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The double-image micrometer of Giovanni Battista Amici

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Giovanni Battista Amici (Modena, 1786 – Florence, 1863) was one of the most renowned instrument makers in 19th century Europe. He constructed a variety of scientific instruments, including reflecting and refracting telescopes, microscopes, micrometers, camerae lucidae, prisms, objective lenses, and other precision measuring devices. Amici also made original contributions to astronomy, especially in the observation of double stars, and he carried out research in botany and histology throughout almost forty years of microscopic observations.

Several historiographical studies exist on Amici's scientific activities and instruments.ⁱ Nevertheless, little attention has been paid so far to his double-image micrometer.ⁱⁱ This article is aimed at providing information about Amici's micrometers. The analysis is focused on its construction, circulation and astronomical use in the 19th century, and it is based mainly on primary sources such as Amici's published and unpublished correspondence; the articles on the double-image micrometer published by both Amici and his contemporaries; and the *Libro de' Conti*, the workshop account notebook that Amici compiled from 1817 until 1863.ⁱⁱⁱ

Amici turned his attention to micrometers for astronomical observations in the earliest phase of his extensive career as an instrument maker. This was shortly after the construction of two reflecting telescopes of 6.5-inch diameter, which in 1811 were awarded the gold medal by the *Istituto delle Scienze* of Milan. 'Back from Tuscany,' Amici announced in August 1812 to Francesco Carlini (1783-1862), astronomer at the Brera Observatory, 'I will dedicate myself to constructing a micrometer'.^{iv} In his correspondence with Baron Franz Xaver von Zach (1754-1832), Amici later acknowledged that an initial source of inspiration had been the work of the Abbé Alexis-Marie de Rochon (1741-1817). Rochon's work, published in 1812 in *Le Moniteur Universel*, was devoted to the geodetic and naval use of a double refraction micrometer capable of measuring the diameters of the Sun and the Moon. Amici was also interested in measuring very small angles with micrometers that could be applied to large Newtonian telescopes.^v

Amici's intention was therefore to construct an optical instrument to measure celestial diameters and distances that would be versatile and easy to use. In addition, this instrument should be highly precise, a property that, according to Amici, was of fundamental importance in astronomical observations, no less than the observer's eye and the telescope itself. This was the case, for instance, with the lamp micrometer built by William Herschel (1738-1822). According to Amici, Herschel had been able to measure very small distances thanks to the great quality of his telescopes and his skill as an observer, rather than the excellence of his micrometer. Conversely, double-image micrometers could not be applied to large Newtonian telescopes without being awkward and error-prone. This was the case with the prismatic micrometer, the objective micrometer by John Dollond (1706-1761), and the micrometer designed by Jesse Ramsden (1735-1800).

Amici considered the strengths and weaknesses of the micrometers based on the principle of the bisected lens. In the light of the objections raised about them by the Astronomer Royal, Nevil Maskelyne (1732-1811), Amici concluded that there were essentially two problems. The first was that it was extremely difficult to build lenses that could be used with large catadioptric telescopes. The second concerned the issue of the lens aberration. The solution proposed by Amici was a divided, concave (negative) lens that should be introduced between the eye-piece and the object glass (Fig. 1). The rays coming from the object glass were received by the bisected lens of the micrometer before they met at the focal point. A double image was then produced by separating the two segments of the lens, and a screw made it possible to measure the separation (Fig. 2). This meant that placing the micrometer between the objective and the eye-piece would overcome the imperfections indicated by Maskelyne, since it eliminated the first one, and greatly reduced the second one. Because of its position Zach later named this micrometer 'amphibious', since it was neither an objective device, nor an ocular one.^{vi}

The micrometer was nevertheless limited to measuring only small angles. Amici therefore considered the application of two achromatic prisms inside the telescope, near the lenses of the micrometer. These prisms had a refraction angle of about sixteen minutes and thirty seconds, and therefore were able to measure wider angles, such as the diameters of the Sun and the Moon. As reported in his correspondence to Carlini, Amici later reconsidered this feature, due to the difficulty of getting truly achromatic prisms.^{vii} He decided to substitute the prisms by two small mirrors (Fig. 3). Rather than using the term 'heliometer', Amici referred to this kind of instrument as a 'reflection micrometer'. It was mainly due to Giovanni Battista Donati (1826-1873) that this kind of micrometer became known as 'Amici's heliometer'.^{viii}

Amici reported these considerations in the article ‘Descrizione di un nuovo micrometro’, which was presented in 1814 and published in 1816 in *Memorie di Matematica e di Fisica della Società Italiana delle Scienze*. This was in fact the very first scientific publication produced by Amici.

