b 1881," which the Royal Society received on June 27 1881.[378] The events of this busy day can be measured by looking at the above Notebook Two entry in conjunction with William's note in "Photographic Spectrum of Comet b 1881":

> On the evening of June 24, I directed the reflector furnished with the spectroscopic and photographic arrangements described in my paper "on the Photographic Spectra of Stars" to the head of the comet, so that the nucleus should be upon on half of the slit. After an hour's exposure the open half of the slit was closed, the shutter withdrawn from the other half, and the instrument then directed to Arcturus for fifteen minutes.[379]

The pressure to observe and photograph celestial events and publish the findings first was constantly on the minds of both William and Huggins. The Hugginses viewed Comet b 1881 again on the next night and obtained a second photograph using half the exposure time.[380] As the Hugginses indicated in their paper in 1881, the photographic process was still not foolproof. On both nights the results were not optimal and the couple found that "this photograph [June 25], notwithstanding the longer exposure, is fainter, but shows

[378] William Huggins, "Preliminary Note on the Photographic Spectrum of Comet b 1881," *Proceedings of the Royal Society of London* 33 (1881 – 1882): 1 – 3.
[379] Ibid., 2.
[380] Ibid., 2.

distinctly the two bright lines and the continuous spectrum, which is too faint to allow the Fraunhofer lines to be seen."[381]

They made a further attempt to photograph Comet b 1881 again on June 30. From the disastrous results we can determine that the photographic method was still very much in the infant stages of development, which caused the Hugginses great frustration. "I think it was Tuesday – we exposed a plate for 1 hour, exactly the same time the comet plate had, and then developed at once. There was no result whatever – not even the faintest blurring of the plate."[382] The level of frustration is notable in this entry, yet the note also reveals a flawed procedure, which the Hugginses could not explain. Unlike Somerville who destroyed all the notes from her magnetism and solar rays experiments, Huggins recorded and kept notes from unsuccessful outcomes. These documents made important experimental guides for future work. Despite the less than ideal photographs Huggins wrote on November 19 of the same year that William "will give lecture at R.I on comet."[383]

Being Written About

As the years evolved Huggins found that she had developed friendships that were built on astronomical interests. The most prominent of these relationships was with Agnes Clerke (1842 – 1907), a well-known popularizer of astronomy. Clerke's *A Popular History of Astronomy in the Nineteenth Century* was first published in 1885, and the two women became friends shortly after the book reached the public. The friendship lasted until Clerke's death in 1907. Huggins' association with Clerke was important because Clerke praised the Hugginses' research pertaining to the chemical analysis of the Orion

[381] Ibid., 2.
[382] Ibid., 2. [emphasized in original]
[383] Ibid., 2.

Nebulae and assured that their [Huggins' and William's] "invaluable cooperation all lovers of astronomy must rejoice to see publicly recognised."[384] Clerke, in an article for *The Observatory,* had endorsed the Hugginses' claim that certain spectral lines within the Nebula band, which Norman Lockyer had mistaken for solely terrestrial elements, could only exist in extra-terrestrial matter.

Clerke continually endorsed the Hugginses' findings and results throughout the latter part of the nineteenth century and into the twentieth century. Clerke had gone so far as to attempt to immortalize William Huggins' name by changing the name of the hydrogen Balmer lines to the "Huggins Series" in one of her books. In *The System of the Stars* (1890), Clerke had labelled the ultra-violet lines in this sequence Huggins alpha, beta, gamma, and so on.[385] This act of renaming never took hold in astronomy. In *History* Clerke gave the Hugginses and their work at Tulse Hill extensive recognition.[386] In addition to *History* and *System of the Stars*, the Hugginses were cited in Clerke's *Problems in Astrophysics* (1902).[387] Clerke knew of the level of collaboration that went on daily at Tulse Hill, and she sanctioned Huggins' contribution to astronomy both as a researcher and as a photographic astronomer.[388] In 1903, Clerke and Huggins were both elected honorary members of the Royal Astronomical Society.[389] Huggins referred to Clerke on many occasions as a close personal friend, wrote Clerke's obituary, and published an account of Clerke's life in the *Astrophysical Journal.*[390] Unlike Somerville

---

[384] Agnes Clerke in Mary Bruck, *Agnes Mary Clerke and the Rise of Astrophysics,* (Cambridge: Cambridge University Press, 2002), 77, 277.

[385] Ibid., 151.

[386] See Agnes M. Clerke, *A Popular History of Astronomy During the Nineteenth Century* (Decorah: Sattre Press, 2003), particularly the hapters on "Solar Spectroscopy" and "Stars and Nebulae"

[387] Agnes M. Clerke, *Problems in Astrophysics*, (London: A. & C. Black, 1902), 115.

[388] Clerke, *History*, 305, 380, 383, 396, 398, 407.

[389] Bruck, *Agnes Clerke and the Rise of Astrophysics,* 174.

[390] Ibid., 223.

who wrote extensively for the popular reader, Huggins never sought a career in this area of astronomy. However, Clerke assured that the Hugginses' contribution to spectroscopy and the "New Astronomy" was visible to the reading public.

Inevitably, Extra-Terrestrial Life

As Clerke was swayed into endorsing Giovanni Schiaparelli's Mars Canal argument in *History*, Huggins was also entangled in the extra-terrestrial life debates of the nineteenth century. The findings outlined in William's paper with Miller, "Spectra of Some Fixed Stars," were related to discussions regarding "other worlds than ours." William and Miller pointed out that some celestial chemicals coincided with terrestrial elements, yet the composition was much denser on earth. They claimed that such difference must indicate a "purpose" to sustain human life as an "arrangement be admitted as designed in the case of the earth."[391] The paper goes on to directly support the possibility of extra-terrestrials by proposing:

> In going beyond the limits of fair deduction to suppose that, were we acquainted with the economy of those distant globes, an equally obvious purpose might be assigned for the differences in composition which they exhibit. The additional knowledge which these spectrum observations give us of the nature and of the structure of the fixed stars, seems to furnish a basis for some legitimate speculation in reference to the great plan of the visible universe, and to the special object and design of those numerous and immensely distant orbs of light.[392]

The paper ended with a discussion on other "systems of worlds" that could contain an "abode of living beings" making the argument that if man can find the composite nature of the cosmos these discoveries would enlighten this debate.[393] This underlying theme can be noted in William's celestial interest and was perhaps one reason for his shift from observational astronomy to spectrum analysis. Tulse Hill was not outside the "plurality of

[391] William Huggins, "Spectra of Some Fixed Stars," 433.
[392] Ibid.,
[393] Ibid., 434.

worlds" controversy and popular authors such as Robert Hunt in *Popular Science Review* and William Carter in *Journal of Science* would use the William and Miller paper to promote life on other stellar worlds and planets such as Venus and Mars.[394]

One vocal participant in the "Pluralities of Worlds" discussion was author Richard Proctor (1837 – 1888). Proctor in *Other Worlds Than Ours* (1870) noted William's sighting of water vapours in Mars' atmosphere and possible water deposits on the surface of the planet to further his argument. Proctor stated that these were favourable features for life, and that the planet "exhibits in the clearest manner the traces of adaptation to the wants of living beings such as we are acquainted with."[395] In addition, Proctor used William's and Miller's "Spectra of Some Fixed Stars" to support another argument in *Other Worlds*, which outlined the physical conditions, or the "constitutions of the stars," required for a sun system to sustain life.[396] Proctor stated that William and Miller had verified that "the spectra of these stars [such as in Betelgeux in Orion and Aldebaran in Taurus] are as rich in lines as the solar [our sun] spectrum itself."[397] For Proctor, this parallel substantiated that life in other stellar systems was possible.

Evolutionary Theory and Nomenclature

Another concept that was tightly intertwined with astronomy was evolutionary theory and Tulse Hill's enthusiastic research on the make-up of nebulae and novas solidified the connection between the research site and this very popular idea in culture. William, in "Spectra of Some Fixed Stars," argued that knowing the chemical

---

394 Michael Crowe, *The Extraterrestrial Life Debate, 1750 -1900* (New York: Dover Publications, 1999), 362.
395 Richard Proctor, *Other Worlds Than Ours* (London: A. L. Fowle, 1870), 370.
396 Ibid., 247.
397 Ibid., 148.

composition of starlight was a way to find the age of suns and stars that were now visible to Victorian telescopes:

> The spectrum observations are not without interest also when viewed in connexion with the *nebular hypothesis* of the cosmical origin of the solar system and fixed stars. For if it be supposed that all the countless suns which are distributed through space, or at least those of them which are bright to us, were once existing in the condition of nebulous matter, it is obvious that, though certain constituents may have been diffused throughout its mass, yet the composition of the nebulous material must have differed at different points ...[398]

A fundamental part of the chemical analysis of starlight was to determine the stage of the nebulous star in the evolutionary process. This purpose was reiterated when William and Huggins began extensive work on the solar corona in 1885. In his paper for the Bakerian Lecture, William theorized that during the early ages of our solar system the sun was brighter:

> The views which I have ventured to put forward in this lecture would lead us to expect a more extended and more brilliant corona surrounded the sun in early geological times and that if the skies were then of their present degree of clearness, the corona would probably have been visible about the sun. May the corona have been still faintly visible in the earliest ages of the human race?[399]

Establishing the age of stars and nebulae allowed the astronomical community to indulge in one of its favourite activities, namely nomenclature.

The obsession to name and categorize heavenly bodies tempted astronomers to fit a very cumbersome and complex cosmos into neatly defined groupings. At the time Huggins began research at Tulse Hill Father Secchi, head of the Pontifical Observatory of Collegio Romano, and Carl Vogel of the National Astrophysical Observatory in Potsdam

---

[398] William Huggins, "Spectra of Some Fixed Stars," 433. [emphasized in original]

[399] William Huggins, "The Bakerian Lecture: On the Corona of the Sun," *Proceedings of the Royal Society of London* 39 (1885): 108 – 35.

were the forerunners in astronomical nomenclature.[400] William Huggins' Bakerian Lecture of 1885 supported the idea that heat signatures could be used to date and thus name a star according to its age. The work at Tulse Hill was inevitably added to the theories surrounding the evolutionary debates that circulated in this branch of science. By the late 1880s Lockyer had proposed that the temperature of the star can be used to determine the stage of evolution of the celestial body rather than its age.[401] However, by the end of Huggins' and William's career in the early twentieth century, it was Harvard College Observatory's Edward Pickering's Draper classification system, which had no evolutionary basis, became the preferred structure of classification by the international astronomical community.[402]

This chapter reveals that Huggins' entry point into astronomy came through her support of William's research aspiration and at this time the photographic process was initiated at the observatory. Her narrative contributions to the Notebooks demonstrated collaboration in practice between husband and wife. At the same time, Huggins' detailed entries created a text that richly intertwined scientific work with personal life. Huggins supported William by narrating the experimental outcomes and processes at their site, and her use of the "I" pronoun in later entries showed awareness of her own independent work. Huggins' tendency to relate both the successful and failed experiments made an important contribution to later work at the observatory. Her friendship with Agnes Clerke turned into a beneficial professional union as Clerke readily highlighted the Hugginses' contributions to astronomy in the public arena. The work at Tulse Hill fuelled the debate

[400] David H. DeVorkin, "Community and Spectral Classification in Astrophysics: The Acceptance of E. C. Pickering's System in 1910," *Isis* 72 (1981): 31.
[401] Ibid., 31.
[402] Ibid., 45.

as to whether the heat signature of a star can tell the star's stage in its evolutionary development.

CHAPTER SIX

THE RESEARCH PAPERS:

1876 – 1889

*****

Writing, Authority, and Chemical Signatures

Huggins' presence changed the way entries were made in the Hugginses Notebooks. Her meticulous authorship in these unpublished texts fortified the implementation of a new method of collecting data as the Hugginses focused on several lively debates in nineteenth- century astronomical culture. Within six months of her arrival the observatory had embraced the use of photography to capture line signatures and set about determining the credibility of this tool. Because photography was a new practice for William as well, Huggins relied on her own initiative to narrate the emergence of this process at the site. At the same time, the photographic plates created a new way to document spectrum bands, which now shared the story of composition with the hand-drawn images the Hugginses still relied on at this early stage. Huggins participated fully in providing photographic evidence of the spectrum image, and the visual narration in the Notebooks now included the questionable photographs.

As with Mary Somerville's case, a close reading of the Hugginses' published scientific papers will be conducted in order to reveal the contributions throughout the text. A sorting of the Huggins papers submitted to *Proceedings* between the years 1876-89 reveal that the Hugginses had various astronomers to contend with as they asserted their authorial presence with innovative theories in spectrum analysis and astrophotography. Huggins aided William in publishing an aggressive thirteen papers for

Proceedings in just thirteen years. In addition, William Huggins' Bakerian Lecture paper, "Corona of the Sun" (1885), outlined a new way to photograph our closest star without an eclipse. Huggins was part of this methodological breakthrough, the success of which would be monumental because it meant that one could now study the sun daily rather than what amounted to about eight days in every century.

Three particular astronomical topics preoccupied the Hugginses' agenda, namely the star – nebulae/gas - nebulae parallel, the self-illuminating capacity of comet tails, and the composition of the solar corona. A textual analysis demonstrates that complicating the study was the Hugginses' determination to use photography to obtain their data. The dry plate method, which had brought Henry Draper success in New York, was improved upon when Huggins and William sensitized the plates with varying amounts of gelatin to perfect the outcome. Their pristine observatory technique gave weight to spectrum photography, and the clarity of the Hugginses' images contributed greatly to the development of this procedure in astrophysics.

In Chapter Six I will do a close reading of the papers that were published under William Huggins' name in *Proceedings* between the years 1876 and 1889 in conjunction with the Notebook entries written by Huggins during this period. My juxtaposition-approach will focus on three high-profile projects, which contributed to the credibility of the Hugginses' photographic work. I will demonstrate that the pressure to be the first astronomers to find several base chemical signatures in a series of stars, comets, and the sun set Huggins' agenda as a spectrum astronomer and a stellar photographer. As her work in these areas intensified, Huggins exerted more confidence in her authorial identity in the Notebooks. She began to use identifiers to distinguish her own work from

William's. I will demonstrate that Huggins' authoritative voice often outshone William's presence in the Notebooks, yet, at the same time, the Hugginses maintained a collaborative practice. An analysis of the Notebooks reveals the tensions between partners as the pressure mounted to publish findings before other practitioners.

The First Paper

William's eagerness to establish an early presence in photographic analysis was evident. A short note outlining the chemical constitutions of stars such as Sirius and Vega, of the planet Venus, and of the moon appeared in *Philosophical Transaction* (1876 – 77). "Note on the Photographic Spectra of Stars" argued that the existence of lines corresponding to hydrogen were sighted on the spectrum of Vega. [403] This claim was fundamental because William had established that the bright lines on the spectrum were not simply absorption lines but were due to the presence of hydrogen making Vega an atypical star.[404]

The paper began with explanatory paragraphs as to why the Observatory had abstained from astrophotography for a long period of time. The paper's first reference was the 1863 work of Miller and William. It focused on methodology and discussed how a photograph of the lines of Sirius was obtained:

> On the 27th January, 1863, and on the 3rd March of the same year, when the spectrum of this star (Sirius) was caused to fall upon a sensitive collodion surface, an intense spectrum of the more refrangible part was obtained. [...] Our other investigations have hitherto prevented us from continuing these experiments further; but we have not abandoned our intention of pursuing them.
> I have recently resumed these experiments by the aid of the 18-inch speculum belonging to the Royal Society's telescope in my possession.[405]

[403] William Huggins, "On the Photographic Spectra of Stars," *Proceedings of the Royal Society of London* 25 (1876 – 1877): 446.

[404] Jack Meadows, *Science and Controversy: A biography of Sir Norman Lockyer* (Cambridge M.A.: Massachusetts Institute of Technology, 1972), 175.

[405] Ibid., 445.

In referencing a thirteen-year-old paper, William was insisting that he was the pioneer of photography and, although no paper had arisen from this process, it was never the less on Tulse Hill's agenda. The paper stated, "I have recently resumed these experiments."[406]

As indicated by William's meticulous drawings of the lines of the spectrum in the Notebooks, any photograph of the signatures would have had to produce perfect images in order to be useful and this paper produced such an image. Barbara Becker has argued that photography was a common practice and that this accounted for William's explanation. Yet, further investigation indicates that a very good result was still rare and warranted an announcement as indicated by Waterhouse's work in the last section. If not, then no explanation would be adequate for a practicing astronomer's thirteen year abstention. As well, referencing a former work to cite a fact in his papers for publication in *Proceedings* was a well-used practice by William.[407] At the end of the paper, William alerted the astronomical community that the photographic process, from this time on, would be part of his research. He stated, "I need not now refer to the many important questions in connexion with which photographic observations of stars may be of value."[408] An enlarged copy of the photograph of the spectrum of Vega was enclosed in the note.[409]

After Huggins' arrival, William became so invested in photography that he joined the Royal Astronomical Society's (RAS) Photographic Committee.[410] His name appeared alongside noted astro-photographers such as Warren De La Rue and Edward Walter

---

[406] Ibid., 445.

