# NINETEENTH-CENTURY COMETS: STUDIES AND OBSERVATIONS IN SICILY

ILEANA CHINNICI
INAF – Osservatorio Astronomico di Palermo

**Abstract**
This article deals with a less well-known aspect of comet studies. It is based on original sources and casts light on some contributions from Sicily to an astronomical research topic having a strong emotional influence on common people. It provides the opportunity to remark on some aspects of the nineteenth-century Sicilian social context, such as the battle against ignorance and superstition, as well as the role of social and professional rank in the naming a new celestial body. Moreover, it treats the contributions of the astronomers of Palermo Observatory to early spectroscopic observations of comets, a scarcely developed topic in studies on history of astronomy. This analysis, motivated by the intent to complete and correct some recent studies on chronicles of comets, provides also a good pretext to retrace the little known history of the Palermo Observatory across the political and social changes of that century.

**Keywords**
Comets, Sicily, Palermo Astronomical Observatory, cometary spectra, Temistocle Zona, Giulio Tomasi di Lampedusa, Annibale Riccò

## *1. Introduction*

The nineteenth century was marked by many observations of comets. According to some authors, 'living in the nineteenth century would have to be a comet observer's dream'.[1] Some spectacular comets appeared, visible to the naked eye even in daylight, while the improved quality of astronomical instruments allowed astronomers to observe faint objects which had generally escaped previous observers. Moreover, the century was marked by the introduction of two new techniques for astronomy, namely photography and spectroscopy: for the first time, comets were photographed and their light submitted to spectral analysis, thus revealing their chemical composition. This century was therefore crucial for extending the knowledge and understanding of these bodies.[2] The contribution of Sicilian people and institutions to cometary astronomy, though minor and less-known, helps to enrich the chronicle of the comets.

## *2. First comets of the century: observations in Palermo*

The first great nineteenth-century comet, which appeared in 1807, was first noticed in Sicily[3] by friar Parisi,[4] an Augustinian monk, who observed the comet on 9 September in the town of Castrogiovanni, nowadays Enna.[5] This information is provided by Niccolò Cacciatore (1780-1841) (**Figure 1**), astronomer at Palermo Observatory, who published a booklet on the comet of 1807[6] (**Figure 2**). Cacciatore was assistant to the renowned Giuseppe Piazzi (1746-1826), founder of the Observatory in 1790 and discoverer of the first minor planet, Ceres, in 1801, who compiled also a well-known star catalogue in two editions (1803 and 1814).[7]

The task of calculating the comet's orbit was entrusted to Cacciatore by Piazzi himself, as argued from a letter by Piazzi to his friend Barnaba Oriani (1752-1832), astronomer in Milan:

> The comet was seen here from 20 September but we have started the observations on 28. In the town of Castrogiovanni an Augustinian writes to have seen it on 9. I have left the observations and calculations to my assistant, who works diligently on them, but he has not yet found a satisfactorily fitting trajectory. When this young lady *[the comet]* will be visible no more, if my bad eyes allow, I shall make some calculations too.[8]

If regular observations of the comet of 1807 started at Palermo Observatory on 28 September, this means that the first sighting in Palermo, occurred - according to Piazzi - on 20 September, and was not actually made by professional astronomers. Cacciatore mentions the nuns of the Holy Savior's Monastery as being the first persons in Palermo to have seen the new celestial body.[9] The booklet by Cacciatore on the comet of 1807 is of no particular interest: it contains no drawings, just positions and calculations. It was, however, the first astronomical work published by Cacciatore and reveals his limitations.[10] For, actually, Piazzi and his assistants were not particularly able in computational work, as shown on the occasion of the discovery of Ceres, when the release of data and orbital calculations was unjustifiably delayed.[11]

Another non-periodic comet, discovered in France, appeared in 1811; the astronomers of Palermo Observatory observed it and this time Piazzi decided to write a booklet on this subject himself.[12] This short publication is quite interesting, because Piazzi adds to the calculations of the orbital elements some considerations about the comets' formation and the risk of their impact on the Earth. The booklet had both a scientific and a popular intent, as Piazzi clearly stated in a letter to his friend Oriani:

> Maybe you have seen my Memoir on the comet of 1811 and probably you didn't like my considerations about the formation of these bodies. They are inventive, indeed, but it is difficult to demonstrate that the things are different from what I have hypothesized. However, by this means, I have rendered not a small service […] Sicily, whose inhabitants were generally taken by panic and fears, seems now quiet and persuaded of what I have written.[13]

Obviously, in the last sentence, Piazzi refers to the popular belief that the comets were dangerous for the Earth; he adds indeed: "We did not neglect calculations, combinations and all sort of arguments, to remove from the minds the fear that one day any comet could smash onto the Earth."[14] Moreover, "if it is true that the masses of these bodies are very light, so that the majority of comets probably vanish after one or two revolutions around the Sun", Piazzi concludes reassuringly: "Maybe the impact of a comet on the Earth would provoke a damage not bigger than that a grain of sand on a rock."[15]