Amici’s efforts to improve his instrument continued until 1823, when he was eventually able to produce a double-image micrometer that could be adapted to large telescopes, and fixed to small portable telescopes as well. This portable telescope, the *cannocchiale micrometrico* or distance measurer, was intended to be used for terrestrial observations (Fig. 4).

In January and November 1823, two letters to Zach were translated into French and published in the *Correspondance astronomique, géographique, hydrographique et statistique* edited by Zach himself. In these letters, Amici gave details about his bisected lens micrometer and described the terrestrial distance measurer, respectively.^{ix} Moreover, Zach introduced Amici’s micrometer to his international network of ‘learned men’, among whom Francis Baily (1774-1844) and especially Sir John Herschel (1792-1871). In this context, it is important to note that Zach’s scientific contacts played a fundamental role. After 1823 Amici’s micrometers became in fact widely known at the international level.

Several micrometers constructed by Amici were sold, donated, or just mentioned by his contemporaries in publications or letters. The historical reconstruction of what happened to these pieces has resulted in a list of all Amici’s micrometers that we know about, which is presented hereafter. The main source of the information listed is the *Libro de’ Conti*, especially for the recipients and the payment dates. The analysis has been integrated with Amici’s correspondence and the diary of his workshop’s visitors.^x The list is chronologically ordered, and refers to the instruments that were used with astronomical and terrestrial telescopes, whereas the ocular micrometers that Amici built for his microscope eyepieces are not included.

- From 1813 on: Amici’s personal micrometers. The exact number of pieces belonging to Amici personally is not clear. For his own astronomical observations at his country house *Villa della Madonnina*, Amici used one or two double-image micrometers with two reflecting telescopes of 8-foot focus and apertures of 11 and 12 inches, respectively. This was the case, for example, of the observation of the annular solar eclipse of September 7, 1820, as well as the daylight observations of Jupiter satellites early in February 1822. Furthermore, Amici brought a piece with him during his 1827 trip to London (see the item on Pearson, June 1826). In letters to Zach, Amici claimed that ‘several micrometers’ were available at his workshop in Modena. Later his instruments were

transferred from Modena to Florence, when Amici moved there in 1831. Further pieces, among which at least a double-image micrometer, were constructed at the workshop attached to the *Reale Museo di fisica e storia naturale* in Florence, the institution where he had an official position as astronomer. In June 1858, Amici observed Donati's Comet (C/1858 L1) with a small refracting telescope and a double-image micrometer. After Amici's death, a number of lists were compiled between 1865 and 1875 of the instruments built by him, which were available at the Observatory in Florence. In particular, these inventories report several instruments for astronomical usage, among which: a double-image micrometer applied to a reflecting telescope of 30-cm diameter and 2.6-m focus; an achromatic telescope of 24-cm diameter and 31-dm focus (the so-called *Amici II*) with a double-image micrometer; an unspecified number of double-image micrometers; a distance measurer (*cannocchiale micrometrico*) and a heliometer, both based on the principle of the divided lens.^{xi} With regard to pieces that have survived until today, the double-image micrometer which is currently exhibited at the Museo Galileo in Florence is signed 'Amici Modena' (Fig. 1). The Museo Galileo also preserves a piece catalogued as 'Amici's heliometer' (Fig. 3).

- c. 1813: Amici constructs an annular micrometer for the 3-foot Dollond telescope of the Bologna Astronomical Observatory (Fig. 5).

- 1817, July 5: an 8-foot Newtonian telescope with a double-image micrometer is sold to the King of Sardinia (total price: 6.000 francs). Following Meschiari's analysis, this telescope was later used by Giovanni Plana (1781-1864) at the Turin Astronomical Observatory.^{xii} In fact, among the instruments collected at this observatory there is a double-image micrometer signed 'Amici Modena'.