[407] See William Huggins, "On the Spectra of Some of the Nebulae" (1864), "On the Spectrum of the Great Nebula in the Sword-Handle of Orion (1865), "On the Brorsen's Comet" (1867 – 1868), "Note on the Heat of the Stars" (1868 – 1869), and "Comet 1 (1871)" to cite only a few cases.

[408] William Huggins, "Photographic Spectra of Stars," 446.

[409] Ibid., 446.

[410] Tucker, *Nature Exposed*, 203.

Maunder.[411] Aside from taking cosmic photos the committee had the important task to "undertake the charge of any astronomical photographs of value."[412] The committee discussed other important topics such as copyright, the gift of photographs to the Royal Society, and where to store these visual documents of the sky. This practice contributed greatly to William' reputation in scholarship as Jennifer Tucker indicates by reminding scholars that "William Huggins, in particular, received commendation for his star photographs."[413]

Stars and Chemicals

After the publication of "Spectra of Stars" a more substantial paper on the same technique titled "On the Photographic Spectra of Stars" (1879 – 1880) came three years later. [414] Again, the paper stated that Tulse Hill was committed to the use of photography in capturing spectrum bands. Aside from a physical description of select stars, the paper set out to find a base chemical that was present in all the celestial bodies studied. Because hydrogen is the most common chemical in the celestial sphere, it was this element, not surprisingly, that was noted as the common chemical connecting the objects:

> The typical spectrum of this region of this class consists of twelve strong lines winged at the edges. The continuous spectrum extends in the photographs beyond S, but no lines are seen more refrangible than the twelfth line at 3699. Two of these lines agree in position with the hydrogen line (y) 4340, and the other line at *h*. The third line agrees with H.[415]

The Hugginses' approach was to collect a large assortment of specimens and to obtain a physical description of each sample. A key claim was that the hydrogen line had different

[411] Ibid., 203.
[412] RAS minutes, Photographic Committee, in Tucker, *Nature Exposed*, 203.
[413] Ibid., 202. Tucker does not mention Huggins' contribution to astrophotography.
[414] William Huggins, "On the Photographic Spectra of Stars," *Proceedings of the Royal Society of London* 30 (1879 – 1880): 20 – 22.
[415] Ibid., 21.

physical appearances within the various spectrum bands of stars. This claim of variance set a path of legitimization for Tulse Hill and subsequent papers continued to re-establish this premise as William and Huggins grouped bodies according to the specific characteristics.

A second key argument in "On the Photographic Spectra of Stars" hinged on the initial claim. The theory suggested that if the width of the hydrogen line in each star spectrum could be determined, each body's stage of development could be known:

> In the spectrum of Arcturus, which belongs to the solar type, this line exceeds in breadth and intensity its condition in the solar spectrum. The white stars may, therefore, be arranged in a series in which the line H2 passes through different stages of thickness, at the same time that the typical lines become narrower and more defined, and other finer lines present themselves in increasing numbers.[416]

The possibility of knowing the stage of a star's maturity by looking at the "thickness" of the hydrogen line was a primary part of William's research at Tulse Hill. It was an ambitious project, and by decoding the hydrogen line, the Hugginses inevitably added to discussions centring on evolutionary theory and cosmology.

In this collaborative research paper, the Hugginses addressed empirical evidence, and at the same time, they adopted a new laboratory tool, the photograph, into analysis. At least three battle fronts were drawn and the success of each was tightly interwoven with the credibility of the other. A true capture of spectrum images that could be used to prove the hydrogen line thesis would give weight to astrophotography. Photographic images clearly showing various widths could be used to substantiate the hydrogen hypothesis. The Hugginses' accurate application of their findings to the development of an evolutionary cosmos would maintain, if not raise, the Observatory/laboratory's status within the international network of astronomers.

[416] Ibid., 21.

The Hugginses' involvement in broad debates was a strategy to maintain connections with other prominent observatories, which the emergence provided the model for big science,[417] and whose' verification Tulse Hill would later greatly rely on. The Hugginses found themselves building theories that supported an evolutionary cosmos rather than the concept of a "steady state" universe. In so doing, Tulse Hill was engaged in the Harvard-led international star catalogue scheme known as the Draper classification system. The Hugginses' ability to obtain a photographic spectrum of Vega with seven distinct lines secured their contribution to the Draper initiative.[418]

Another long standing claim by William, reliant on the hydrogen line findings, was based on establishing the possible "breadth" of this chemical line to determine if all nebulae had hydrogen breadths that were similar to stars. If so, this finding would end the two nebular hypothesis and conclude that all nebulae were composed of stars and none were solely gaseous. It was William's initial work that argued that some nebulae, "which [give] a gaseous spectrum are systems possessing a structure, and a purpose in relation to the universe, altogether distinct and of another order from the great group of cosmical [sic] bodies to which our sun and the fixed stars belong."[419] Many decades later, future astrophysicists were able to refute the single nebula theory and substantiate the Hugginses' gaseous nebula claim.[420]

Two Types of Nebulae, Writing, and a Shaky Tool

---

[417] Richard Staley, "Michelson and the Observatory: Physics and the Astronomical Community in Late Nineteenth-Century America," in *The Heavens on Earth: Observatories and Astronomy in Nineteenth Century Science and Culture*, eds., David Aubin, Charlotte Bigg, and H. Otto Sibum (Durham: Duke University Press, 2010), 226.

[418] Hector Macpherson, *A Century's Progress in Astronomy* (Edinburgh: William Blackwood and Sons, 1906), 172.

[419]William Huggins in Belkova, *Minding the Heavens*, 185 – 186.

[420] North, *Astronomy and Cosmology*, 450.

Well into the 1880s, Huggins and William added their voice to the dual nebula hypothesis; yet, in the early years, this argument did not rely, solely, on photographs, instead images were often reinforced by hand drawings. A heated discussion ensured, via readings at the Royal Society, to consider the question of whether a solely gaseous nebula could also disperse chemical signatures similar to those of fixed stars and our sun. This idea was originally proposed by William Herschel, and he had referred to the solely gaseous nebula as consisting of a "shining fluid." [421]

The couple presented their two-type nebula theory with a paper titled, "On Bright Lines in the Spectra of Nebulae." [422] This short publication claimed that the variance or "thickness" of chemical lines directly correlated to the absence of stars in the make-up of the nebula:

> Such an appearance would not be presented by a globular space uniformly filled with stars or luminous matter, which structure would necessarily give rise to an apparent increase of brightness towards the centre, in proposition to the thickness traversed by the visual ray. We might therefore be inclined to conclude its real constitution to be either that of a hollow spherical shell, or of a flat disk presented to us [...] This absence of condensation admits of explanation without recourse to the supposition of a shell or flat disk, if we consider them to be masses of glowing gas. [423]

The Hugginses determined that the spectra of this nebula was similar to a spectra of chemical vapours produced solely by hot gases in the laboratory. Star spectrums consist of dark lines on bright background; however, in this case the Hugginses saw one narrow green line. As the two-nebula hypothesis heated up, the debate not only tested Huggins' analytical skills in spectrum analysis and photography but also immersed this maturing

[421] Huggins in Leila Belkora, *Minding the Heavens: The story of Our Discovery of the Milky Way* (Bristol: Institute of Physics Publishing, 2003), 184.

[422] William Huggins, "On Bright Lines in the Spectra of Nebulae," *Proceedings of the Royal Society of London* 26 (1877): 179 – 81.

[423] Ibid., 180.

researcher in chemistry.[424] Towards the end of the nineteenth century the Hugginses' solely gaseous nebula theory was still heatedly debated, and the Hugginses had erroneously placed the Orion in this category. Huggins, like Mary Somerville, saw her share of defeats in spectrum analysis and like Somerville her miscalculation was largely due to the still primitive nature of the equipment she employed.

Miscalculations and friction between Huggins and William were evident upon close reading of the Notebooks. Several Notebook entries indicated that there were incidents when Huggins was "certain" of a phenomenon, and her patience was put to the test when William continually found her findings inconclusive.[425] A serious episode occurred in 1889 when Huggins insisted that some major pieces of their equipment may be flawed. Huggins stubbornly refused to check the apparatus. Eventually, Huggins convinced William to realign the equipment at the site, and a near catastrophe that would have involved the Observatory reporting false findings and thus subverting their authority in astrophotography was avoided.[426]

The Hydrogen Line

In 1879, after two and a half years of research, the Hugginses submitted a short paper on the hydrogen line and the appearance of the line in a photograph. "On the Spectrum of the Flame of Hydrogen,"[427] which set out to establish the degree of the line's prominence in star signature bands, was received by the Royal Society on June 16. Hydrogen proved to be a keystone of research not only because of its presence in a large

[424] The Hugginses had a total of 24 terrestrial chemicals to work with in the laboratory. Ronan, *Their Majesties' Astronomers*, 174.

[425] Notebook Three, March 11th, 1889. The Huggins Collection in the Special Collections, Wellesley College. In this entry, Huggins was "certain" of an alignment problem between the telescopic spectrum and the comparison apparatus. William had stated that the comparison was "satisfactory."

[426] See Becker, *Unravelling Starlight*, 229 – 232.

[427] William Huggins, "On the Spectrum of the Flame of Hydrogen," *Proceedings of the Royal Society of London* 30 (1879 – 1880): 576 – 80.

number of celestial bodies but because hydrogen was easy to produce in the laboratory and easily photographed. An image of the "flame of hydrogen burning in air"[428] was captured without incident on many occasions ensuring the reliability of the sample.

In the late 1870s other astrophysicists and chemists such as G. D. Liveing, J. Dewer, George Stokes (whom the Hugginses met with regularly), and Norman Lockyer also acknowledged that hydrogen provided a solid base signature and could be used to further determine the presence of other chemicals in stars. "Flame of Hydrogen" stated that the results published were still unfinished and that "I [William] think that it is desirable that I should give an account of some experiments which I made on this subject some months since without waiting until the investigation is more complete."[429] The rush to publish some results and to draw some sort of synthesis from the findings in order to remain visible in this debate was evident. The Hugginses', similar to Somerville, maintained their status in a particular specialization with publications.

Another incident during 1879 – 1880 demonstrated the Hugginses' eagerness to be an active voice within the hydrogen debate. William stated that he had heard about a chemical experiment conducted by Liveing and Dewar which focused on key elements such as hydrogen and oxygen:

> Messrs. Liveing and Dewar state, in a paper read before the Royal Society on June 10 (ante p. 494), that they have obtained a photograph of the ultra-violet part of the spectrum of coal gas burning in oxygen, [...] Under these circumstances I think that it is desirable that I should give an account of some experiments which I made on this subject some months since without waiting until the investigation is more complete.[430]

[428] Ibid., 576.
[429] Ibid., 576.
[430] Ibid., 576

Tulse Hill was eager to add to research in chemistry as well. Hydrogen, similar to magnetism in Somerville's London days, had its own tight network of scientists. William and Stokes used photographic plates to capture its signature while Liveing and Dewar still submitted artist drawings of the spectrum.[431] The astronomers using either a photograph or a sketch were able to achieve collaborative results, which aside from noting various characteristics of hydrogen also found the presence of water in the coal spectrum. These small incidences of verification give insight into Tulse Hill's efforts to maintain connections with others in their field and to reinforce the credibility of photography with their contemporaries.

Huggins' ability to perform in a dynamic environment established her reputation in the eyes of her husband at Tulse Hill. It was without doubt that William was sincere about his comment that "I had the great happiness of having secured an able and enthusiastic assistant, by my marriage in 1875."[432] The determination to publish aggressively in *Proceedings* was a common characteristic for both astronomers. Although "Flame of Hydrogen" was instrumental because it showed how the Hugginses were able to capture the spectrum images in numerous photographs for publication, it is important to note that a band signature of the chemical was drawn by hand for clarity and submitted as part of the paper.[433] This act of verification indicates just how suspect photography was in spectrum analysis in 1879. Indefinite or mistaken results could easily trigger a collapse of a methodology in the making.

The Great Nebula in Orion and Writing Uncertainty

[431] G. D. Liveing and J. Dewar, "On the Spectrum of Water," *Proceedings of the Royal Society of London* 30 (1879 – 1880): 580.
[432] William Huggins in Ronan, *Their Majesties' Astronomer*, 177.
[433] Ibid., 577.

On March 7, 1882, the couple was able to capture a photograph of the spectrum of the Great Nebula in Orion, and the image with their findings was sent to the Royal Society two days later.[434] The couple theorized that hydrogen variations could be practically applied to distinguish between stars, star-filled nebulae, and gaseous nebulae. This 1882 event provided the opportunity to see if the theory could be demonstrated. Two outcomes were possible: First, clear spectrum photographs of the Orion. Second, evidence of a gaseous nebula. The Hugginses were able to achieve the former though they could not give confirmation of the latter.

A close textual analysis of "Photographic Spectrum" provides a portrait of all the processes that Huggins integrated in her work. My aim is to demonstrate that Huggins was, by 1881, routinely using an assortment of astronomical and chemical tools, engaged in not only gathering data but putting forth hypotheses, advancing the acceptance of photography in the "New Astronomy," and finally establishing an authorial voice in the process. At the same time, the Hugginses' aggressive publication agenda demonstrated the couple's determination to maintain their authoritative voice in this area of astronomy. "Photographic Spectrum" indicated that a photograph of "the spectrum of the great nebula in Orion, extending from a little below F to beyond M in the ultra-violet"[435] was taken with a spectroscope with "special arrangements" secured to an "18 inch Cassegrain telescope with metallic speculum."[436] A slit opening, exposed for a forty-five minute time window that concluded with the "coming up of clouds,"[437] was noted.

---

[434] William Huggins, "Note on the Photographic Spectrum of the Great Nebula in Orion," *Proceedings of the Royal Society of London* 33 (1881 – 1882): 425 – 28.
[435] Ibid., 425.
[436] Ibid.
[437] Ibid., 427.

The photograph showed a spectrum band, and the brightness of the lines pointed to a concentrated presence of nitrogen and hydrogen. Even with this successful image the couple cautiously noted that "in the photograph these lines which had been observed in the visible spectrum are faint, but can be satisfactorily recognised and measured."[438] Upon investigating the spectrum image a noticeable blurriness was evident around the lines.[439] The paper indicated that there were still numerous unknown lines on the spectrum and many variables could account for the different degree of brightness, which could be seen by the naked eye and on the photographic plates:

> In these stars this line [white star spectrum] is less strong than the hydrogen line near G; but in the nebula it is much more intense than Hy. In the nebula the hydrogen line F and Hy are thin and defined, while in the white stars they are broad and winded at the edges. [...] I cannot say positively that the lines of hydrogen between Hy and the line at 3730 are absent. If they exist in the spectrum of the nebula, they must be relatively very feeble. I suspect, indeed, some very faint lines at this part of the spectrum, and possibly beyond A 3730, but I am not certain of their presence.[440]

The tension between the need to substantiate the photographic process and the need to articulate findings accurately was clear. The use of words such as "suspect" and "cannot say positively" indicated the hesitation the Hugginses felt. The "feeble" nature of certain lines raised questions as to whether the image was faint or whether the element in question truly existed in the nebula.

The Hugginses were unable to use the varying breadth of the hydrogen line to support their solely gaseous nebula theory with the Orion. In the conclusion, a guarded William stated:

---

[438] Ibid.,
[439] Ibid., 426.
[440] Ibid., 427.

> I hope by longer exposures and with more sensitive plates, to obtain information on this and other points. It is, perhaps, not too much to hope that the further knowledge of the spectrum of the nebulae afforded us by photography, may lead by the help of terrestrial experiments to more definite information as to the state of things existing in those bodies. [441]

By this time, Tulse Hill was undoubtedly a "physical observatory"[442] merging observations with Bunsen burners, testing tubes, and practitioners knowledgeable in chemical analysis. The incorporation of chemicals was not solely applicable to the stars, as the Hugginses also experimented with adding varying amounts of gelatin and silver nitrate to the dry photographic plates. It was their willingness to continually try out various compounds that led to increasingly clearer images of star bands.

