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CHARLOTTE MOORE SITTERLY

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Abstract: Charlotte Moore Sitterly was a scientist in an era when it was rare for a woman to have the opportunity to devote her life to forefront science. Following her graduation from Swarthmore College in 1920, she accepted a position at Princeton University as an assistant to Henry Norris Russell. In 1925 she started a study of the solar spectrum. She could then not know that she would devote much of her scientific career to gathering basic atomic data that are invaluable to the scientific community, even today. In 1931 she obtained a Ph.D. degree at the University of California, Berkeley, and returned to Princeton as a staff member of the Princeton University Observatory. In 1945 Moore moved to the National Bureau of Standards (NBS), to supervise preparation of the widely-used tables of atomic energy levels. Following the successful launching (1946) of a V2 rocket to obtain the ultraviolet spectrum of the Sun, she started working also with Richard Tousey and his group at the Naval Research Laboratory (NRL). Ultimately, they extended the solar spectrum down to 2200 angstroms. She continued her affiliations with both the NBS and the NRL until her death in 1990. Charlotte Moore was a rare scientist who devoted her career to obtaining accurate numbers, thus enabling the scientific community to open her tables and know that the data are reliable.

Keywords: Sitterly, Moore, multiplet tables.

1 INTRODUCTION

Charlotte Moore (Figure 1) was born in 1898 in Ercildoun, a country village in Chester County, Pennsylvania. This was an auspicious time to be born for one who would spend her adult life insuring that spectroscopists would have access to accurate wavelengths. One year before her birth, Henry A. Rowland, Johns Hopkins University's first Professor of Physics, completed publication of 20,000 lines in the solar spectrum. These would become part of Charlotte Moore's library, and today astronomers still use Rowland-style gratings. One year after her birth, Lewis E. Jewell of Johns Hopkins defended his (Jewell's) measurements of Hδ in the solar spectrum. It was Jewell who measured and calculated the values published in Rowland's tables. In that same year, 1899, Julius Scheiner, at the Potsdam Observatory, published the first-known spectrum of the Andromeda Galaxy, and announced that it was composed of stars like the Sun. Charlotte was two years old when Samuel P. Langley extended the solar spectrum still farther into the infrared (see Figure 2). Charlotte was 16 years old when Bohr advanced his model of the hydrogen atom.

Charlotte's parents had no college degrees, but they were teachers who taught in an 'old style' (her term) academy and later became interested in public school education. They worked in the education system of Chester County for many years, and her father became Superintendent of Public Schools. Her parents were strict about learning, especially grammar. Charlotte was the youngest in a family of three daughters and one son. They all attended public schools.

Because of their Friends (Quaker) background, her parents chose Swarthmore College for Charlotte, who apparently had little choice in the decision. When interviewed by David DeVorkin in 1978 (Sitterly, 1978), Moore said:

> We were not well off financially. I had to do a lot of extra work to get through college. I used to do substitute teaching because it paid well. Substitute teaching and tutoring were the two fields in which a woman could get some money toward working her way through college; almost everything else favored the men. I taught every grade from first grade up to senior high school.

Moore's attitude toward college was to learn as much as possible in various fields. Ultimately she majored in mathematics, and took an astronomy course using Forest Ray Moulton's general astronomy text. She graduated in 1920, but failed to get the graduate fellowship that she applied for. Her advisor, John A. Miller, surely recognized her as an unusual student, when he suggested that she consider taking a job with

Figure 1: Charlotte Emma Moore Sitterly, 1898–1990 (courtesy: National Institute of Standards and Technology).

Henry Norris Russell at Princeton. She neither made an application nor met Russell in advance, but the job was hers. Her brilliance was evident even then.

In those years, Russell was devoting his time to problems of spectroscopy, chemical abundances, and stellar evolution. When Charlotte joined him at Princeton, she was his only assistant, although the work he needed done would have taxed several. Her office was located in an old back room over the furnace, from which she breathed coal fumes all the time. As Russell's 'assistant' she supplied Russell with whatever materials he needed, and he usually needed them in a hurry. She got to know Russell's graduate students, Donald Menzel, Theodore Dunham, and Bancroft Sitterly, among others. She would marry Bancroft over a decade later.

Nancy Roman (1991: 1492) has written:

> Russell was a quick and brilliant thinker. Although he did tell Charlotte how to do the various things he wanted done, his explanations were quick, leaving her to fill in the details and all of the background.

Her first job was to determine an accurate position of the Moon from photographic plates, a procedure that Charlotte described as 'terribly involved'. Shortly after, she was working on double stars and a "… wealth of spectroscopic material." (Sitterley, 1978) She attended some of Russell's evening graduate school lectures, and within five years she was the first author on a Moore-Russell publication (Moore and Russell, 1926).