- 1823, May 26: a micrometer, recipient unknown (230.20 francs).

- 1823, September: Amici donates a double-image micrometer to Zach. The occasion was a visit to Zach in Genoa that eventually took place in September 1823 after a postponement due to the death of Amici's father (May 1823).

- 1824: in late August or early September Amici donates a distance measurer to Herschel, on the occasion of a brief stay of Herschel in Modena during his travels around Italy. Herschel had already met Amici on April 29, 1824. They applied the micrometer to celestial objects, and measured the distance of the two stars of Polaris, as well as Jupiter's polar diameter. After his return to England, Herschel exhibited the micrometer at the first seasonal meeting of the Royal Astronomical Society,

which occasion was reported in the *Philosophical Magazine* (30 November 1824). Herschel and Amici then exchanged their observations on double stars, and commented on them. For instance, Amici did observe α Herculis as triple, while Herschel did not. Conversely, Herschel thought that all Amici's distances were rather small, some of them – like that of ϵ Boötis – being too little.^{xiii} In his articles Herschel reported some observations made by Amici.^{xiv} Early in 1826, Amici was able to obtain micrometer measurements of about two hundred stars. Nevertheless, Amici never published his catalogues (Fig. 6). In 'Notes on the Progress of Double-Star Astronomy' (1900), William Joseph Hussey (1862-1926) claimed that early in the 1820s there were just four double-star observers then living: Amici, Herschel, William Struve (1793-1864), and James South (1785-1867).^{xv}

- 1824, September: a distance measurer is bought by Plana for the Turin Observatory (230 Italian *lire*). The instrument was sent there in March 1825, and paid for on April 19, 1825.

- 1824, September 26: Amici mentions in a letter to Plana a distance measurer requested by an amateur observer from London.^{xvi}

- 1825, February: a micrometer is delivered to Giuseppe Bianchi (1791-1866), astronomer at the University of Modena (350 francs). In 1834 Bianchi compiled an inventory of the instruments available at the Observatory of Modena, which had been officially inaugurated in 1827. Bianchi mentions a double-image micrometer of Amici applied to a 30-inch Dollond achromatic telescope, as well as Amici's equatorial telescope of 2.5-foot focus with a filar micrometer. The latter was probably the filar micrometer which is currently attached to the Amici transit instrument exhibited at the Modena Observatory. Among the observations that Bianchi carried out with the Amici double-image micrometer, it is worth mentioning the measurement of the diameter of Venus (1831) and the distances of Jupiter's satellites (1836). It is interesting to note that Domenico Ragona (1820-1892), who succeeded Bianchi as the director of the Modena Observatory, reported in 1868 that a new double-image micrometer constructed by Amici had been 'recently' acquired. Ragona claimed that he had been able to put this micrometer into operation, and to adapt it to the new equatorial telescope. He used the micrometer to observe the Pleiades, Jupiter's satellites, and Venus. However, in Ragona's article there is no mention of the double-image micrometer previously used by Bianchi.^{xvii}

- 1825, February: a double-image micrometer is delivered to Santini, director of the Padua Astronomical Observatory.^{xviii} Santini's interest in this instrument dates back to 1817, when he read

Amici's first article on it, and considered its use with a 4-foot achromatic telescope. Nevertheless, Santini was not able to acquire the necessary funds to buy it, at least until late 1824. He essentially used the micrometer to measure Jupiter's and Saturn's diameters, as well as Jupiter's satellites' distances. A description of this instrument appeared in Santini's work *Teorica degli stromenti ottici destinati ad estendere i confini della visione naturale* (1828).

- 1825, July 15: a distance measurer sold to Poldi, Parma (230 francs).