The Comet

A textual analysis of the Hugginses' Notebooks shows that the Comet b 1881 caused much excitement at Tulse Hill. The Hugginses were able to capture a telling photograph of the spectrum of the comet tail. This important event and picture allowed the couple to advance their argument that the tail of a comet was, in fact, self-illuminating. In turn, the couple embarked on finding the chemicals present within these luminous tails. Finding astronomers to agree on the former was much easier than finding consensus on the latter and much hinged on the couple's ability to substantiate chemical presence. William Huggins' paper, "On the Photographic Spectrum of Comet b 1881," stated that a photograph had been taken of the comet and that its composition was of carbon and hydrogen.[443] The couple argued that "[p]art of the light from comets is

[441] Ibid., 427 - 28.

[442] Aubin, Bigg, and Sibum, "Observatory Techniques," 11. Physical Observatory is used to define an observatory which incorporated experimental practices.

[443] William Huggins, "On the Photographic Spectrum of Comet b 1881," *Proceedings of the Royal Society of London* 33 (1881 – 1882): 1 - 3.

reflected solar light, and another part is light of their own."[444] In a later postscript dated July 9, 1881, Tulse Hill again adamantly argued that any light emanating from the comet was so bright that it was impossible for light to have been reflected from the sun.

On May 31, 1882, the Hugginses were able to again capture a photograph of the comet. The conclusion drawn was that the brightness of light from this celestial body was more intense than could be possible if the light were reflected from our star.[445] It is surprising that the Hugginses could offer no theoretical account for the greater brightness of the comet on this second sighting. It was Lockyer who quickly pointed out that the comet would appear bright as it travelled closer to the sun, and on this celestial body Lockyer was a much shrewder theorist.[446] Despite the lack of a theoretical explanation regarding the variation in the illumination over several days, the Hugginses proposed to have found a new element in the nucleus of the comet:

> Eye observations by several observers on the visible spectrum of the comet had already shown that this comet for the first time since spectrum analysis was applied to the light of these bodies in 1864, gives a spectrum which differs essentially from the hydrocarbon type to which all the comets previously examined spectroscopically [sic] (about twenty) belong.[447]

The couple excitedly published their findings citing the presence of a non-terrestrial chemical within this heavenly body.

The paper used the deviation in chemical consistency to promote a system of nomenclature. By repeating the fact that, "the photographic spectrum differs greatly from that of the comet of last year,"[448] the Hugginses concluded that the heavens encompassed

---

[444] Ibid., 2.
[445] William Huggins, "On the Photographic Spectrum of Comet (Wells) I, 1882" *Proceedings of the Royal Society of London* 34 (1882 – 1883): 148 – 50.
[446] Meadows, *Science and Controversy*, 180.
[447] William Huggins, "Photographic Spectrum," 148.
[448] Ibid., 148.

many more different "families" or "swarms" of bodies than previously believed. These families included a large variety of celestial objects such as meteorites that "come down to us [and] differ greatly in their chemical constitution."[449] The Hugginses had always maintained that meteorites were bodies that were different from comets although possibly from the same family. Lockyer proposed a counter theory, which stated that the comet head was a swarm of meteors and that some lingering meteorites were in fact residuals of these luminaries that had broken off from the source.[450] This debate haunted both Lockyer and the Hugginses well into the 1890s with Lockyer's theory eventually to be proven inaccurate.

Solar Astronomy

Before Huggins' arrival William had only occasionally directed the Tulse Hill spectroscope to the sun and each time the attempts to establish credible findings had been unsuccessful. Nine entries in William's Notebook in 1866 demonstrated that he was playfully making solar observations, yet he eventually abandoned the solar project.[451] The work that the Hugginses did in solar astronomy between June 1882 and April 1886 was not recorded in the Notebooks. There is a four-year period for which no entries can be found, pertaining to any work, in any of the Notebooks donated to Wellesley College. The possibility that another Notebook was started during this period, meant solely for solar observations, is a scenario that is highly conceivable. For the Hugginses to not have records of their activities at Tulse Hill during this time, after years of meticulous record

[449] Ibid., 148.
[450] Meadow, *Science and Controversy*, 180.
[451] William Huggins, Notebook Two, The Huggins Collection in the Special Collections, Wellesley College.

keeping, raises the probability of lost material.[452] There were also no entries in any Notebook pertaining to the important research on photographing the solar corona, which William Huggins would eventually focus on for the esteemed Bakerian Lectures Series.[453] The records resumed in April 1886 in William's hand writing, and Huggins began entries in November of the same year.[454] The notes continued in Notebook Two, which hold the bulk of the work on photography done at the Observatory.

Aside from the lecture in the Bakerian Lecture, the Hugginses' work on the solar corona produced several papers that dealt with both the findings and a solid photographic approach to capturing the solar image. Agnes Clerke, as previously noted, had immortalized William's name in *History* for his methodology both in spectrum analysis and astrophotography rather than his findings.[455] 1885 was a celebrated year for Huggins' husband, as it was then that William received his second gold medal from the R.A.S. The last time William received a medal was in 1867 with William Allen Miller.

Using a well-thought-out photographic technique, the Hugginses illustrated that the sun's disk can be studied all year. Their work focused on observing solar prominences or "red flames" at the base of the solar corona, which previous to the newly introduced photographic method could only be done during the period of totality. Not only were eclipses few in number, but this period lasted for around two minutes during each eclipse. Huggins' and William's goal in determining the composition of the sun and the hotness of this star was to establish its age. Yet, the brightness of the light emanating

---

[452] I corresponded with Barbara Becker on this matter. Becker was unable to locate any written record of the work at Tulse Hill within this four year period.

[453] William Huggins, "The Bakerian Lecture: On the Corona of the Sun" *Proceedings of the Royal Society of London* 39 (1885): 108 – 135.

[454] William Huggins and Margaret Huggins, Notebook Two, The Huggins Collection in the Special Collections, Wellesley College.

[455] Clerke, *History of Astronomy*, 387.

from behind the moon during an eclipse often made variations indistinguishable. "The spectroscopic method by which the prominences may be seen with an eclipse, fails for the corona, because a small part only of the coronal light is resolved by the prism into bright lines, and [of] these lines no one is sufficiently bright and coextensive with the corona to enable us to see the corona by its light."[456] As this sentence indicates, the application of the spectroscope to the solar prominence did not always yield readable results.

The Hugginses proposed the use of a photographic plate in order to make the variances more distinct. This embryonic approach was theoretically concrete but the execution was thorny. With such an intensely bright object the couple often worried about "false effects." The paragraph below from Huggins' Bakerian Lecture paper describes their painstaking method:

> It was of importance at the same time to magnify the small advantage the coronal light might have by some method of observation which could bring out strongly minute differences of illumination. Such a power is possess[ed] by a photographic surface. I took some pains to satisfy myself that under suitable conditions of exposure and development a photographic place can be made to record (strongly) minute differences of illumination existing in different parts of a bright object [457]

The photographs needed not only to be taken on clear days but on certain days in which the sun appeared "whity" [sic], and it was with the pairing of both these natural conditions that an acceptable image could be produced and categorized. The ability to outline a procedure step by step was a technique the Hugginses mastered well. To verify this method, the Hugginses compared their photographs with those images of the sun during the period of totality taken by fellow astronomers either in photographic or hand-drawn form. During a period of two months the Hugginses were able to capture twenty

[456] William Huggins, "Bakerian Lecture," 110.
[457] Ibid., 112.

images successfully. The outcome of this work in the early 1880s was exciting; the Hugginses were able to establish that the corona was a "true solar appendage" rather than an "optical appearance due to diffraction."[458]

Once the material presence was established the Hugginses argued that the corona was a gaseous fog consisting of some non-terrestrial elements with no outer boundary. They believed that the atmosphere or the corona attracted some meteoroid and material from the tails of comets.[459] To link their conclusions to the evolutionary debate in astronomy, the paper stated that during the earlier age of the sun the corona was more visible but the corona lost its brilliance as the heat of the sun died down.[460] In addition, this astronomical team discovered a "rift on the east of the north pole of the sun."[461] This sighting was also noted by astronomers present during the May 1883 eclipse expedition on Caroline Island. So new was the photographic process that the Hugginses again relied on others to verify the application of this tool. These small acts of verification added to the validity of photography in astrophysics and credibility to the couple's collaborative voice within the larger community of astronomers.

The Bakerian Lecture gained the Hugginses recognition in America and extended their authorial presence. William's work in collaboration with Huggins received positive notice from Edward Pickering, and *Science Magazine* ran a series of solar photographs taken by Tulse Hill in three issues between the years 1885 and 1886.[462] The notices in *Science* were written by William Pickering, Edward Pickering's younger brother, and

---

[458] Ibid.,
[459] Ibid., 122.
[460] Ibid., 135.
[461] William Huggins, Bakerian Lecture, 115.
[462] William Huggins, "An Attempt to Photograph the Solar Corona" *Science* 15, no 119 (1885): 397 – 398. William Huggins and William Pickering, "An Attempt to Photograph the Solar Corona" *Science* 6, no 142 (1885): 362 – 63. William Huggins, "An Attempt to Photograph the Solar Corona" *Science* 6, no 19 (1886): 303 - 04.

they questioned the Hugginses' photographic methodology. Even in the mid-1880s the application of photography to spectrum analysis was still in its infancy.

In this section we have seen that at Huggins' entry point into research Tulse Hill was focused on the two-type nebula debate, the self-illuminating comet tail issue, and the argument for the physical existence of the solar corona. A textual analysis of the Notebooks shows that as William's and Huggins' partnership developed Huggins often exerted her own authorial stance. This practice proved essential as Tulse Hill avoided reporting false results because of Huggins' insistence on continually verifying outcomes. Huggins had developed such informality with the Notebooks that these documents, at times, became her personal space. The Observatory aggressively used photography in innovative ways, and the clarity of the images that the Hugginses were able to obtain added their authorial presence to the birth of this tool in astrophysics. From this terrain, Huggins went on to cultivate her own voice in publication.

CHAPTER SEVEN

MARGARET HUGGINS AND

ENGAGEMENT

*****

A Collaborative Voice

"I have added the name of Mrs. Huggins to the title of the paper because she has not only assisted generally in the work, but has repeated independently the dedicate observation made by [her] eye."[463] These words, written in 1889, introduced Margaret Huggins to the Royal Society as an astronomer in her own name and established her presence in *Proceedings*. It can be argued that if Huggins' entry point into research was softly tread with a small notation in the Hugginses' Notebooks citing a photograph of Sirius, this entry point into publication was not so docile. Indeed, the paper, "On the Spectrum, Visible and Photographic, of the Great Nebula in Orion," was an aggressive work of twenty pages in length. "Visible and Photographic" launched two new hypotheses, addressed the miscalculations of a vocal and prominent fellow astrophysicist, and advanced the evolutionary theory of the cosmos. More importantly, for Huggins, the paper addressed her contribution to the science by stating that on more than one occasion Huggins' independent work collaborated William's findings. In these ways it was a paper truly worthy of marking Huggins' beginning in the scientific world; the paper illuminated her work in spectrum analysis by outlining the vital and "dedicate observations made by [her] eye."[464] However, the paper emphasized that Huggins was present as a collaborating witness and that her presence was solely to verify a sighting. This position

---

[463] William Huggins and Mrs. Huggins, "On the Spectrum, Visible and Photographic, of the Great Nebula in Orion," *Proceedings of the Royal Society of London* 46 (1889): 40.
[464] Ibid.

was similar to the role Mary Somerville played in the Arago and Herschel papers on solar rays and vegetable juice and like Somerville, it was an influential space. A full textual analysis of the Hugginses published work indicates that Huggins never published any paper on her own and that her writing always engaged the work of William.

In the same year the Hugginses co-authored an additional paper on Uranus and Saturn outlining the spectrum that was visible and chemical signatures that were definable.[465] William published a short paper on his own on ultra violet light, which had been a long term project at Tulse Hill.[466] In 1890, a follow-up paper on the Great Nebula in Orion appeared from the Hugginses. In total, an impressive fifteen papers were co-authored by William and Huggins over the next thirteen years, speaking to the "very hard work" the couple engaged in at Tulse Hill. Adding to the intricacy of the Hugginses study of celestial light was the fact that the couple was constantly at odds with prominent astronomer Norman Lockyer. The Hugginses became engulfed in debating Lockyer's research and by the turn of the century his findings came to occupy several pages of the Notebooks.

In Chapter Seven I will perform a textual analysis of the Hugginses co-authored papers on the Orion Nebula in order to demonstrate that Huggins' authorship was based on acts of engagement and that this became Huggins' role in the Hugginses papers. I will argue that adding Huggins' name to published papers was a risky manoeuvre as demonstrated by the Hugginses' carefully chosen words. I will conduct a close reading of other selected scientific papers in order to assess Huggins' evolving presence in

465 William Huggins and Mrs. Huggins, "Note on the Photographic Spectra of Uranus and Saturn," *Proceedings of the Royal Society of London* 46 (1889): 231 – 33.

466 William Huggins, "On the Limit of Solar and Stellar Light in the Ultra-Violet Part of the Spectrum," *Proceedings of the Royal Society of London* 46 (1889): 131 – 35.

Proceedings. This close reading will demonstrate that Huggins' start in astrophysics and astrophotography was the high point of her career. Later, Tulse Hill was referred to as an "outpost" of astronomical research. The word "outpost" suggests that the Observatory in the later years was somehow removed or at a distance from the inner astrophysical community. The Hugginses came to rely greatly on institutional sites to verify their findings and at times the presence of others overshadowed the couple's own visibility.

Mrs. Huggins' Name ...

The passage in "Visible and Photographic" which explained the addition of Huggins' name was guarded in tone. The sentence pointed out that Huggins had performed independent research on a set of experiments and that this was the reason for her inclusion. This explanation is reminiscent of Herschel's and Arago's addition of Somerville's name to scientific journals, which also referenced a set of experiments she had conducted. Both women were clearly defined as collaborating participants whose work supported existing hypotheses.

As well, the addition of the name was a strategic move. The Notebook entries indicated that Huggins did independent research at Tulse Hill throughout the years, and her work was routinely used to substantiate William's outcomes and the accuracy of his procedures. Yet, it was on this occasion that the Hugginses first decided to add Huggins' name and it was used to specifically point out that two independent and equally qualified astronomers did achieve the same results. With this insertion Huggins was presented as being the same calibre as other astronomers such as Lockyer, Dewer, and Maunder, all of whom the Hugginses named in "Visible and Photographic" as part of the ongoing research network on the nebula. This tactic was also employed by Whewell, Arago, and Herschel in their inclusion of Mary Somerville into the circle of astronomers.[467]

"Visible and Photographic," firstly, addressed the composition of the Orion and, secondly, it stated that not all celestial elements had a terrestrial twin. It was a forceful work that discussed the papers of fellow practitioners and articulated both the inconsistencies and corroborating data about this great star system. In turn, the paper used the findings from this project to give an overall synthesis regarding other nebulae, which the Hugginses had worked on in the past. This act was a common strategy of the Hugginses. Barbara Becker argues that William could have introduced Huggins on a "gentler slope" rather than to begin by putting her name on a controversial paper. However, Huggins was no passive practitioner and, as indicated by her Notebook entries, she could more than handle whatever storm the paper was to generate. In 1889 Huggins was forty-one, an experienced astro-photographer, and in a robust period of her life. Her friends had characterized her as "Bohemian" and "outgoing." Huggins would not care to wait for a "docile" paper to mark her entry point as an active astronomer. More tellingly, as the paper stated, Huggins made "independent" observations and assisted "generally in work." William deliberately positioned Huggins in a secondary position by using the word "generally".

"Visible and Photographic" can be divided into three co-dependent arguments. First, it introduced the existence of a new line on the spectrum of Orion that was of an unknown element. Second, the paper argued that the unknown element was solely celestial in nature and therefore could not be found anywhere in terrestrial space. The disagreement that this hypothesis ignited surrounded not so much the presence of

[467] See chapter two.

exclusively celestial elements in the cosmos, but rather the question of whether such an element was apparent on the Orion spectrum. The Hugginses were questioned about their photographic accuracy in this case. This was a serious consideration as the failure to prove their practice to be flawless could spark doubt regarding any other findings that William and Huggins published. Third, the paper also caused questions for William as he had first considered it to be a star system, and later the Hugginses considered it to be solely gaseous in nature.

The paper began by stating that a new line on the spectrum of the Great Nebula in Orion, which was very near the magnesium band, had been detected:

> On the 5th February, 1888, a photograph of the spectrum of this nebula was obtained with a narrow slit; the same apparatus, so far as the essential parts, which were described in my paper on the 'Photographic Spectra of the Stars' being employed.
> In this photograph, in addition to the strong line about A 3730 [new and unknown line], a pair of less conspicuous lines is seen on the less refrangible side of the strong line.[468]

Using a photographic image to prove the presence of a line so near the magnesium line demonstrates the mark that photography was making at the Hill, as well as the confidence the Hugginses had in this tool. In the paper the astronomers went on to reinforce the prestigious place of this art in science:

> These considerations induced me not to attempt eye-observations, but from the first to use photography, which possess extreme sensitiveness in the discrimination of minute differences of illumination, and also the enormous advantage of furnishing a permanent record from an instantaneous exposure of the most complex forms. I have satisfied my self by some laboratory experiments that under suitable conditions of exposure and development a photographic plate can be made to record minute differences of illumination existing in different parts of bright object, such as a sheet of drawing paper, which are so subtle as to be at the

[468] William Huggins and Mrs. Huggins, "Visible and Photographic," 410. The paper used the "I" and the "me" in this section to indicate that Huggins had made the observations. However, this dissertation will demonstrate that the paper used "Mrs Huggins" on numerous occasions to verify the data that William had collected.