She was also exhausted. So in 1925 she asked Russell for leave to work at Mt. Wilson, to help with the revision of the *Rowland Astronomical Tables* (St. John, et al, 1928). She worked mostly with Charles St. John, and was called a computer, as were all the women working there. She considered this an insult. She remained in touch with Russell, and saw him each summer when he spent one month at Mt. Wilson. Charlotte returned to Princeton in 1928, continuing the spectroscopic work. In 1931 she earned her Ph.D. from the University of California at Berkeley, after two years of graduate study while Russell was away in Europe. The first year she took courses at Berkeley, but she spent the second year at Mt. Wilson Observatory offices in Pasadena analyzing sunspot spectra. Princeton's graduate school would open to special women only in 1961.

Although she could have accepted other positions, Charlotte returned to Princeton in 1931, and Russell offered her a Research Assistantship. In 1936, she became a Research Associate. In 1937, she married Bancroft Sitterly, the graduate student she had known since their Princeton days in the early 1920s. She continued to gather data for Russell, and he continued to ask her for "…his colossal jobs. He never asked for small ones. He thought I over stressed (accuracy), but I would never give him a list that I wouldn't stand in back of." (Sitterly, 1978). Perhaps due to her Quaker upbringing and to her parents' examples, Charlotte may have recognized that her major role in science could be to make accurate wavelength values available to the scientific community. But regardless of her intentions, she is remembered best for the several editions of her monumental work, *A Multiplet Table of Astrophysical Interest* (Moore, 1933, 1945, reprints in 1959 and 1972; Figure 3). Even today, these publications identify her as an important scientist.

In 1945, Russell was failing, and Charlotte moved to the US National Bureau of Standards. She continued some work with Russell, but she intended to complete her work on the infrared solar spectrum with Harold Babcock. Edward Condon, the Bureau Director, wanted a complete project on atomic energy levels, which was an enormous undertaking.

However, for Charlotte, there were thrills yet to come. In 1946, the Naval Research Laboratory (NRL) launched an XUV rocket and obtained its first successful rocket solar spectrum. Charlotte was so excited that she called Richard Tousey, whom she did not know, to congratulate him on the success. She recalled a day long ago in Princeton, when she and Russell and others were discussing what the ultraviolet solar spectrum would look like. They had fun guessing, but concluded that they would never live to see it, because no one could build a spectrograph stable enough.

At the Bureau of Standards, the Atomic Energy Levels Program was Charlotte's full time work, and the XUV program had to be fitted in when possible. But it did become a large part of her interest. In later years she divided her time between the Bureau of Standards and the NRL. She continued gathering data and organizing tables of atomic spectra long after retirement age, publishing her last collection (Moore, 1985) shortly before her 87th birthday.

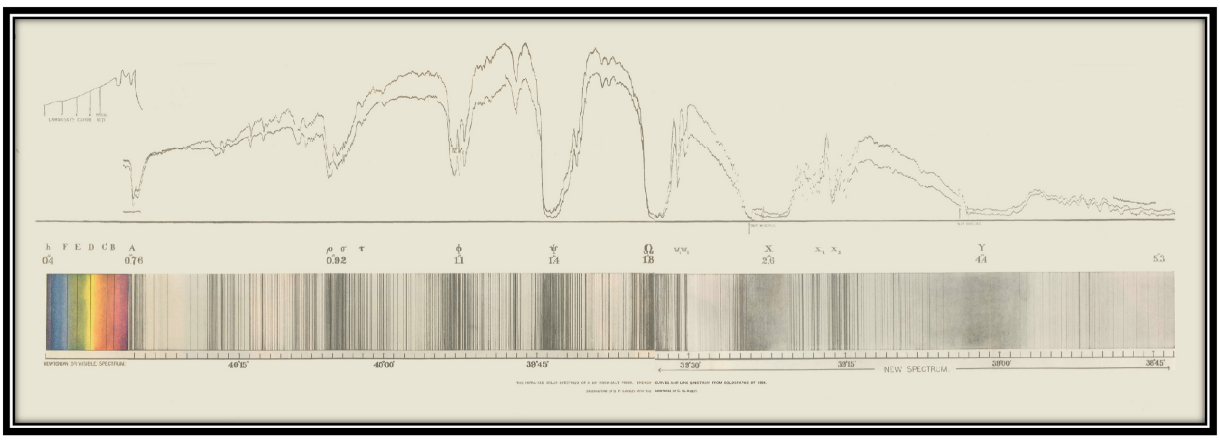

Figure 2: The infra-red solar spectrum of a 60 deg rock-salt prism. From bolographic observations of 1897-1898 (after Langley, 1900: Plate 20).