- 1825: around the end of the year, Herschel receives the double-image micrometer that he had requested from Amici when they met in Modena in 1824. According to correspondence from Herschel, the instrument 'narrowly escaped destruction at the Custom House where the box containing it was violently forced open & broken to pieces. However it escaped quite unhurt & I hope soon to fix it on my large telescope'.^{xix} This was a 7-foot achromatic telescope. The cost of the micrometer was 8 gold *luigi*. As requested by Amici, this amount was remitted to him by means of purchasing scientific journals which Herschel sent to Amici. Copies were sent, for instance, of the *Memoirs of the Astronomical Society*, the *Edinburgh Philosophical Journal*, and the *Journal of the Royal Institution of Great Britain*. As from 1854, Herschel lent the micrometer to William Rutter Dawes (1799-1868). Dawes, who successfully used it in conjunction with a filar micrometer, commented: 'It was, I believe, but little if all used by Sir John in his observations at the Cape. As I was desirous of trying such a micrometer on my refractor, Sir John lent it me for that purpose, and I found it very efficient on many objects. In reply to a favourable report of its performance, Sir John most kindly made me a present of it as a new year's gift on the first of January, 1855'.^{xx} Measurements of the position angles of double stars with the divided glass micrometer were reported by Dawes in his 'Catalogue of Micrometrical Measurements of Double Stars' (1867). Regarding observations of double stars carried out in the southern hemisphere, it is worth mentioning that James Dunlop (1793-1848), who had gone to Paramatta in 1823, completed a catalogue with accompanying micrometer measures. These measurements were obtained with a double-image micrometer based on Amici's principle.^{xxi} An Amici double-image micrometer, said to have been made for Herschel, is currently recorded as being held by the Science Museum's Small to Medium Object Store Blythe House, London (Fig. 7).

- 1825: together with the micrometer mentioned above, Amici sent Herschel a distance measurer commissioned by Sir Richard Rawlinson Vyvyan (1800-1879). As reported by Herschel, 'Sir R. Vyvyan's [instrument] came perfectly safe & I have written to advertise him of its arrival'.^{xxii}

- 1826, May 1, and May 6: two terrestrial telescopes are sent to Paolucci and His Royal Highness (*Sua Altezza Reale*) the Prince of Salerno, respectively (230 francs each).

- 1826, June 3: a micrometer is sold to William Henry Fox Talbot (1800-1877). Talbot visited Amici in September 1822 and March 1826. Actually, Amici had completed a first piece already in February 1823, and then sent it to Talbot. However, somehow the micrometer could not be delivered, and was returned to Amici. Therefore, the Italian instrument maker decided to sell the instrument to another buyer. In the light of Talbot's renewed interest, Amici made another piece for him, which was in fact paid for in June 1826 (240 francs).^{xxiii}

- 1826, June 3: the entry in the *Libro de' Conti* reads a 'micrometer for telescope' (250 francs/10 pounds) to William Pearson (1767-1847). It is not clear whether this was a double-image micrometer. Actually, a double-image micrometer made by Amici is described in detail in Pearson's *Introduction to practical astronomy* (1829). The piece was in fact the instrument that Amici brought with him on his 1827 trip to Paris and London: 'At the time when we printed our descriptions of the various micrometers,' Pearson noticed in his treatise, 'we had not seen the double-image micrometer of the ingenious Amici of Modena (...); but the distinguished inventor has since been in England, and has supplied us with the identical instrument, which he had used in observations of double stars'.^{xxiv}

- 1826, September: Amici constructs a double-image micrometer for Thomas John Hussey (1792-1854). In April 1826, Herschel informed Amici that 'A friend of mine Mr. Hussey who is furnishing an observatory, is very desirous to possess one of your double image Micrometers in all respects similar to that you were so good as to get executed for me, & with the same divided circle for angles of position, only read off with a vernier to minutes (this is essential, as by a peculiar mode of using it, I have reason to believe in some cases it will not be safe to trust to estimation for the minutes), and capable of being like mine, for a telescope of 20 foot focus or, if necessary for one of 7 or 10 foot (...). Mr. Hussey also wishes to know whether you would undertake to make him a reflecting mirror of 12 inches in diameter and 20 foot focus, & at what price?'.^{xxv} Actually, Amici sent the micrometer to Hussey in September 1826, while he brought with him the 12-inch mirror requested by Hussey during his trip to London in the summer of 1827.

- 1827, May: when Amici visited Paris in 1827, François Jean Dominique Arago (1786-1853), astronomer at the Paris Observatory, commissioned a double-image micrometer for the *Bureau des Longitudes*. The micrometer, for which 240 francs was paid, was presented at the Bureau session

that took place on July 29, 1829: ‘Mr Arago presents the micrometer with two lenses that Mr Amici has constructed for the Bureau and which has just arrived. This instrument can be adapted equally easily to the equatorial telescope and the large mobile cabinet telescope’.^{xxvi} This piece is currently preserved at the Paris Observatory.