> very limit of the power of recognition of a trained eye, and even, as it appeared to me, those which surpass that limit.[469]

In order to substantiate the numerous hypotheses in the paper, the Hugginses, first, contextualized the experiments within a foolproof methodology by claiming that photography was not only more "sensitive" to "minute differences of illumination" but also established a "permanent" record of "complex forms." The couple had always argued that the photograph could be used in cases in which the eye was too sensitive to the brightness of celestial objects. This claim was now being advanced with the argument that the use of photograph could detect "minute differences of illumination" more accurately than the eye. Popularizer Agnes Clerke also deemed "the photographic lens [more reliable] over the 'fallible human retina.'"[470]

By looking at Huggins' and William's Notebook entries, it is evident that each researcher had a solid strategy for establishing proof of the new line near the magnesium band. Rather than keeping all the notes together, Huggins made comments in Notebook One and Two in the winter of 1888 on the Orion experiments and Huggins made observations in Notebook Three. This division further indicates that each astronomer was conducting independent research and documenting their findings separately. For the Observatory/laboratory, winter and early spring were the only seasons in which the Great Nebula was in full view, and the couple was eager to make use of this short time span.

The strategy that both William and Huggins employed was to burn magnesium independently in the laboratory and to compare the outcome produced by the flame to the Orion absorption spectrum. After establishing the signature characteristics of the flame,

---

[469] Ibid., 411.

[470] Bernard Lightman, "The Visual Theology of Victorian Popularizers of Science: From Reverent Eye to Chemical Retina," *Isis* 97 (2000): 671.

the Hugginses tested their methodology and equipment by directing the spectroscope to the sun to capture the solar spectrum. The magnesium flame had been ignited and studied on many occasions, yet this cautionary measure dictates the stringent experimental practices common at the facility. Our closest star was used as the foundational object because magnesium was known to be part of its make-up. In Notebook Two Huggins stated:

> First, we directed the telescope & spectroscope to the sky [...] then Mg was flashed in as required. We did not leave the apparatus until we both felt satisfied that the coincidence between the dark b [lines] of daylight & the bright b [lines] of the burning Mg was perfect.[471]

As the passage stressed, both astrophysicists were "satisfied" by the "perfect" correlation between the line in the solar band, and the line in the coal band, before the apparatus was deemed "now ready for use."[472] In the winter of 1888, having again established the signature, the Hugginses proceeded to direct the spectroscope at the Nebula in Orion.

In Notebook Three Huggins made a small but significant entry accompanied by a sketch of the nebula spectrum. The main nebula line on the band did, in fact, appear slightly off and to the left of the magnesium line.[473] What is telling is that Huggins' initial entry at this point was a hand-drawn sketch and not a photograph. Although the argument in the paper, "Visible and Photographic," was based on photographic evidence the Notebook entry clearly indicates the procedural steps as they unfolded. The Hugginses wisely relied on the well-worn technique of hand illustrations before embarking on photographic procedures.

---

[471] Margaret Huggins, October 12, 1888. Notebook Two. The Huggins Collection in the Special Collections, Wellesley College.

[472] Ibid., October 12, 1888.

[473] William Huggins, Notebook Three, The Huggins Collection in the Special Collections, Wellesley College.

Huggins was to verify William's sighting on March 11th with an entry in Notebook One. She had begun referring to William as "W" in the notes in order to distinguish his work from her own. From the start, the couple planned on a two-tier observation and verification process:

> "W" thought the bright line did fall coincident [in the same location on the band]. Then I observed. I found a difficulty in getting good observations. [...] but one thoroughly good observation showed me as distinctly as I saw it on Saturday night that the bright line was not truly coincident but on one side. I left off feeling certain on the point.[474]

The final conclusion remained that the brightest nebula line was not a part of the magnesium family:

> Although I [William] consider the results to be satisfactory, I prefer to say that I, and Mrs. Huggins independently, believed fully at the time that we saw the appearance which all former observations of this line led me to expect, namely, the nebular line to fall within the termination of the magnesium band, and to form with the band-boundary a double line.[475]

By the repetition of statements similar to the one stated above, one can sense the nervous tone in which this somewhat revolutionary claim was put to print. The paper continued by specifically pointing out the days when Huggins independently worked on observations, and these days corresponded to the entries Huggins made in Notebook One.[476] "Visible and Photographic" noted March 9, 11, and 16 of 1889 as days of observations for Huggins, following with the note that "all these nights the comparisons were repeated independently and fully confirmed by Mrs. Huggins."[477] A note in the paper stated, "No terrestrial line which does not fall almost exactly at these positions in

---

474 Margaret Huggins, Notebook One, March 11, 1889. Notebook One, The Huggins Collection in the Special Collections, Wellesley College.
475 William Huggins and Mrs Huggins, "Visible and Photographic," 49.
476 Margaret Huggins, Notebook One. Notebook One, The Huggins Collection in the Special Collections, Wellesley College.
477 William Huggins and Mrs. Huggins, "Visible and Photographic," 51.

the spectrum can have any claim to further consideration."[478] This inclusion indicates that the Hugginses further theorized that the line not only was that of a new element but that this element did not have a terrestrial twin.

Norman Lockyer and a Greater Need for Consensus

The conflict between Lockyer and William concerning the make-up of nebulae began years before the Great Orion appeared. The paper that situated Huggins as a published astronomer further polarized Lockyer's hypothesis of the solely meteor nebula and William's theory that certain nebulae were solely gaseous. And, to further alienate the two astronomers from each other, additional disagreements arose concerning the makeup of the solar corona, the Doppler Effect, and correct photographic techniques. A brief account of Lockyer's early work in astronomy will point out the intertwining celestial objects that both William and Lockyer investigated and how many became sites of conflict.

It was William who had introduced Lockyer to the idea of spectroscopy in 1864.[479] Lockyer immediately became interested in this new specialization and attached a spectroscope to his large 6 ¼ inch telescope.[480] By 1865 Lockyer had turned his refractor to the sun. At this time Lockyer and William became aware of each other's interest in determining the composition of our star. The debates surrounding the sun during the mid-1860s were varied and creative. The more common theories ranged from thinking of the sun as a gigantic organism, to the sun being composed of granular sunspots, to seeing the

---

[478] Ibid., 51.
[479] Meadows, *Science and Controversy,* 46.
[480] Ibid., 46.

sun as an organic object with changing willow leaf designs on the surface and no corona at the center, and even to thinking of the sun as an inhabitable orb.[481]

Lockyer wrote a short but important paper in 1865, which stated that the sun's core was of a higher temperature than the sunspots seen near or at the surface:

> The interior of the sun is a nebulous gaseous mass of feeble radiating-power, at temperature of dissociation; the photosphere is, on the other hand, of a high radiating–power, and at a temperature sufficiently low to permit of chemical action. In a sun-spot we see the interior nebulous mass through an opening in the photosphere, cause by an upward current, and the sun-spot is black, by reason of the feeble radiating-power of the nebulous mass.[482]

This theory accounted for the dark lines appearing on the spectrum of sunspots. These dark lines, Lockyer argued, were not visible on the spectrum taken of the background surface of the sun. William immediately disagreed with Lockyer's theory and set off the first of their many theoretical differences focusing on an array of heavenly bodies. William stated that the temperature between the sunspots and the background was consistent, and thus that both spectrums were similar and that the spectrum of the sunspots did not exhibit any dark lines. Yet, in the following year, after additional work on this star at Tulse Hill, it was William who was forced to recant his statement. We can remember that it was during this time that William became interested in solar studies in addition to directing his spectroscope at nebulae and comets.

The next Lockyer/William controversy surfaced in 1868 surrounding a methodological matter and a case of "who thought of it first." Both Lockyer and William were to claim that they were the first to initiate research on photographing the solar

---

[481] David Brewster, *More Worlds than One: The Creed of the Philosopher, and the Hope of the Christian* (London: John Camden Hotten, 1854), 97. Meadows, "Origin of Astrophysics," 6.

[482] Norman Lockyer, "Spectroscopic Observations of the Sun," *Proceedings of the Royal Society of London* 15 (1866 – 1867): 256 – 58.

prominence without an eclipse.[483] The claim was short-lived as it was soon determined that J.C.F. Zollner, a German astronomer and the scientist who coined the term "astrophysics," had been the first to suggest a viable methodological approach to this challenge and had published before either Lockyer or William could get to print. Yet, this disagreement exhausted both men's goodwill towards each other.

In the midst of this dispute, Lockyer and William had individually invented a cumbersome technique to photograph the entire prominence during one exposure time. The method was to move the slit of the spectroscope during the exposure time to cover the image.[484] The argument that ensued, again, centred on who came up with this idea first. In the end, the issue was solely for the purpose of debate. The moving slit technique was so difficult to employ that it was deemed impractical and both astronomers abandoned the process. However, the clash further enlarged the wedge of discontent between the two men.

The next and final row between Lockyer and William in the late 1860s focused, once more, on methodology. William, in a paper to the Royal Society in 1867 had stated that he was able to account for the shift in the velocity of some of the bright stars.[485] Lockyer, by this year, had turned his full attention to the sun and was attempting to measure the rate of movement of this celestial body. Lockyer claimed he did not know about William's work, and thus could not accredit William with devising a methodological approach to account for an object's velocity. What William had done was

---

[483] Meadows, *Science and Controversy*, 54.

[484] See William Huggins, "Note on a Method of Viewing the Solar Prominences without an Eclipse," *Proceedings of the Royal Society of London* 17 (1868 – 1869): 302 – 03.

[485] See William Huggins, "Further Observations on the Spectra of the Sun, and some of the Stars and Nebulae, with an Attempt to Determine There from Whether These Bodies are Moving towards or from the Earth," *Proceedings of the Royal Society of London* 16 (1867 – 1868): 382 – 86.

to account for the Doppler Effect in his analysis. [486] William, for some reason, thought that Lockyer had stolen his application of this theory and applied it to other objects in the sky. All these touchy issues made for a more than uneasy connection between Lockyer and William. Two decades later, when Huggins' name was added to the Hugginses papers, these disagreements had not been forgotten.

Meteorite Swarms or Gaseous Swirls

"Visible and Photographic," once more, took Lockyer's work head-on by arguing that some nebulae such as Orion were gaseous in nature and not meteor swarms. The paper directly challenged Lockyer's meteor hypothesis because Lockyer's swarm theory relied on the fact that all lines within the nebula spectrum belonged to elements both celestial and terrestrial in nature. According to Lockyer, these known elements "bang[ed]" together in extreme heat to create the meteorites and the meteors that hurled through space in swarms. Lockyer further argued that all lines must belong mainly to either the nitrogen or the magnesium family. Lockyer's meteorite theory, which was essential to his life's work, relied on the fact that all of the brighter lines fell within the magnesium band.

William was to cite Lockyer to show that Lockyer's claim was irrational: "In a paper communicated to the Royal Society on November 15th, 1887, I [Lockyer] showed that the nebulae are composed of sparse meteorites, the collision of which bring about a rise of temperature sufficient to render luminous on of their chief constituents – magnesium."[487] In "Visible and Photographic," the Hugginses argued that one line was a solely celestial element and thus could not be magnesium. "Although the number of

---

[486] The Doppler Effect accounts for the change in frequency of a wave as an object is moving relative to the observer. The Doppler Effect was name after Christian Doppler who proposed this theory in 1842.

[487] Lockyer in Huggins, Visible and Photographic," 48.

direct comparisons which I [William] had made of the brightest line in the nebulae with N1 [nitrogen] and with the lead line, not to speak of the accordant results of the micrometric measures of other observers, left great doubt in my mind whether this line could be coincident with 'the remnant of the magnesium fluting at 500'…"[488] William had determined that "coincidence" did not occur because the nebula line fell after the termination of the magnesium band. It was at this point that the paper added Huggins' voice as a collaborating researcher.[489] In addition, the Hugginses stated that the inability of many astrophysicists to sight the new line was because their fellow practitioners had not taken into account the speed at which the nebula travelled towards the earth. This point must have greatly angered Lockyer as Lockyer had considered the Doppler Effect in his analysis of comets as they move towards the sun.

Lockyer's work was seriously considered by the couple as William and Huggins analyzed what could trigger the downfall of their theory. In Notebook Six the astronomers devoted a large section to clippings of Lockyer's research and his findings well into the twentieth century. The last dated entry was written on January 22 1908, and revisited Lockyer's continual work on the Orion Nebula. This entry was made after the Grubb telescope left Tulse Hill and at a time when the Hugginses were no longer experimentally involved in astronomy. The entry reads as follows:

> Observation With Telescope
> January 22, 1908 Nebula in Orion — In Hall
> Seeing good
> And 12 mm telescope
> [photograph of a spectrum]
> Map I: Spectra of metal at temperature in oxy-coal-gas blowpipe

[488] Ibid., 48.
[489] Ibid., 49.

The name "Lockyer" is on the right margin of the page [490]

The numerous other clippings on Lockyer, which were glued onto the pages of the Notebook, included his work on carbons, on the Aurora Borealis, on binary stars, and on the worrisome possible "fluting" of spectral lines.[491] Some entries specified how the Hugginses replicated Lockyer's experiments and the results they achieved. Even after Huggins had made her entry point into astrophysics Lockyer's persistent research provided the Hugginses with ongoing questions that needed to be addressed in order to solidify their own gaseous nebula theory. These pages showed perhaps too intense an interest the couple developed towards one astrophysicist. At the same time, it demonstrates that Lockyer had established an authorial presence a space that was once reserved for only William and Huggins.

[490] Lockyer in Hugginses Notebook Six. The Huggins Collection in the Special Collections, Wellesley College

[491] Ibid.