To Vera Rubin with
appreciation of her
valuable assistance
C. E. Moore Sitterly

NATIONAL BUREAU OF STANDARDS

Technical Note

36

NOVEMBER 1959

A MULTIPLET TABLE OF ASTROPHYSICAL INTEREST

Revised Edition

Charlotte E. Moore

Part I—Table of Multiplets

Part II—Finding List of All Lines in the Table of Multiplets

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Figure 3: The title page of the 1959 revised edition of the *Multiplet Table* (Moore, 1959).

The scientific community recognized that her work was a gift to all, and Moore was awarded numerous prizes. In 1937 she received the second Annie Jump Cannon Award of the American Astronomical Society, an award that is reserved for women. But her highest honors came much later: the William F. Meggers Award of the Optical Society of America, for outstanding work in spectroscopy, in 1972, and the Catherine Wolfe Bruce Gold Medal of the Astronomical Society of the Pacific, for lifetime achievement, in

1990. She was notified of the latter award, but died before it could be formally presented to her.

For more details of Charlotte's life, I highly recommend the extensive and interesting interview that David DeVorkin recorded in 1978 (Sitterly, 1978). It is clear from Charlotte's first words that she is a 'take charge' person. In the interview, she said: "My own library was not very extensive until my husband supplemented it with his good books." To this, David, who surely intended to start from the beginning, replied, "Yes, we'll talk about that later. Dr. Sitterly, I know that you were born in 1898 in Ercildoun", and they went on from there. Of the many articles following her death in 1990, the one written by Nancy Roman (1991) for the *Bulletin of the American Astronomical Society* is especially sensitive and interesting.

2 PERSONAL CONTACT

I will conclude this brief account of Charlotte Moore Sitterly's life with a few personal comments. I no longer remember when and where I met Dr Sitterly. In her conversation with DeVorkin, she describes phoning Dr Tousey at the Naval Research Lab after the first successful rocket (X1JV) ultraviolet spectrum of the Sun had been safely returned in 1946 (Baum, et al, 1946). I worked in Dr Tousey's division as a summer student in 1947 and 1948, and my first project was to determine the optical properties of the spherical glass bead that was the detector for the rocket flight. I do not remember whether I met Charlotte during that time. I do remember that I periodically went with other scientists (all male) to the Naval Station in southern Maryland where the rockets were launched. I also remember that there was no ladies room on the base, so I had to use the Captain's bathroom. I suppose that Charlotte did also.

In 1952 I returned to Washington with a husband, an infant, and a Master's degree in astronomy, having studied physics under Richard Feynman, Philip Morrison, and Hans Bethe at Cornell University while my husband, Bob, was completing his Ph.D. there. I entered the Georgetown University graduate school in astronomy, the only astronomy graduate program in Washington, and took a wonderful course in spectroscopy with Carl C. Kiess, of the National Bureau of Standards. He tried to interest me in looking for and classifying the weak lines in the solar spectrum for my doctoral thesis, but I was interested in galaxies. I chose to write my thesis under George Gamow, who was then in the George Washington University Physics Department, but my Ph.D. degree is from Georgetown University, and it is in astronomy.

In my graduate student years there were few women astronomers in Washington. I took advantage of Charlotte's friendliness and her willingness to discuss astronomy and spectroscopy with a young student. Periodically I would visit her at the Bureau of Standards (now NIST) to discuss spectroscopy and astronomy. I started measuring spectra for her, using a measuring machine at Georgetown University that could accommodate her enormously-large solar plates from Mt. Wilson. They were too large for the Bureau of Standards measuring machinery. I continued visiting her over many years, talking spectroscopy, and being introduced to many of the Bureau of Standards spectroscopists and visitors. Occasionally Bob and I would drive her to lectures of interest. She was a brilliant scientist, a lovely lady, and a delight to know.

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Vera Rubin is an astronomer at the Department of Terrestrial Magnetism of the Carnegie Institution of Washington in Washington, DC, USA. She is best known for her work on the rotation curves of galaxies, which convinced most astronomers that the galaxies contain vast amounts of dark matter. She has been awarded many honors, including the Gold Medal of the Royal Astronomical Society, the Henry Norris Russell Lectureship of the American Astronomical Society, the Catherine Wolfe Bruce Gold Medal of the Astronomical Society of the Pacific, the Cosmology Prize of the Peter Gruber Foundation and the U.S. National Medal of Science.