- 1827, June: on the occasion of Amici’s stay in London, Joseph Jackson Lister (1786-1869) requested a mirror for a telescope of 6-inch aperture and 7- or 8-foot focus (20 pounds), together with a micrometer (10 pounds).

- 1829, October 10: two terrestrial telescopes of 2-foot and 14-inch focus, respectively, are sold to the Topographic Bureau of Naples (320 and 240 francs). Amici was requested to make these instruments by Colonel de Sauget, head of the Bureau. In fact, it was Charles Babbage (1791-1871), after a visit to Amici in January 1828, who drew the attention of de Sauget to the application of Amici’s micrometers to astronomical and terrestrial telescopes. The two *cannocchiali micrometrici* were eventually delivered in August 1831. One of them is at present on exhibition at the Museum of the *Istituto Geografico Militare* in Florence.^{xxvii}

- 1832: a micrometer to Admiral Tsisagou (240 francs).

- 1833, December 28: a micrometer to Matteo Livoni, Rome (310 *lire*).

- 1834, August: on the occasion of a visit to stay at the Padua Astronomical Observatory of Valentino Amici (1810-1863), the third and youngest son of Giovanni Battista, a double-image micrometer was donated by Amici to Santini, together with a 3-foot achromatic telescope.^{xxviii} Santini and Valentino Amici used these instruments to observe double stars.

- 1836, May 26: a micrometer to Angelo Bellani, Monza (deposit of 117.6 francs).

- 1836, May 28: Plana buys a double-image micrometer (250 francs). Fascinated by a similar instrument that Amici had just made for the telescope of Santini (Padua), Plana commissioned Amici to make a double-image micrometer for a 5-foot telescope of the Turin Astronomical Observatory. Plana planned to use this micrometer for measurements of double star distances.

- 1840: Johann Franz Encke (1791-1865), director of the Berlin Observatory, refers to several distances of double stars measured with an Amici’s *ocular-Heliometer*. This instrument is

mentioned in further publications on the observations on double stars and Jupiter carried out by Encke, Heinrich Louis d'Arrest (1822-1875), and Johan Gottfried Galle (1812-1910). Moreover, Encke described Amici's micrometer in a paper published in 1848.^{xxix}

- 1841, July 13: a bisected-lens micrometer is sold to Caldecott (275 francs/11 pounds). 'When I had the pleasure of seeing you in Florence in the latter part of April last,' Caldecott wrote to Amici in August 1840, 'I mentioned to you that I was very anxious to possess one of your Micrometers for an equatorial which Mr. Dollond of this city was constructing for me (...). The focal length of the object glass is 7 English feet and the aperture 5 Inches'.^{xxx} Caldecott made observations with these instruments at the observatory of Trivandrum (Kerala, India).

- 1842: around the end of the year, Amici constructed a double-image micrometer for Jean Élie Benjamin Valz (1787-1867) to be used with a 5-inch telescope of 6-foot focus. It is not clear whether Valz used this instrument at the Marseille Observatory, the institution of which he was director from 1836, or privately at Nimes.

- 1845, September: a micrometer was delivered to the Royal Library of Naples through Count Grifeo.

- 1861: Amici presented several instruments at the Italian Exhibition in Florence, including a distance measurer and a double-image micrometer. Actually, the latter was reported as a heliometer in the 1864 account written by the exhibition committee members.^{xxxi}