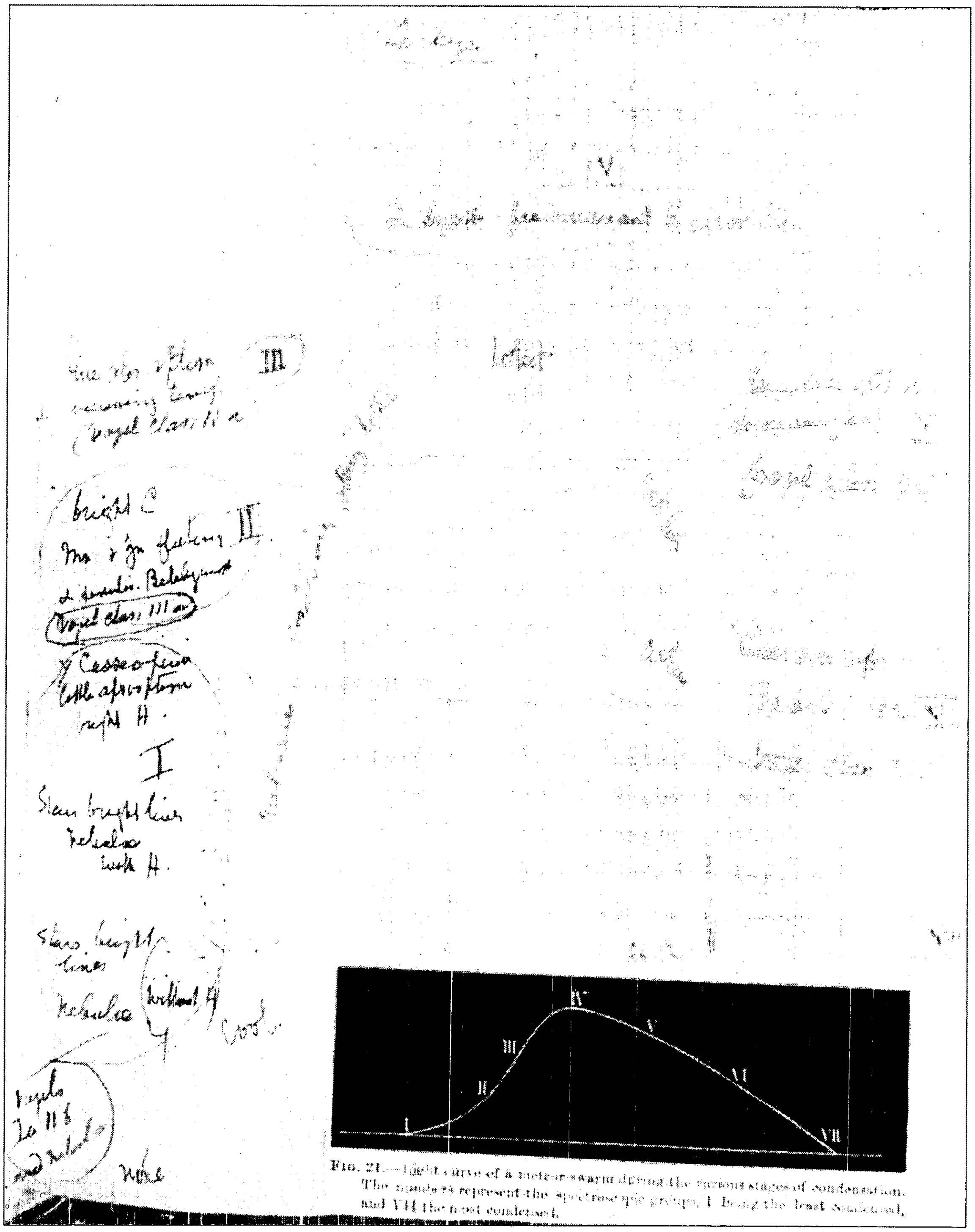


Figure 5
"Lockyer"
<u>Notebook Six</u>
Wellesley College Library/Special Collection

Aside from purely a scientific divide one can detect a difference in personal viewpoints as to the way Lockyer believed an amateur astronomer should conduct astronomy and the way William had wanted to preserve the "grand amateur tradition." Lockyer was very much a showman and an avid popularizer. Unlike William who had a personal fortune, Lockyer depended on popular lectures and eclipse expeditions to feed his large family.[492] Lockyer was not only at his best conducting a "public display" of photographing astronomical phenomena before a paying audience during expeditions, but he relished in lecturing and exhibiting his photographs at public talks afterwards.[493] As well, Lockyer was the editor of *Nature*. William, on the other hand, seemed to shun the public and interacted exclusively with well-respected scientists, astronomers, and Huggins. Although Tulse Hill was an amateur facility, William behaved as if he were running an institutional space, allowing only a select few to enter the site. William may have seen popular astronomers such as Lockyer as staining the grand tradition and went out of his way to refute Lockyer's theories deeming then unscientific. Lockyer may have felt that grand amateurs such as William stood in his way. As Bigg argues in "Staging the Heavens," "ongoing implicit assumption in Britain that scientific investigation was an activity for men of independent means made it difficult for the rising generation of middle-class scientists such as Lockyer, who had to live from their work."[494] Judging from the intense notes in Notebook Six focusing on Lockyer, there did seem to be a personal vendetta towards this professional popularizer of astronomy.

---

[492] See Meadows, *Science and Controversy*. Bigg, "Staging the Heavens."
[493] Bigg, "Staging the Heavens," 317.
[494] Ibid., 313.

The fight for the possibility of an exclusively gaseous nebula was one "red in tooth and claw,"[495] as the Hugginses papers indicated. Although Huggins did not know it at the time, her entry point into publication was based on a theory that would be proven false in her lifetime.[496] Like Somerville, Huggins also experienced criticism for her work in the embryonic stages of a specialization in astronomy. Huggins' first publication stated the discovery of a new line, theorized about a new element in space, reinforced a long-lasting Hugginses hypothesis about the nebula, and took on a well-respected fellow astronomer. As well, this paper demonstrated that photography had solidified a place in astrophysics at Tulse Hill. The paper ended by concluding that nebulae were at the very beginning of an evolutionary process of a celestial body. In 1890, a follow up paper from Tulse Hill drew the same conclusions.[497] Again, the paper stressed that both William Huggins and Mrs. Huggins made independent observations employing astrophotography, which verified the findings stated in the work.

Ongoing Research

The inclusive pronoun "we" was to mark the remainder of the Hugginses' papers and on very few occasions in the next fifteen years would Huggins and William refer to each other by name in their published works. Aside from the Great Nebula in Orion debate, "William Huggins and Mrs. Huggins," and later "Sir William Huggins and Lady Huggins," pointed their spectroscope and camera to various stars in search of elements

---

[495] Alfred Tennyson, "In Memoriam A.H.H." in Alfred Lord Tennyson: Selected Poems (Toronto: Penguin Books, 2008), LVI.

[496] William's and Huggins' inability to see more than a "bright" green line on the nebula spectra was due to the fact that their equipment could not distinguish the multitude of duller lines overshadowed by the primary line. If the couple had seen the other lines, they would have realized that the Orion was not a solely gaseous nebula. See also Belkora, *Minding the Heavens*, 186.

[497] William Huggins and Mrs. Huggins, "On a Re-Determination of the Principal Line in the Spectrum of the Nebula in Orion, and on the Character of the Line," *Proceedings of the Royal Society of London* 48 (1890): 202 – 13.

such magnesium, nitrogen, hydrogen, and carbons. The latter years of research focused on grouping celestial bodies by their key elements. These projects verified the fact that Huggins' entrance into the embryonic stages of astrophotography established a long lasting and visible career in authorship. The Hugginses' work in photography helped transform a tool from an instrument of verification to a device that astrophysicists used as their main source of knowledge acquisition. Indeed, by the end of the Hugginses' careers photographs of the spectrum were preferred to hand-drawn images rendering obsolete a practice which had existed since Antiquity in astronomy.

The previous section demonstrated that Huggins' work at Tulse Hill was extensive and that both Huggins and William thought that credit was indeed due to her. Another more practical and perhaps too calculating reason was the reality that William was now sixty-five and Huggins was forty-one. The couple may have considered the fact that William was likely to die much sooner than Huggins. Huggins had no independent income, no means of a livelihood, and no children to care for her. If the Hugginses continued to keep Huggins' contribution to science in the spotlight, she would have a chance at a civil list pension. William, in fact, did receive a civil list pension of one hundred pounds a year, which was granted to him in 1890. Upon his death in 1905, Huggins continued to receive this humble sum.[498]

One can make the argument that William was an early advocate of women's rights and that he sincerely felt Huggins ought to be given her rightful place in astronomy regardless of the fact that she was a woman. This theory, however, is flawed. In 1906 William had heard that Hertha Ayrton was in line for the Hughes Medal for her work on

[498] Mary Somerville was receiving 300 pounds a year as early as 1834, which caused considerable outrage. Yet, even on this amount the Somervilles had to move to Italy to live with economy.

electric arcs and sand ripples.[499] William was sick with a cold and forfeited his chance to vote on the issue at the Royal Society. William later stated that he was sorry he had missed the meeting because he surely would have voted against her fearing that if she won the award further papers from the Royal Society would be teeming "with publications from all the advanced women."[500] Ayrton did receive the Hughes Medal from the Royal Society.

In the Presence of Others

In the next publication of *Proceedings,* the Hugginses contributed a detailed thirteen page paper on the work of Charles Wolf's and Georges Rayet's Spectrum on Bright-Line Stars.[501] This paper demonstrated the extensive network of observatories/laboratories that Tulse Hill attempted to maintain communication with during its research. The citations in the paper included the following astronomers from at home and abroad: Charles Wolf and Georges Rayet in Paris, Hermann Carr Vogel in Potsdam, Bernhard Hasselberg in Sweden, Charles Piazzi Smyth and Ralph Copeland in Scotland, E.C. Pickering in America, and Norman Lockyer in England. The Hugginses struggled to remain a part of this international network of astronomers, which now stretched across the ocean.

The paper demonstrated that the Hugginses were well educated in the work of others in their field, and that research at Tulse Hill was not for the purpose of simply publishing the findings the couple obtained. With nearly every individual observation and experimental outcome the paper noted, the Hugginses were able to cite a similar finding

---

[499] Becker, "Eclecticism, Opportunism and the Evolution of a New Research Agenda," 417.
[500] Ibid., 417.
[501] William Huggins and Mrs. Huggins, "On Wolf and Rayet's Bight-Line Stars in Cygnus," *Proceedings of the Royal Society of London* 49 (1890 – 1891): 33 – 46.

from another astronomer or name a disputed result. Just as Mary Somerville affiliated herself with William Wollaston, John Herschel, and François Arago in her papers, by the late nineteenth century the Hugginses felt it necessary to demonstrate their connections with institutional observatories. Again, the inclusive "we" and "us" were maintained throughout the paper:

> We suspected bright lines or bands in the region more refrangible than the blue band, but in such faint objects this is a point with should be determined by photograph.
> Professor E.C. Pickering has since kindly informed us that his photographs of the star No. 4001, which extend into the ultra-violet region, show beyond the blue band the bright hydrogen lines at 434 …[502]

The Hugginses' interest was now somewhat shaped by projects that engaged the numerous observatory/laboratories that still corresponded with Tulse Hill. The Hugginses' publications in *Proceedings* were, time after time, dense with references to the work of others and their papers began to read like a virtual "who's who" of astrophysicists in Europe and America.

During this same time a general trend in astrophysics was international collaboration. The most prevalent example of such global teamwork can be seen by the French Academy of Science's invitation to foreign countries for an Astrographic Congress in April of 1887. Nineteen countries sent a total of fifty-six scientists to this event.[503] During the conference a decision was made to create, collectively, a photographic map of the skies. In "The Impact of Photography in Astronomy," Lankford argues that this 1887 event officially marked the acceptance of photography as a research tool in astronomy. Astrophotography had left the embryonic stage as this technique was

[502] Ibid., 36.
[503] John Lankford. "The Impact of Photography on Astronom,." in *The General History of Astronomy: Astrophysics and Twentieth Century Astronomy to 1950,* ed. Owen Gingerich (London: Cambridge University Press, 1984), 29.

established. This worldwide endeavour sought to create formality in many areas of knowledge dissemination in astrophysics. The incomplete Carte du Ciel project[504] led to what became known as Commission 23 of the International Astronomical Union (IAU) in 1919.

In 1891, three short years after Huggins' name first reached publication, the Nova Aurigae appeared. It was, in the Hugginses' own words, a "remarkable, and, in some respects, unprecedented celestial phenomenon."[505] This happening in the heavens was first noted by the Astronomer Royal of Scotland, Ralph Copeland. As with previous papers, the Hugginses exhibited their close connection with Copeland by stating, "We received a telegram from Dr. Copeland in the early morning of the 2nd instant, and began our observations of the star on the night of the 2nd instant."[506] The nova was to occupy years of work and the Hugginses produced a total of three papers on this birth in the cosmos.[507] As with the initial paper, the Hugginses' list of astronomers who exchanged information with Tulse Hill was extensive. The intersection of knowledge was important because this access allowed the Hugginses to extend the observation window on this new star:

> After March 7, the remarkable swayings [sic] to and fro of the intensity of the light, set up probably by commotions attendant on the cause of its outburst, calmed down, and the star fell rapidly and with regularity to about the 11th magnitude by March 24, and then down to about 14.4th magnitude by April 1. On April 26, however, it was still visible at Harvard Observatory, magnitude 14.5 on the scale of the meridian photometer.[508]

---

504 Ibid.,

505 William Huggins and Mrs. Huggins, "Preliminary Note on Nova Aurigae," *Proceedings of the Royal Society of London* 50 (1891 – 1892): 465.

506 Ibid.,

507 William Huggins and Mrs. Huggins, "On Nova Aurigae," *Proceedings of the Royal Society of London* 51 (1892): 485 – 495. William Huggins and Mrs. Huggins, "On the Bright Bands in the Present Spectrum of Nova Aurigae," *Proceedings of the Royal Society of London* 54 (1893): 30 – 36.

508 William Huggins and Mrs. Huggins, "On Nova Aurigae," 492.

As the Hugginses pointed out, with their visibility diminishing on the Aurigae, Harvard engaged the viewing time.

With these traces of the transmission of information, Huggins' admission into the circle of astronomers transcended the research level. Behind these notations in the published papers were personal exchanges that hinged not only on professional respect but her aptitude for keeping friendships alive with fellow stargazers. Huggins became a close friend of James Dewar and his wife. The Hugginses were frequent visitors at Crosby Hall.[509] Dewar was cited extensively in the Hugginses papers for his work in spectrum analysis. Other astronomical friends included Sarah Whiting and Annie Cannon from the Harvard Observatory.

"Outpost at the Frontier of Astrophysical Science"

At the dawn of the twentieth century, the "little private Observatory at Upper Tulse Hill" was referred to as "one of the most important outposts at the frontier of astrophysical science" by Edwin Frost of Yerkes Observatory writing in *Science* magazine.[510] After the research on the Aurigae Nova in the early 1890s the work at Tulse Hill slowed as the facility continued to distinguish the character of various spectral lines focusing on calcium in 1897. In this same year, William became Knight Commander of the Order of Bath and the names "Sir William and Lady Huggins" appeared in published works rather than "William Huggins and Mrs. Huggins." At this time the Hugginses entered a period during which they were much interested in showing the public what they had accomplished through the decades at this "outpost." In 1899, at the end of "the

[509] Annie J. Cannon, "A Review of Astronomy," *The Observatory* 1 (1877): 323 – 24.
[510] Edwin B. Frost, "Review of 'An Atlas of Representative Stellar Spectra from A 4870 to A 3300 by William Huggins and Lady Huggins'" *Science, New Series* 13 (1901): 223.

wonderful century,"[511] the Hugginses produced a two volume *Atlas of Representative Stellar Spectra*, which outlined the "spectroscope progress" involved in understanding the makeup of starlight.

After the publication of *Atlas,* the research work continued to dwindle with only a sprinkling of short papers appearing in 1903, 1905, and 1906 on the spectrum of radiation.[512] In these latter years it was determined that the Hugginses' theory that the Orion was a gaseous nebula with a few stars was correct. The Hugginses had stated on numerous occasions that they saw one chief green line in various nebula spectrums. The couple relied on this line to argue one of their most adamant theories namely that some nebulae were mostly gaseous with some stars. Thus, not all nebulae were filled with stars. With more powerful spectroscopes coming into practice at the end of the century it was determined that nebulae do come in various forms and that some were indeed mostly gaseous.

The Hugginses were correct in arguing that there were some chemicals that are only in the celestial domain and cannot be found anywhere on earth.[513] One sighting of such a chemical was proposed in Huggins' and Miller's paper "On the Spectra of Some of the Nebulae" (1864).[514] However, neither Huggins and Miller, or the Hugginses, were

---

[511] Alfred Russel Wallace, *The Wonderful Century: Its Successes and Its Failures* (Toronto: M. Morang, 1898).

[512] William Huggins and Lady Huggins, "On the Spectrum of the Spontaneous Luminous Radiation of Radium at Ordinary Temperatures," *Proceedings of the Royal Society of London* 72 (1903 – 1904): 196 – 99. William Huggins and Lady Huggins, "Further Observations on the Spectrum of the Spontaneous Luminous Radiation of Radium at Ordinary Temperatures," *Proceedings of the Royal Society of London* 72 (1903 – 1904): 409 – 13. William Huggins and Lady Huggins "On the Spectrum of the Spontaneous Luminous Radiation of Radium: Part III. Radiation and Hydrogen," *Proceedings of the Royal Society of London* 76 (1905): 488 – 92. William Huggins and Lady Huggins "On the Spectrum of the Spontaneous Luminous Radiation of Radium: Part IV. Extension of the Glow," *Proceedings of the Royal Society of London Series A. Containing Papers of a Mathematical and Physical Character* 77 (1906): 130 – 31.

[513] Ibid., 196.

[514] Agnes Clerke was credited with naming this new element "nebulium." See Mary Bruck, *Agnes Mary Clerke and the Rise of Astrophysics*, 142.

not credited with naming any such element. What distressed the Hugginses most was that Lockyer was credited with finding a new element, helium, during his lifetime.[515]

In 1907 the Hugginses' Grubb telescope found a new home at the Department of Astrophysics at Cambridge. Noteworthy is the fact that even the return of the telescope was imbued with "Romantic" discourse by Howard Grubb who supervised the move.[516] Grubb was to note:

> Lady Huggins had asked me to let her know when I [Grubb] was ready to close the box [which contained the large object glass from the telescope], and when I intimated that I had it safely in the case, she took Sir William by the hand and brought him across the room to have a last look at their very old friend. They gazed long and sadly before I closed the lid.[517]

It seemed that Huggins' "very hard work" in astrophotography would always be remembered alongside her relationship with her husband, and the life they were perceived to have lived at Tulse Hill. As embedded as the Hugginses were in the Victorian value of hard work, one wonders if the couple would have felt disappointed at such constant whimsical references. Yet, such constructions may be unavoidable in a science so rich with amorous connotations in popular culture,[518] and in these works Huggins was not the author but surrendered her authority to the biographers. William died in 1910 and Huggins in 1915.

In this chapter we have seen that Huggins' early years at the Observatory were far more productive than her later years. The energy with which she entered into research at

---

[515] Grubb in North, *Astronomy and Cosmology*, 450.

[516] Historian of Astronomy. Colin Ronan, had stated that by all accounts the "romantic marriage" between Huggins and William was of the "Browning order." Ronan, *Their Majesties' Astronomers*, 177.

[517] Grubb in Ronan, *Their Majesties Astronomers*, 181.

[518] The notion of two solitary observers, in a lonely observatory, diligently peering into the night sky in order to unravel the mysteries of the universe was romanticized by Thomas Hardy in his popular novel *Two on a Tower* (1882). The characters in Hardy's *Tower* were as much seduced by knowledge of the heavens as they were by each other. This Romantic vision, of the "Browning order," worked its way into the depictions of the Hugginses' life at Tulse Hill.

Tulse Hill as a budding practitioner demonstrated her passion for making astrophotography a respected tool in astronomy. William and Huggins continued to be active in astronomical culture, yet as the years progressed their visibility diminished. As the twentieth century began what William, and no doubt Huggins, realized was that their private Observatory/laboratory was no match for the observatories/laboratories that became showplaces of the new era. As William was to remark in this solemn but telling piece near the end of his life:

> The question is, is it worth my while to continue working in this direction [spectrum research] now that it is being done under circumstances with which no zeal and perseverance on my part will enable me to be in an equal position [...] It is scarcely worthwhile to do what will be done well, no doubt, elsewhere – I do not at this moment see clearly any entirely new direction of work.[519]

The word "outpost" sombrely portrayed the twilight day of the last "grand amateur astronomers" who resided at Tulse Hill with their "very old friend."

[519] Huggins in Meadows, "Origins of Astrophysics," 199.

CONCLUSION

COMPARATIVE ANALYSIS

*****

Mary Somerville and Margaret Huggins

If we want to compare Mary Somerville and Margaret Huggins we need to identify the sites of embodiment such as the author, scientific facilities, acts of collaboration, fashionable areas of study, budding methodologies, and international projects that framed the evolving authorial identities of these two scientific writers. In so doing, we established an analytical link to map our exploration. The common space is the cultivation of a collaborative voice, which both women used as a tool to enter into scientific networks and scientific authorship. Somerville's and Huggins' findings and experimental approaches were published in scientific journals, and both writers wrote with ease while engaging the theories of others. Aside from the journals both Somerville and Huggins produced other types of authored artifacts. Somerville made a career in popular writing, and Huggins kept a detailed record of laboratory practices in six unpublished Notebooks and co-wrote a series of astronomical articles.

Somerville's and Huggins' entry points into practice coincided with the catalyzing impact of two popular frontiers in scientific culture. Magnetism was reemerging as a fashionable area of study when Somerville took an interest in experimentation, and the implementation of photography in astronomy was at the embryonic stage of development when Huggins began observations at Tulse Hill. Somerville and Huggins each established symbiotic relationships with men of science to gain access to the facilities and tools necessary to begin their scientific work. The career trajectory of these practitioners illuminated how spaces for doing science within the domestic domain became less productive as precision sites, built for observation and experimentation, became the norm. Somerville and Huggins both saw their initial theories refuted; yet, both were able to continue work in astronomical experimentation and regain credibility as authors. What their writing demonstrated was that both authors were most confident writing in voices that extensively incorporated collaborating theories and scientific names within their own scientific papers and other publications. The Somerville/Huggins analysis adds a new layer to the study regarding the relationship between gender and science writing. These two women exerted their influence through auxiliary roles, yet their positions were by no means secondary in authorship.

Gender and Entering into Practice and Writing

Somerville's investigation of solar rays in spectrum analysis was reliant on her ability to reapply William Wollaston's use of the prism to detect magnetic influence from our sun. Her experiments were conducted at home, and a similar space was also utilized by Wollaston and Somerville's supporter, Samuel Christie.[520] Jack Meadows points out that Wollaston's laboratory consisted of a tray of "apparatuses" brought in by his servants when he wanted to work.[521] The parallel between Somerville's experimental space and those of Christie and Wollaston, and the fact that experimental research was conducted in this setting, brings into question the marking of the domestic domain as a gendered space.

Somerville's magnetism results proved sufficiently interesting to no less a person than Sir John Herschel. This ongoing relationship between Somerville and Herschel, furthermore, tests the traditional notion of the inaccessibility of experimental practice and

520 See Meadows, *Victorian Scientist*, 58 – 72.
521 Ibid., 58.

knowledge dissemination for women in the early 1800s. Somerville's authorial worth can be detected in Herschel's insistence in adding her name to his ongoing research on solar rays and vegetable juice in 1845 and 1846.

Although Somerville is a well-worn example of how a woman can be involved in science and the dissemination of scientific ideas, she was not an advocate for woman's equal participation in science. Somerville's concern focused, rather, on the status of science itself. As William Buckland observed:

> Everybody whom I spoke to on the subject agreed that if the Meeting is to be of scientific utility, ladies ought not to attend the reading of the papers as it would overturn the thing into a sort of Albermarle dilettanti meeting instead of a serious philosophical union of working men. I did not see Mrs. Somerville, but her husband decidedly informed that such is her opinion of this matter.[522]

Science, in Somerville's eyes, was a "serious philosophical union of working men" such as William Wollaston, Dominique Francois Arago, and John Herschel.

Huggins began work in the "New Astronomy" as photography was emerging as a possible tool in this specialization. William's results often proved inconclusive and this uncertainty forged a rich and productive research agenda not only in astronomy but in the development of photography for light analysis at Tulse Hill. William's relationship with Huggins was revealed in six Notebooks. These artifacts came to articulate not only scientific work but a marital alliance built on astronomical questions. Her much valued presence at the observatory/laboratory and her essential authorial existence in published papers adds debate to the late nineteenth- century to early-twentieth argument that astronomy was a masculine science.

---

[522] William Buckland in Susan David Bernstein, "'Supposed Differences': Lydia Becker and Victorian Women's participation in the BASS," in *Repositioning Victorian Sciences: Shifting Centres in Nineteenth-Century Scientific Thinking*, eds. David Clifford, Elisabeth Wadge, Alex Warwick, and Martin Willis (London: Anthem Press, 2006), 87.

On issues surrounding women, science, education, and the community of scientific men Huggins advocated knowledge in the field. She stated that, "I find that men welcome women scientists provided they have proper knowledge,"[523] and that "when women have really taken the pains to fit themselves to assist or to do original work, scientific men are willing to treat them as equals."[524] These sentiments no doubt mirrored her own experience with William. Huggins' concern, similar to Somerville's, was centered on upholding the esteem place of science and astronomy rather than the access of women to these areas of study. Neither women were the "Lydia Becker" of their time, yet both Somerville and Huggins fostered a quieter emancipation of women through examples of solid scientific practice and writing.

Spousal Collaboration

Somerville's success in gaining exposure for her scientific work was reliant on spousal collaboration. William Somerville not only read Somerville's paper before the Royal Society but acted as her promoter by sending her solar rays and magnetism paper to Arago in France. The Somerville collaboration challenges the traditional perception of a husband and wife scientific partnership in that Somerville, rather than William, was the experimenter and writer.

Contrary to the Somervilles, William's and Huggins' scientific cooperation was built on conventional practice such as that explored by scholars in *Creative Couples in the Sciences* (1996) and *Uneasy Careers and Intimate Lives: Women in Science (1788-1979)* (1987). Various assessments have been made by Marilyn Bailey Ogilvie and

---

[523] "Margaret Lindsay Huggins Obituary Notice," *Monthly Notices of the Royal Astronomical Society* 76 (1916): 278.
[524] Ibid.

Barbara Becker pertaining to Huggins' role at the observatory. [525] Ogilvie positions Huggins as someone who "added to the bulk of astronomical knowledge" by happily assisting William.[526] Becker re-positions Huggins as much more than an "able assistant."[527] William, along with Huggins, worked equally in the observatory/laboratory and made independent observations and conducted experiments. I move the scholarship forward by demonstrating that in the Notebooks, Huggins excelled in her role as narrator and it was in this space that she, rather than William, was the leading voice. The intricate bond between Huggins and William established a space for Huggins' authorial presence to emerge as a collaborative voice to William.

The first published paper on the Orion (1889), which set Huggins in a role of verification, was the only Hugginses paper that specifically identified the two participants. The paper also established Huggins as an independent participant at the Observatory, yet the carefully chosen words indicate the caution the Hugginses were taking with this inclusion. In a second 1889 paper on Uranus and Saturn, William and Huggins gravitated between the "I" and "we" pronouns to distinguish their work. After framing Huggins' position with these two papers, further submission noted her contribution, simply, with the inclusive "we" pronoun.

Two additional papers clarifying the Hugginses position on the Orion (1890) were written in first person plural. One paper on Sirius (1890), one on Cygnus (1890-1), and three papers on the Nova Aurigae (1892-3) were written in first person plural with William using the "I" pronoun when he referred to previous work. The third set of

---

[525] See Barbara Becker, "Dispelling the Myth," 98 – 111. Marilyn Bailey Ogilvie, "Marital Collaboration: An Approach to Science," 104 – 125.
[526] Marilyn Bailey Ogilvie, "Marital Collaboration: An Approach to Science," 114.
[527] See Barbara Becker, "Dispelling the Myth," 98 – 111.

papers, six in total, focusing on chemical analysis (1897 – 1905) were all written in first person plural. The "we" pronoun points to shared contributions, yet should not be read as giving the two equal status. We must remember that William's name always appeared before Huggins' on the title, which does imply a leading role. The fact that the Hugginses felt at ease with this usage suggests that the addition of Huggins' name, using the word "we," to scientific work was not met with conflict. She, like Somerville, had established her place in scientific society.

The variety of pronouns used in their published works, the assortment of pronouns visible in the six Notebooks, and the signifier of "W" indicated a scientific partnership that held agreements and challenges. This agenda led to varying degrees of self-confidence for both William and Huggins as each took reign of respective domains. The pronouns pointed to incidents of collective work and independent assessments, which were founded on the arguments addressed and celestial bodies studied. Regardless as to whether Huggins worked happily as an able assistant or if her role was one equal to William, her authorial voice, either in published or unpublished form, often illustrated an important position that was well utilized to bring credibility to Tulse Hill.

Interdependent Voices and Narration

Somerville's narration in her first scientific paper, "Magnetizing Power," clearly demonstrated an interdependent voice as she discussed the workings of nature. The paper, began by referencing previous work by Domenico Morichini in the introductory paragraph. Next, the paper made reference to Wollaston. Somerville's utilization of Morichini was used to build an alliance between her own findings and his results. In addition, she was positioning herself within the same circle of experimenters as the

Italian natural philosopher. Somerville's reference to Wollaston's loan of the prism was employed, again, to form a union with the British man of science. The fact that Somerville knew to use these small indicators of association illustrated an authorial bond with her peers.

Somerville's work on solar rays and vegetable juices synchronized with Herschel's interest in this area and Arago's desire to bring science to the public in Paris. Herschel and Arago used Somerville's work in an auxiliary manner adding substantiating evidence to their findings. Importantly, the Arago/Somerville experiments allowed the collaborators to precede M. Melloni in publishing a conclusion. The narration in Somerville's scientific papers demonstrated that her status as a credible scientific person was best achieved by association as she added her voice to the theories and hypotheses of others.

Somerville's more substantial contribution to astronomy was in popular writing. In *Mechanism*, Somerville created a style of writing similar to friendly chatter and this informality was praised by her readers. Four years later Somerville highlighted her polymath abilities in a more mature form of narration with *Connexion*. The broad range of topics in both books created a narrative which highlighted the interdependent nature of various theories as natural philosophers spoke about the cosmos.

Hugginses scholars have argued that Huggins' major contribution to Tulse Hill was photography. This dissertation has demonstrated that Huggins' record keeping, her ability to clearly articulate the process involved in experimentation, and her narration of the unfolding of nature in the Notebooks were essential to the work done at the observatory/laboratory. These notes indicate the strong acts of engagement that took place before papers were sent to the Royal Society. Seemingly small indicators such as pronouns, sentence structures, and notations were keys as to how experiments unfolded, and Huggins' diligence allowed readers to detect the anxieties that both she and William experienced as hypotheses were put forth, refuted, reinstated, and questioned.

The Notebooks often portrayed William in a "point of view" role and became a scientific autobiography as Huggins gave an account of what she experienced at Tulse Hill.

Analyzing the Notebooks in conjunction with William Huggins' solo work and the Hugginses' joint papers reveal in minute detail the processes that bring working experiments to print. As we have seen the Hugginses papers were dense with supporting data from other facilities and their findings were interdependent upon the work of other practitioners. Another point that prevailed was that for Huggins and other writers the key word that frequently appeared in descriptions of their life at Tulse Hill was "romantic" in the "Browning order."[528]

Future Work

This dissertation invites more work to be done on other key actors in astronomical history, and the tools these practitioners employed to gain entry into practice. The dissertation bridges two scholarly domains, namely, the history of astronomy and literary theory. One possible site for exploration is the evolution of the narrative voice in scientific papers of other men of astronomy throughout their career. An appealing choice would be the Hugginses' nemesis Norman Lockyer. Lockyer was also involved in popularization and was the editor of *Nature*. Lockyer, because of his career as a popularizer, perhaps had other barriers to overcome as he sought recognitions amongst the grand amateur astronomers. At the same time, one can reveal how non- scientific

[528] William Huggins in Ronan, *Their Majesties' Astronomer*, 177.

publications added to the richness of Lockyer's experimental writing. Interdisciplinary work offers those who have passions for two fields the opportunity to reapply methodological approaches well established in one area of scholarship to an alternate discipline. In this way, this dissertation finds affinity with the work of both Mary Somerville and Margaret Huggins as these practitioners imprinted a very old sky with emergent techniques as they cultivated their authorial voices.

BIBLIOGRAPHY

Abrams, M. H. *A Glossary of Literary Terms*. Boston: Heinle & Heinle, 1999.

Ashfield, Andrew, and Peter de Bolla. *The Sublime: A Reader in British Eighteenth-Century Aesthetic Theory.* Cambridge: Cambridge University Press, 1996.

Ashworth, William J. "The Calculating Eye: Baily, Herschel, Babbage and the Business of Astronomy." *The British Journal for the History of Science* 27, no. 4 (1994): 409 – 441.

Aubin, David, Charlotte Bigg, and H. Otto Sibum. "Introduction: Observatory Techniques in Nineteenth-Century Science and Society." In *The Heavens On Earth: Observatories and Astronomy in Nineteenth Century Science and Culture,* edited by David Aubin, Charlotte Bigg and H. Otto Sibum, 1- 32. Durham: Duke University Press, 2010.

Barlow, Peter. "Observations and Experiments on the Daily Variation of the Horizontal and Dipping Needles under a Reduced Directive Power." *Philosophical Transactions of the Royal Society of London* 113 (1823): 326 – 341.

Becker, Barbara. "Eclecticism, Opportunism and the Evolution of a New Research Agenda: William and Margaret Huggins and the Origins of Astrophysics." Ph.D diss., John Hopkins University, 1993.

---. "Dispelling the Myth of the Able Assistant: William and Margaret Huggins at the Tulse Hill Observatory." In *Creative Couples in the Sciences*, edited by Nancy G. Slack, Helena M. Pycior and Pnina G. Abir-Am, 98 – 111. New Brunswick: Rutgers University Press, 1996.

---. *Unravelling Starlight: William and Margaret Huggins and the*

Rise of the New Astronomy. Cambridge: Cambridge University Press, 2011.

Belkora, Leila. *Minding the Heavens: The Story of our Discovery of the Milky Way*. Bristol: Institute of Physics Publishing, 2003.

Bernstein, Susan David. "'Supposed Differences': Lydia Becker and Victorian Women's Participation in the BASS." In *Repositioning Victorian Sciences: Shifting Centres in Nineteenth-Century Scientific Thinking*, edited by David Clifford, Elisabeth Wadge, Alex Warwick, and Martin Willis, 85 – 94. London: Athem Press, 2006.

Bigg, Charlotte. "Staging the Heavens: Astrophysics and Popular Astronomy in the Late Nineteenth Century." In *The Heavens On Earth: Observatories and Astronomy in Nineteenth Century Science and Culture,* edited by David Aubin, Charlotte Bigg and H. Otto Sibum, 305 – 324. Durham: Duke University Press, 2010.

Bowditch, Nathaniel. *Celestial Mechanics by the Marquis de la Place*. Bronx: Chelsea Publishing Company, Inc., 1966.

Bowler, Peter and Nicholas Whyte. *Science and Society in Ireland 1800 – 1950: The Social Context of Science and Technology in Ireland.* Chester Spring: Dufour Editions, 1997.