- 1877: in an article published in *Astronomische Nachrichten*, William Doberck (1852-1941) compared the observations of double stars made by Amici with those by Edward Cooper (1798-1863). Doberck, who at that time worked at the Irish Observatory of Markree, commented: 'It is greatly to be regretted that Amici's measurements of the distances of double stars have not been published yet. Any measurements made so long ago are of importance – in addition these distances are much smaller than Herschel's. Amici's micrometer was superior to the old wire-micrometers, but I suppose the definition was no better in his telescopes than in Herschel's'. Two years later, the publication *A Handbook of Double Stars: For the Use of Amateurs* was edited by Edward Crossley, Joseph Gledhill, and James M. Wilson. In this book, the authors mentioned that Amici's micrometer was used by Doberck and Dawes, and claimed that Amici's invention, consisting of two prisms, 'is considered the best of its kind'. William Chauvenet (1820-1870) also reported in his *Manual of spherical and practical astronomy* (1863) that Amici was said to have produced the best

micrometers for the duplication of the images of objects.^{xxxii}

- 1929: a double-image micrometer by Amici was exhibited at the first National Exhibition of the History of Science, which took place in Florence from May to October 1929.

- i An extensive bibliography on Amici's scientific activities and instruments can be found in the volume: Alberto Meschiari (ed.), *National Edition of the Works and Correspondence of Giovanni Battista Amici* (Napoli, 2006), Vol. I, pp. 91-117.
- ii On the double-image micrometer invented by Amici, see Danielle Fauque, 'Amici et le Principe de Duplication d'Image: Le Micromètre d'Amici', *Nunciarius*, **5** (1990), pp. 71-77. For a history of the micrometers, see Randall C. Brooks, 'The Development of Micrometers in the Seventeenth, Eighteenth and Nineteenth Centuries', *Journal for the History of Astronomy*, **22** (1991), pp. 127-173.
- iii The main source of information is the Giovanni Battista Amici Archive at the Biblioteca Estense, Modena (hereinafter BE, Archivio Amici). Amici's correspondence with French and British scientists has been published in Alberto Meschiari (ed.), *National Edition of the Works and Correspondence of Giovanni Battista Amici* (Firenze), Vol. III-1 (2010) and Vol. III-2 (2012), respectively. For the correspondence with Zach, see Alberto Meschiari, 'Letters Between Baron von Zach and Giovanni Battista Amici, 1822-1825', in *The Collected Correspondence of Baron Franz Xaver von Zach* (2008), Vol. 4. For the correspondence with Italian scientists mentioned in this article, see Alberto Meschiari, *Corrispondenza di Giovanni Battista Amici con Francesco Carlini* (Milano, 2001), and Alberto Meschiari, 'Corrispondenza di Giovanni Battista Amici con Giovanni Plana', *Nunciarius*, **1** (2000). Some letters between Amici and Santini are at the Padua Astronomical Observatory. Amici's workshop account notebook has been published in: Alberto Meschiari, *Il Libro de' Conti del Laboratorio di Giovanni Battista Amici e Altri Documenti Inediti* (Firenze, 2003).
- iv Letter from Amici to Carlini, 26 August 1812. BE, Archivio Amici, folder 1126, 8710.
- v Letter from Amici to Zach, 17 January 1822. BE, Archivio Amici, folder 1134B, 10286-10293.
- vi Letter from Zach to Amici, 25 October 1823. BE, Archivio Amici, folder 1109, 7950.
- vii Carlini described the double-image micrometer constructed by Amici in the publication 'Descrizione di un Nuovo Micrometro del Sig. G. B. Amici, Prof. Di Matematica nell'Università di Modena', *Biblioteca Italiana o sia Giornale di Letteratura, Scienze ed Arti*, **8** (1817), pp. 289-295.
- viii See Giovanni Battista Donati, *Elogio del Prof. Gio. Battista Amici* (Firenze, 1864).
- ix 'Sur Les Micromètres Prismatiques' and 'Nouveau Micromètre Intermédiaire', in Alberto Meschiari (ed.), *National Edition of the Works and Correspondence of Giovanni Battista Amici* (Napoli, 2006), Vol. I, p. 275 and p. 289, respectively.