Brewster, David. *More World than One: The Creed of the Philosopher, and the Hope of The Christian*. London: John Camden Hotten, 1854.

---, "Review of *On the Connexion of the Physical Sciences*," *Edinburgh Review* 59 (1834). In *Mary Somerville: Scientific Papers and Reviews,* edited by James Secord, 154 – 171. Bristol: Thoemmes Continuum, 2004.

Brock, Claire. "The Public Worth of Mary Somerville." *British Journal for the History*

Of Science 39 (2006): 255 – 272.

Bronte, Emily. *Wuthering Heights*. New York: Vintage, 2009.

Brougham, Henry. *Practical Observations Upon the Education of the People: Addressed to the Working Classes and Their Employer*. Manchester: E.G. Morten, 1825.

Bruck, Mary. *Agnes Mary Clerke and the Rise of Astrophysics*. Cambridge: Cambridge University Press, 2002.

Bruck, M.T. and I Elliott, "The Family Background of Lady Huggins," *Irish Astronomical Journal* 20 (1992): 210.

Cannon, Anne. "A Review of Astronomy." *The Observatory* 1 (1877): 323 – 324.

---, "Lady Huggins," *Observatory* 38 (1915): 323.

Cantor, Geoffrey. "The Rhetoric of Experiment." In *The Uses of Experiment: Studies in the Natural Sciences*, edited by David Gooding, Trevor Pinch, and Simon Schaffer, 159 – 180. Cambridge: Cambridge University Press, 1989.

Chant, Clarence. "Death of Lady Huggins." *Royal Astronomical Society of Canada Journal* 9 (1915): 149 – 150.

Chapman, Allan. *The Victorian Amateur Astronomer: Independent Astronomical Research in Britain, 1820-1920.* Chichester: Praxis Publishing, 1996.

---. *Mary Somerville and the World of Science*. Bristol: Canopus Publishing Limited, 2004.

Christie, Samuel Hunter. "On the Diurnal Deviations of the Horizontal Needle when Under the Influence of Magnets." *Philosophical Transactions of the Royal Society of London* 113 (1823): 342 – 392.

---. "On the Magnetism Developed in Copper and Other Substances During Rotation." *Philosophical Transactions of the Royal Society Of London* 115 (1825): 497 – 509.

---. "On the Magnetism of Iron Arising from its Rotation." *Philosophical Transactions of the Royal Society of London* 115 (1825): 347 – 417.

---. "On Magnetic Influence in the Solar Rays." *Philosophical Transactions of the Royal Society of London* 116 (1826): 219 -239.

---. "On Magnetic Influence in the Solar Rays." *Philosophical Transactions of the Royal Society of London* 118 (1826): 379 – 396.

Clerke, Agnes M. *Modern Cosmogonies*. London: A and C Black, 1895.

---. *Problems in Astrophysics*. London: A and C Black, 1902.

---. *The Systems of the Stars*. London: A and C Black, 1905.

---, *A Popular History of Astronomy During the Nineteenth Century*. Decorah: Sattre Press, 2003.

Clifford, David. "Repopulating Heaven: Victorian Lunar Studies and the Anxiety of Loneliness." In *Repositioning Victorian Science: Shifting Centres in Nineteenth-Century Scientific Thinking*, edited by David Clifford, Elisabeth Wadge, Alex Warwick and Martin Willis, 171 – 182. London: Anthem Press, 2006.

Creese, Mary R., S. *Ladies in the Laboratory: American and British Women in Science*. London: The Scarecrow Press Inc., 1998.

Crosland, Maurice and Crosbie Smith. "The Transmission of Physics from France to Britain: 1800 – 1840." *Historical Studies in the Physical Sciences* 9 (1978): 1 – 61.

----, *Modern Theories of the Universe from Herschel to Hubble*. New York: Dover Publications Inc., 1994.

---, *The Extraterrestrial Life Debate, 1750 – 1900*. New York: Dover, Publications Inc., 1999.

Dale, Peter Allan. *In Pursuit of a Scientific Culture: Science, Art and Society in the Victorian Age*. Madison: University of Wisconsin Press, 1989.

"Dame Huggins Lindsay Huggins." *The Quarterly Journal of the Royal Astronomical Society* LXXVI (1915): 278 – 282.

Davy, Humphry. "An Account of Some New Experiments on the Fluroic Compounds; With Some Observations on Other Objects of Chemical Inquiry." *Philosophical Transactions of the Royal Society of London* 105 (1815): 62 – 73.

---. "Some New Experiments and Observations on the Combustion of Gaseous Mixtures, with an Account of a Method Preserving a Continued Light in Mixtures of Inflammable Gases and Air without Flame." *Philosophical Transactions of the Royal Society of London* 107 (1817): 77 – 85.

---. "New Experiments on Some of the Combinations of Phosphorus." *Philosophical Transactions of the Royal Society of London* 108 (1818): 316 – 337.

---. "On the Fallacy of the Experiments in which Water is said to have been formed by decomposition." *Philosophical Transactions of the Royal Society of London* 108 (1818): 169 – 171.

---. "New Experiments on Some of the Combinations of Phosphorus." *Philosophical Transactions of the Royal Society of London* 108 (1818): 1 - 22.

---. "On the Magnetic Phenomena Produced by Electricity." *Philosophical Transactions* *of the Royal Society of London* 111 (1821): 7 - 19.

---. "On a New Phenomenon of Electro-Magnetism." *Philosophical Transactions of the Royal Society of London* 113 (1823): 152 – 159.

DeVorkin, David H. "Community and Spectral Classification in Astrophysics: The Acceptance of E. C. Pickering's System in 1910." *Isis* 72 (1981): 29 – 49.

Dewhirst, David and Michael Hoskin. "The Message of Starlight: The Rise of Astrophysics." In *Cambridge Concise History of Astronomy*, edited by Michael Hoskin, 219 – 305. Cambridge: Cambridge University Press, 1999.

Dibner, Bern. *Oersted and the Discovery of Electromagnetism*. New York: Blaisdell Publishing Company, 1962.

Elliott, Ian. "The Huggins Sesquicentenary." *Irish Astronomical Journal* 26 (1999): 65.

"Extract of a Letter from Mrs. Somerville to M. Arago, Detailing some Experiments Concerning the Transmission of the Chemical Rays of the Solar Spectrum Through Different Media." *Edinburgh New Philosophical Journal* 22 (1837): 180 – 183.

Fara, Patricia. *Fatal Attraction: Magnetic Mysteries of the Enlightenment*. London: Icon Books, 2005.

Forgan, Sophie. "The Architecture of Display: Museums, Universities and Objects in Nineteenth-Century Britain." *History of Science* 32, no. 2 (1994): 139 – 162.

---, "'But Indifferently Lodged …' Perception and Place in Building for Science in Victorian London." In *Making Space for Science: Territorial Themes in the Shaping of Knowledge*, edited by Crosbie Smith and Jon Agar. 195 – 215. Manchester: University of Manchester, 1998.

Forgan, Sophie and Graeme Gooday. "Constructing South Kensington: The Buildings and Politics of T.H. Huxley's Working Environments." *The British Journal for the History Science* 29, no. 4 (1996): 435 – 468.

Foucault, Michel. "des espaces autres." *Architecture, Motion, Continuity* 5 (1984): 46 – 49.

Frost, Edwin. "Review of 'An Atlas of Representative Stellar Spectra from A 4870 to A 3300 by William Huggins and Lady Huggins.'" *Science, New Series* 13 (1901): 222 - 224.

Galison, Peter, and Lorrain Datson. "The Image of Objectivity." *Representations* 40 (1992): 81 - 128.

Gassiot, John. "On Spectrum Analysis: With a Description of a Large Sectroscope [sic] Having Nine Prisms, and Achromatic Telescopes of Two – Feet Focal Power [Abstract]." *Proceedings of the Royal Society of London* 12 (1862 – 1863): 536 – 38.

Gillispie, Charles, G. *Pierre-Simon Laplace (1749 - 1827): A Life in Exact Science.* Princeton: Princeton University Press, 1997.

Gooding, David. "Mapping Experiments as a Learning Process: How the First Electromagnetic Motor was Invented." *Science, Technology & Human Value* 15, no. 2 (1990): 165 – 201.

---, "Magnetic Curves and the Magnetic Field: Experimentation and Representation in the History of a Theory." In *The Uses of Experimentation: Studies in the Natural Sciences*, edited by David Gooding, Trevor Pinch, and Simon Schaffer, 183 – 224. Cambridge: Cambridge University Press, 1993.

Hannavy, John. *Masters of Victorian Photography*. Oxford: The Alden Press, 1976.

Hardy, Thomas. *Two on a Tower*. Oxford: Oxford University Press, 1998.

Harte, H. H. *The System of the World*. Dublin: 1830.

Hartley, H. *Humphry Davy*. Menston: Scolar Press, 1971.

Hentschel, Klaus. *Mapping the Spectrum: Techniques of Visual Representation in Research and Technology*. Oxford: Oxford University Press, 2002.

Herschel, John. "Review of Mechanism of the Heavens, Quarterly Review, 4 (July 1832)." In *Mary Somerville: Scientific Papers and Review*. edited by James Secord, 537 – 539. Bristol: Thoemmes Continuum, 2004.

---. "On the Chemical Action of the Rays of the Solar Spectrum on Preparations of Silver and Other Substances, both metallic and non-metallic; and on some Photographic Processes." Abstract of the Papers Printed in the *Philosophical Transactions of the Royal Society of London* 40 (1837): 206.

---, "On the Chemical Action of the Rays of the Solar Spectrum on Preparations of Silver and Other Substances, both metallic and non-metallic; and on some Photographic Processes." *Philosophical Transactions of the Royal Society of London* 42 (1840): 205 – 210.

---. "On the Actions of the Rays of the Solar Spectrum on Vegetable Colours." *Philosophical Transactions of the Royal Society of London* 55 (1842): 397 – 398.

Hirshfeld, Alan. *The Electric Life of Michael Faraday*. New York: Walker & Company, 2006.

Hoskin, Michael. "Newton and Newtonianism." In the *Cambridge Concise History of Astronomy,* edited by Michael Hoskin, 130 - 167. Cambridge: Cambridge University Press, 1999.

Howarth-Loomers, B.E.C. *Victorian Photography: A Collector's Guide*. London: Ward Lock Limited, 1974.

Huggins, William. "On the Spectra of Some of the Chemical Elements [Abstract]." *Philosophical Transactions of the Royal Society of London* 154 (1864): 43 – 44.

---. "On the Spectrum of Some of the Nebulae. And On the Spectra of Some Fixed Stars." Pro*ceedings of the Royal Society of London* 13 (1864): 491 - 493.

---, "On the Spectrum of the Great Nebula in the Sword-Handle of Orion." *Proceedings of the Royal Society of London* 14 (1865): 39 - 42.

---, "Further Observations on the Spectra of Some of the Nebulae, with a Mode of Determining the Brightness of These Bodies [Abstract]." *Proceedings of the Royal Society of London* 15 (1866 – 1867): 17 – 19.

---, "On the Spectrum of Comet 1, 1866." *Proceedings of the Royal Society of London* 15 (1866 – 1867): 5 -7.

---. "Description of a Hand Spectrum – Telescope." *Proceedings of the Royal Society of London* 16 (1867 – 1868): 241 – 243.

---, "Further Observations on the Spectra of the Sun, and of Some of the Stars and Nebulae, with an Attempt to Determine From Whether These Bodies are Moving towards or from the Earth." *Proceedings of the Royal Society of London* 16 (1867 – 1868): 382- 386.

---. "On the Spectrum of the Brorsen's Comet." *Proceedings of the Royal Society of*

London 16 (1867 – 1868): 386 – 389.

---. "Note of a Method of Viewing the Solar Prominences without an Eclipse." *Proceedings of the Royal Society of London* 17 (1868 – 1869): 302 – 303.

---. "Note on the Heat of the Stars." *Proceedings of the Royal Society of London* 17 (1868 – 1869): 309 – 312.

---. "Note on the Spectra of Erbia and Some other Earths." *Proceedings of the Royal Society of London* 18 (1869 – 1870): 546 – 553.

---. "On a Registering Spectroscope." *Proceedings of the Royal Society of London* 19 (1870 – 1871): 317 – 318.

---. "On the Spectrum of the Great Nebula in Orion, and on the Motion of Some Stars towards or from the Earth." *Proceedings of the Royal Society of London* 20 (1871 – 1872): 379 – 394.

---. "Note on the Telescopic Appearance of Encke's Comet." *Proceedings of the Royal Society of London* 20 (1871 – 1872): 87 – 89.

---. "Note on the Wide-slit Method of Viewing the Solar Prominences." *Proceedings of the Royal Society of London* 21 (1872 – 1873): 127 – 128.

---. "On the Spectrum of Coggia's Comet." *Proceedings of the Royal Society of London* 23 (1874 – 1875): 154 – 159.

---. "On the Photographic Spectrum of Stars." *Proceedings of the Royal Society of London* 25 (1876 – 1877): 445 - 6.

---. "On Bright Lines in the Spectra of Nebulae." *Proceedings of the Royal Society of London* 26 (1877): 179 -181.

---. "On the Spectrum of the Flame of Hydrogen." *Proceedings of the Royal Society of London* 30 (1879 – 1880): 576 – 580.

---. "Note of the Photographic Spectrum of the Great Nebula in Orion." *Proceedings of the Royal Society of London* 33 (1881 – 1882): 425 – 428.

---. "On the Photographic Spectrum of Comet b 1881." *Proceedings of the Royal Society of London* 33 (1881 – 1882): 1-3.

---. "On the Photographic Spectrum of Comet (Wells) I, 1882." *Proceedings of the Royal Society of London* 34 (1882 – 1883): 148 – 150.

---. "On a Method of Photographing the Solar Corona without an Eclipse." *Proceedings of the Royal Society of London* 34 (1882 – 1883): 409 –414.

---. "On the Function of the Sound-Post and the Proportional Thickness of the Strings of the Violin." *Proceedings of the Royal Society of London* 35 (1883): 241 – 248.

---, "An Attempt to Photograph the Solar Corona." *Science* 15:119 (1885): 397 – 398.

---. "The Bakerian Lecture: On the Corona of the Sun." *Proceedings of the Royal Society of London* 39 (1885): 108 – 135.

---. "An Attempt to Photograph the Solar Corona." *Science* 6:142 (1886): 303 – 304.

---. "On the Limit of Solar and Stellar Light in the Ultra-Violet Part of the Spectrum." *Proceedings of the Royal Society of London* 46 (1889): 133 – 135.

Huggins, William and Margaret Huggins. "On the Spectrum, Visible and Photographic, of the Great Nebula in Orion." *Proceedings of the Royal Society of London* 46 (1889): 40 – 60.

---. "Notes on the Photographic Spectra of Uranus and Saturn." *Proceedings of the Royal Society of London* 46 (1889): 231 – 249.

---. "On a Re-Determination of the Principle Line in the Spectrum of the Nebula in Orion, and on the Character of the Line." *Proceedings of the Royal Society of London* 48 (1890): 202 – 231.

---"On Wolf and Rayet's Bright-Line Stars in Cygnus." *Proceedings of the Royal Society of London* 49 (1890 – 1891): 33 – 46.

---. "Preliminary Note on Nova Aurigae." *Proceedings of the Royal Society of London* 50 (1891 – 1892): 465.

---. "On Nova Aurigae." *Proceedings of the Royal Society of London* 51 (1892): 485 – 495.

---. "On the Bright Bands in the Present Spectrum Of Nova Aurigae." *Proceedings of the Royal Society of London* 54 (1893): 30 – 36.

---, "Further Observations on the Spectrum of the Spontaneous Luminous Radiation of Radium of Ordinary Temperature." *Proceedings of the Royal Society of London* 72 (1903 – 1904): 409 – 413.

---. "On the Spectrum of the Spontaneous Luminous Radiation of Radium at Ordinary Temperature." *Proceedings of the Royal Society of London* 72 (1903 – 1904): 196 – 199.

---. "On the Spectrum of the Spontaneous Luminous Radiation of Radium: Part III. Radiation and Hydrogen." *Proceedings of the Royal Society of London* 76 (1905): 488 – 492.

---. "On the Spectrum of the Spontaneous Luminous Radiation of Radium: Part III.

Radiation and Hydrogen." *Proceedings Royal Society of London* 76 (1905): 488 – 492.

---. "On the Spectrum of the Spontaneous Luminous Radiation of Radium: Part IV Extension of the Glow." *Proceedings of the Royal Society of London, Series A. Containing Papers of a Mathematical and Physical Character* 77 (1906): 130 – 131.