- x Alberto Meschiari, 'Registro dei Visitatori dello Studio di Giovanni Battista Amici dal Giugno 1818 al Gennaio 1844', *Atti della Fondazione Giorgio Ronchi*, **3** (2001), pp. 445-486.
- xi See Simone Bianchi, 'Gli Strumenti di Giovan Battista Amici dalla Vecchia Specola di Firenze al Nuovo Osservatorio di Arcetri', *Nunciarius*, **2** (2010), pp. 357-382.
- xii Alberto Meschiari, 'Corrispondenza di Giovanni Battista Amici con Giovanni Plana', *Nunciarius*, **1** (2000).
- xiii Letter from Herschel to Amici, 12 April 1825. BE, Archivio Amici, folder 554, 3784.
- xiv See for example John Herschel and James South, *Observations of the Apparent Distances and Positions of 380 Double and Triple Stars*, from *The Philosophical Transactions* (London, 1825).
- xv William Hussey, 'Notes on the Progress of Double-Star Astronomy', *Publications of the Astronomical Society of the Pacific*, **12** (1900), pp. 91-103 (p. 93).
- xvi Letter from Amici to Plana, 26 September 1824. BE, Archivio Amici, folder 1132, 9720-9723.
- xvii See Giuseppe Bianchi, *Atti del R. Osservatorio Astronomico di Modena*, Tomo I (Modena, 1834), and Domenico Ragona, 'Sull'Oculare a Separazione di Immagini Applicato all'Equatoriale del Reale Osservatorio di Modena' *Mémoires de la Société Impériale des Sciences Naturelles de Cherbourg*, **13** (1867-68), pp. 289-312.
- xviii Letters from Santini to Amici. BE, Archivio Amici, folder 944, 6772 and 6775.
- xix Letter from Herschel to Amici. BE, Archivio Amici, folder 554, 3789-3790.
- xx William Dawes, 'Catalogue of Micrometrical Measurements of Double Stars', *Memoirs of the Royal Astronomical Society*, **35** (1867), p. 147
- xxi James Dunlop, 'Approximate Places of Double Stars in the Southern Hemisphere, Observed at Paramatta in New South Wales', *Memoirs of the Astronomical Society of London*, **3** (1829), p. 258.
- xxii Letter from Herschel to Amici. BE, Archivio Amici, folder 554, 3789-3790.
- xxiii See also 'The correspondence of William Henry Fox Talbot' available at <http://foxtalbot.dmu.ac.uk/index.html>.
- xxiv William Pearson, *An Introduction to Practical Astronomy* (London, 1929), Vol. 2, p. 564.
- xxv Letter from Herschel to Amici, 15 April 1826. BE, Archivio Amici, folder 554, 3796-3797.
- xxvi 'Mr Arago présente le micromètre à deux lentilles que Mr Amici a construit pour le Bureau et qui vient d'arriver. Cet instrument pourra s'adapter à une égale facilité à la lunette de l'équatorial et à la grande lunette mobile des cabinets' (*Séance du 29 juillet 1829 du Bureau des Longitudes*, Paris Observatory). I would like to thank Emilie Kaftan for this information.
- xxvii See also <http://www.igmi.org/museo/strumento.php?sender=ricerca&id=51>.
- xxviii Letter from Amici to Santini, 3 June 1834. ASOPd (Archivio Storico dell'Osservatorio Astronomico di Padova), Fondo Santini, Corrispondenza, Vol. II.
- xxix See Johan Encke, *Astronomische Beobachtungen auf der Königlichen Sternwarte zu Berlin* (Berlin, 1840) and (Berlin, 1848). *Ibid.*, 'Über das Mikrometer von Amici' *Bericht Über die zur Bekanntmachung Geeigneten Verhandlungen der K. Preußischen Akademie der Wissenschaften zu Berlin*, **31** (1848), pp. 76-78.
- xxx Letter from Caldecott to Amici, 29 August 1840. BE, Archivio Amici, folder 195, 2081.

xxxix See Alberto Meschiari, 'Come Nacque l'Officina Galileo di Firenze (Gli Anni 1861-1870)', *Atti della Fondazione Giorgio Ronchi*, **6** (2005), p. 904.

xxxii William Doberck, 'On Cooper's and Amici's Double-Star-Measures', *Astronomische Nachrichten*, **90** (1877), p. 303, and 'Observations with Amici's double-image micrometer', *Astronomische Nachrichten*, **92** (1878), p. 239.

Edward Crossley, Joseph Gledhill, and James M. Wilson, *A Handbook of Double Stars: For the Use of Amateurs* (London, 1879), p. 50. William Chauvenet, *A Manual of Spherical and Practical Astronomy* (Philadelphia, 1863), Vol. 2, p. 449.

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