Huggins, William and William Arthur Miller. "On the Lines in the Spectra of Some of the Fixed Stars." *Philosophical Transactions of the Royal Society of London* 154 (1864): 413 – 435.

---. "On the Spectrum of a New Star in Corona Borealis." *Proceedings of the Royal Society of London* 15 (1866 – 1867): 146 – 149.

Huggins, William and William Pickering. "An Attempt to Photograph the Solar Corona." *Science* 6, no. 142 (1885): 362 – 363.

Jackson, Myles W. *Spectrum of Belief: Joseph von Fraunhofer and the Craft of Precision Optics*. Cambridge: MIT Press, 2000.

Jenkins, Alice. "Spatial Imagery in Nineteenth-Century Representations of Science: Faraday and Tyndall." In *Making Space for Science: Territorial Themes in the Shaping of Knowledge*, edited by Crosbie Smith and Jon Agar, 181 – 194. Manchester: University of Manchester, 1998.

King, H.C. *Exploration of the Universe: The Story of Astronomy*. London: Secker & Warburg, 1964.

Kohlstedt, Sally Gregory. "Women in the History of Science: An Ambiguous Place." *Osiris* 10 (1995): 39 – 58.

Kragh, Helge. *Conceptions of the Cosmos: From Myths to the Accelerating Universe: A History of Cosmology*. Oxford: Oxford University Press, 2007.

"Lady Huggins." *The Observatory* (1915): 255.

"Lady Huggins." *New York Times* (March 26, 1915): 13.

Lankford, John. "Amateurs and Astrophysics: A Neglected Aspect in the Development of a Scientific Specialty." *Social Studies of Science* 11 (1981): 275 – 303.

---. "Amateurs versus Professionals: The Controversy over Telescope Size in late Victorian Science." *Isis* 72 (1981): 11 - 28.

---. "The Impact of Photography on Astronomy." In *Astrophysics and Twentieth Century Astronomy to 1950,* edited by Owen Gingerich, 16 – 39. Cambridge: Cambridge University Press, 1984.

Levitt, Theresa. "' I thought this might be of interest …' The Observatory as Public Enterprise." In *The Heavens On Earth: Observatories and Astronomy in Nineteenth Century Science and Culture,* edited by David Aubin, Charlotte Bigg and H. Otto Sibum, 285 – 304. Durham: Duke University Press, 2010.

Lightman, Bernard. "'The Voices of Nature:' Popularizing Victorian Science." In *Victorian Science in Context*, edited by Bernard Lightman, 187 – 211. Chicago: University of Chicago Press, 1997.

---. *Victorian Popularizers of Science: Designing Nature for New Audiences*. Chicago: University of Chicago: 2007.

Liveing G. D. and J. Dewar. "On the Spectrum of Water." *Proceedings of the Royal Society of London* 30 (1879 – 1880): 580 – 582.

Lcokyer, Norman. "Spectroscopic Observations of the Sun." *Proceedings of the Royal*

Society of London 15 (1866 – 1867): 256 – 258.

---, "Notice of an Observation of the Spectrum of a Solar Prominence." *Proceedings of the Royal Society of London* 17 (1868 – 1869): 91 – 92.

MacLeod, Roy M. *The 'Creed of Science' in Victorian England.* Aldershot: Ashgate, 2000.

MacPherson, Hector. *A Century's Progress in Astronomy.* Edinburgh: William Blackwood and Sons, 1906.

Macpherson, James. *The Poems of Ossian.* New York: E. Kearny, 1846.

"Margaret Lindsay Huggins Obituary Notice." *Monthly Notices of the Royal Astronomical Society* 76 (1916): 278.

McMillan, Dorothy. *Queen of Science: Personal Recollections of Mary Somerville.* Edinburgh: Canongate Classics, 2001.

Meadow, Jack. *Science and Controversy: A Biography of Sir Norman Lockyer.* Cambridge: Massachusetts Institute of Technology, 1972.

---, "The New Astronomy." In *Astrophysics and Twentieth Century Astronomy to 1950,* edited by Owen Gingerich, 59 - 72. Cambridge: Cambridge University Press, 1984.

---. "The Origins of Astrophysics." In *Astrophysics and Twentieth Century Astronomy to 1950*, edited by Owen Gingerich, 3 – 15. Cambridge: Cambridge University Press, 1984.

---. *Victorian Scientist: The Growth of a Profession.* London: British Library, 2004.

Meek, Donald. "The Sublime Gael: The Impact of Macpherson's Ossian on Literary Creativity and Cultural Perception in Gaelic Scotland." In *The Reception of*

Ossian in Europe. edited by Howard Gaskill, 40 – 66. London: Thoemmes Continum, 2004.

Miller, William Allen. "On the Photographic Transparency of Various Bodies, and on Photographic Effects of Metallic and Other Spectra Obtained by Means of the Electric Spark [Abstract]." *Proceedings of the Royal Society of London* 12 (1862 – 1863): 159 – 166.

Milton, John. "Paradise Lost." In *John Milton: The Complete Poems*. Edited by John Leonard. London: Penguin Books, 1998.

Morus, Iwan Rhys. *Frankenstein's Children: Electricity, Exhibition, and Experiment in Early-Nineteenth-Century London.* Princeton: Princeton University Press, 1998.

---. *When Physics Became King*. Chicago: University of Chicago Press, 2005.

Neeley, Kathryn. *Mary Somerville: Science, Illustration and the Female Mind.* Cambridge: Cambridge University Press, 2001.

Newall, Hugh F. "Dame Huggins Lindsay Huggins." *Royal Astronomical Society* 76 (1916): 278 – 282.

North, John. *The Norton History of Astronomy and Cosmology*. New York: W.W. Norton & Company, 1995.

Ogilvie, Marilyn Bailey. "Marital Collaboration: An Approach to Science." In *Uneasy Careers and Intimate Lives: Women in Science,* edited by Pnina G. Abir-am and Dorinda Outram, 104 – 125. New Brunswick: Rutgers University Press, 1987.

Patterson, Elizabeth Chambers. *Mary Somerville and the Cultivation of Science, 1815 – 1840.* Boston: Martinus Nijhoff Publisher, 1984.

Pepys, W. H. "An Account of an Apparatus on a Peculiar Construction for performing

Electro-magnetic Experiments." *Philosophical Transactions of the Royal Society of London* 113 (1823): 187 – 188.

Proctor, Richard. *Other Worlds Than Ours*. London: A. L. Fowle, 1870.

Rauch, Alan. *Useful Knowledge: The Victorian, Morality, and the March of the Intellect*. Durham NC: Duke University Press, 2001.

Reiss, Peter and Ludwig Moser. "Ueber die magnetisirende Eigenschaft des Sonnenlichts." *Poggendorff's Annalen* xcii (1829): 563 – 592.

"Review of *On the Connexion of the Physical Sciences*," *Athenaeum* (15 Mar. 1834). In *Mary Somerville: Scientific Papers and Review*, edited by James Secord, 1 - 7. Bristol: Thoemmes Continuum, 2004.

"Review of *On the Connexion of the Physical Sciences*," *Edinburgh Review* (1834). In *Mary Somerville: Scientific Papers and Review*, edited by James Secord, 154 - 71. Bristol: Thoemmes Continuum, 2004.

"Review of *On the Connexion of the Physical Sciences*," *Literary Gazette* (1834). In *Mary Somerville: Scientific Papers and Review*, edited by James Secord, 1 – 5. Bristol: Thoemmes Continuum, 2004.

"Review of *On the Connexion of the Physical Sciences*," *Mechanic's Magazine* 20 (1834). In *Mary Somerville: Scientific Papers and Review*, edited by James Secord, 1- 13. Bristol: Thoemmes Continuum, 2004.

"Review of *On the Connexion of the Physical Sciences*," *The Printing Machine: Or, Companion to the Library* (1834). In *Mary Somerville: Scientific Papers and Review*, edited by James Secord, 78 – 80. Bristol: Thoemmes Continuum, 2004.

"Review of *On the Mechanism of the Heavens" Athenaeum* (1832). In *Mary*

Somerville: Scientific Papers and Reviews, edited by James Secord, 1-6. Bristol: Thoemmes Continuum, 2004.

"Review of *On the Mechanism of the Heavens" Edinburgh Review* (April 1832). In *Mary Somerville: Scientific Papers and Reviews,* edited by James Secord, 1 –25. Bristol: Thoemmes Continuum, 2004.

"Review of *On the Mechanism of the Heavens" Literary Gazette* (1831). In *Mary Somerville: Scientific Papers and Reviews,* edited by James Secord, 1 – 5. Bristol: Thoemmes Continuum, 2004.

"Review of *On the Mechanism of the Heavens" Monthly Review* 1 (January 1832). In *Mary Somerville: Scientific Papers and Review*, edited by James Secord, 133 – 141. Bristol: Thoemmes Continuum, 2004.

"Review of *On the Mechanism of the Heavens" Quarterly Review* 1 (July 1832). In *Mary Somerville: Scientific Papers and Review*, edited by James Secord, 537 – 539. Bristol: Thoemmes Continuum, 2004.

Ronan, Colin A. *Their Majesties' Astronomers: A Survey of Astronomy in Britain Between the two Elizabeths*. London: The Bodley Head, 1967.

Roscoe, H. E. and T. E. Thrope. "On the Absorption-spectra of Bromine and of Iodine Monchloride." *Philosophical Transactions of the Royal Society of London* 167 (1877): 207 – 212.

Rousseau, Pierre. *Man's Conquest of the Stars*. London: Jarrolds Publishers, 1959.

Sabine, Edward. "The Bakerian Lecture. An Account of Experiments to determine the Amount of the Dip of the Magnetic Needle in London, in August 1821; with Remarks on the Instruments which are usually Employed in Such

Determinations." *Philosophical Transactions of the Royal Society of London* 112 (1821): 1 – 21.

---. "President's Address." *Proceedings of the Royal Society of London* 13 (1864): 494 – 520.

Schaffer, Simon. "The Nebular Hypothesis and the Science of Progress." In *History, Humanity and Evolution: Essays for John C. Greene*, edited by James R. Moore. 131 – 164. Cambridge: Cambridge University Press, 1898.

---. "Physics Laboratories and the Victorian Country House." In *Making Space for Science: Territorial Themes in the Shaping of Knowledge*, edited by Crosbie Smith and Jon Agar, 149 – 180. Manchester: University of Manchester, 1998.

---. "Where Experiments End: Tabletop Trials in Victorian Astronomy." In *Scientific Practice: Theories and Stories of Doing Physics*, edited by Jed Z. Buchwald, 257 – 299. Chicago: University of Chicago Press, 1995.

Schuster, Arthur. "On the Spectra of Metalloids-Spectrum Oxygen." *Philosophical Transactions of the Royal Society of London* 170 (1879): 37 – 54.

Scoresby, William. "Experimental and Observations on the Development of Magnetical [sic] Properties in Steel and Iron by Percussion." *Philosophical Transactions of the Royal Society of London* 112 (1822): 141 – 152.

Secord, James. *Victorian Sensation: The Extraordinary Publication, Reception, and Secret Authorship of 'Vestiges of the Natural History of Creation'.* Chicago: University of Chicago Press, 2003.

---, "Introduction." *Mary Somerville: On the Mechanism of the Heavens*. Bristol:

Thoemmes Continuum, 2004.

---, "How Scientific Conversation Became Shop Talk." In *Science in the Marketplace: Nineteenth Century Sites and Experiences*, edited by Aileen Fyfe and Bernard Lightman, 23 – 59. Chicago: University of Chicago Press, 2007.

Smith, Crosbie and Jon Agar. "Introduction: Making Space for Science." In Making *Space for Science: Territorial Themes in the Shaping of Knowledge*, edited by Crosbie Smith and Jon Agar, 1 – 24. London: University of Manchester, 1998.

Somerville, Martha. *Personal Recollections from Early Life to Old Age of Mary Somerville.* London: John Murray, 1873.

Somerville, Mary. "On the Magnetizing Power of the More Refrangible Solar Rays." *Philosophical Transactions of the Royal Society of London* 116 (1825): 132 – 139.

---. *On the Mechanism of the Heavens*. London: John Murray, 1831.

---. *On The Connexion of the Physical Sciences*. London: John Murray, 1834.

---, "Experiences sur la transmission des rayons chimiques du spectre Solarie, a travers, differents milieux. Extrait d'une lettre de Mme Somerville a M. Arago." *Comptes rendus hebdomadaires des séances de L'Academie des Sciences* 3 (1836): 473 – 476.

---. "On the Action of the Rays of the Spectrum on Vegetables Juice. Extract of a letter from Mrs. M. Somerville to Sir J.F.W. Herschel, Bart., F.R.S. dated Rome, 1845." *Abstracts of the Papers Communicated to the Royal Society of London* 5 (1845): 569 – 70.

---. "On the Action of the Rays of the Spectrum on Vegetable Juice. Extract of a letter from Mrs. M. Somerville to Sir J.F.W. Herschel, Bart. F.R.S. dated Rome, 1845." *Philosophical Transactions of the Royal Society of London* 136 (1846): 111 – 120.

Staley, Richard. "Michelson and the Observatory: Physics and the Astronomical Community in Late Nineteenth-Century America." In *The Heavens on Earth: Observatories and Astronomy in Nineteenth-Century Science and Culture,* edited by David Aubin, Charlotte Bigg, and H. Otto Sibum, 225 – 252. Durham: Duke University Press, 2010.

Steinle, Friedrich. "Looking for a 'Simple Case': Faraday and Electromagnetic Rotation." *History of Science* 33:2 (1995): 179 – 202.

Taylor, Richard and Richard Phillips. "Magnetizing Power of the Solar Rays." *The Philosophical Magazine or Annals Chemistry, Mathematics, Astronomy, Natural History, and General Science* (1830): 155.

Tenn, Joseph. "The Hugginses, the Draper, and the Rise of Astrophysics." *Griffith Observer* (1986): 1 – 15.

Tennyson, Alfred. *Alfred Lord Tennyson: Selected Poems*. Toronto: Penguin Books, 2008.

Tucker, Jennifer. *Nature Exposed: Photography as Eyewitness in Victorian Science*. Baltimore: John Hopkins University, 2005.

Varey, Simon. *Space and the Eighteenth-Century Novel.* Cambridge: Cambridge University Press, 1990.

Verschuur, Gerrit L. *Hidden Attraction: The History and Mystery of Magnetism.* New York: Oxford University Press, 1993.

Wallace, Alfred Russel. *The Wonderful Century: Its Successes and its Failures.* Toronto: G. Morang, 1898.

Waterhouse, J. "On the Reversed Photographs of the Solar Spectrum beyond the Red, Obtained on a Collodion Plate." *Philosophical Transactions of the Royal Society Of London* 24 (1875 – 1876): 186 – 189.

Whewell, William. "Review of On the Connexion of the Physical Sciences." *Quarterly Review* 51 (1834): 54 – 58.

Whiting, Sarah Frances. "Lady Huggins." *Science, New Series* 41 (1915): 853 – 855.

---. "The Tulse Hill Observatory Diaries." *Popular Astronomy* (1916): 158 – 63.

Whyte, Nicholas. *Science, Colonialism and Ireland (Irish Cultural Studies)* Cork: Cork University Press, 2000.

Williams, Pearce, L. *Michael Faraday.* London: Chapman & Hall, 1965.

---, *The Origin of Field Theory.* New York: University Press of America, 1989.

Wollaston, William. "On Cystic Oxide, a New Species of Urinary Calculus." *Philosophical Transactions of the Royal Society of London* 100 (1810): 223 – 230.

---. "On the Non-Existence of Sugar in the Blood of Persons Labouring under Diabetes Mellitus." *Philosophical Transactions of the Royal Society of London* 101 (1811): 96 – 109.

---, "A Synoptic Scale of Chemical Equivalent." *Philosophical Transactions of the Royal Society of London* 104 (1815): 1 – 22.

---. "On Cutting Diamonds." *Philosophical Transactions of the Royal Society of London* 106 (1816): 265 – 269.

---. "Observations and Experiments on the Mass of Native Iron Found in Brasil [sic]." *Philosophical Transactions of the Royal Society of London* 106 (1816): 281 – 285.

---. "On the Finite Extent of the Atmosphere." *Philosophical Transactions of the Royal Society of London* 112 (1822): 89 – 98.

---. "On the Apparent Magnetism of Metallic Titanium." *Philosophical Transactions of the Royal Society on London* 113 (1823): 400 – 401.

---. "On Metallic Titanium." *Philosophical Transaction of the Royal Society of London* 113 (1823): 17 – 22.

Notebooks

This dissertation would not have been possible without access to six Notebooks, which were gifted from Margaret Huggins to Wellesley College in 1915. The Hugginses Notebooks are housed in the Special College at Wellesley and were generously made available for study and photography by the archivists on site.