In his booklet, Piazzi presents the hypothesis that the comets originated by the accretion of some fluid matter and that they went through several evolutionary phases before being destroyed by dissolution in the ether. In Piazzi's opinion, this explains the existence of non-periodic comets:

> … it is not far from truth that, little by little, [the comets] are originated and destroyed, and that those expected and not come back, have probably already dissolved in vapors and [once so] consumed, could have contributed to feed the accretion of the appearing new ones.[16]

Piazzi's ideas, though inventive, were not new, as Oriani replied:

> Your conjectures about the formation of the comets are very ingenious and match in part Laplace's ideas stated in the fourth edition of the *Exposition du Système du Monde*[17] and Herschel's ideas[18] on the origin of nebulae.[19]

Piazzi's booklet contributed to the circulation of 'modern' astronomical theories of that time in the Kingdom of the Two Sicilies, thus continuing the original cultural motivation of Palermo Observatory, which had been established in the 1780s in the context of an educational reform inspired by Enlightenment principles.[20]

In 1817 Piazzi moved to Naples to supervise the completion of the new Observatory at Capodimonte and left Niccolò Cacciatore as his substitute in Palermo. The latter published a booklet on another comet, discovered in 1819 in France, but this time he did not appeal to Piazzi's influential supervision; the latter gave a summary judgment about Cacciatore's work in a letter to Oriani: "Cacciatore has published a short Memoir on the last comet of June. If he had limited himself to the calculations, he would have done much better."[21]

Probably rebuked by Piazzi, who was however very attached to him, Cacciatore did not publish any other extended works on the subsequent comets, limiting himself to record their observational data in his book *Del Reale Osservatorio di Palermo*, containing all the astronomical work carried out in those years at Palermo Observatory.[22] The book was published in 1826, the year of Piazzi's death, probably to promote Cacciatore's appointment as Director. Unfortunately, Cacciatore was to distinguished himself more for his personal controversies than for his scientific achievements. Cacciatore clashed with University colleagues because of his disregard of teaching duties and because of the privileges he sought - and obtained - from the Royal Government, acting regardless of any rule in order to defend his family interests. The Observatory became a sort of personal property where he could hire and house his relatives. The prestige of the Observatory, of course, declined, but the indulgence and protection of some powerful political personalities prevented the replacement of the controversial director.[23] As listed in Appendix A, comets of 1830 and 1835 were observed by the first assistant Luigi Martina,[24] while the observations of the comet of 1831 were published by another assistant, Innocenzo Cacciatore.[25] This is essentially due to the fact that in the years 1830-32 Niccolò Cacciatore spent much time in Trapani for some geodetic works related to coastal cartography and then for establishing a meteorological observatory, the first one in Sicily after Palermo.[26]

Nevertheless, it is worth mentioning here an extended article written by Cacciatore in 1835 about the expected return of Halley's comet. This paper was published in the monthly journal *Giornale di Scienze, Lettere ed Arti per la Sicilia* with the title: 'Reflections on the imminent return of Halley's Comet; for rational people of 1835'. The title itself shows that the article was intended for popularization and it was aimed at reassuring the readers about the presumed ill-omened effects of the appearing of the famous comet - again, it is evident that Cacciatore's intent derives from late-Enlightenment[27] values. The following sentences, excerpted from the paper, give evidence of the spirit of that time:

> The imminent return of the comet called after Halley […] should bring a stop to the prejudices and fears usually appearing with these innocent celestial bodies. […] there are plenty of people, unfortunately, who take advantage of the weakness of others […] and their progress is based on the others' ignorance. Indeed, credulity, often dishonorable and concealed, is found in every [social] class. Weak minds are present in all times and all countries. […] Therefore, at any time, in any place, in every social class, there will be those who, being ashamed of their ignorance and wanting to hide their weakness […] will secretly fear the comets' influence; while some will believe in numeral powers in lottery games; others in the hidden forces of bad magic; and others in good faith will consult soothsayers, astrologers and solitary old women as to their future. Astronomy, indeed, wages perpetual war against all prejudices [and struggles against] the charlatanism which always takes advantage of ignorance [and] superstition […] Astronomy always lifts the mask of mystery from imposture […] and […] availing herself of mathematical severity, lifts the obscure veils of the hidden causes […] and get man accustomed to cease marveling but rather to let his mind expand into the immense spaces of the universe.[28]

The article by Cacciatore on Halley's comet, after a long historical and scientific 'excursus' on the comets, whose phenomenology he explains, ends with the following - reassuring for the readers - statements:

> From these considerations, and from many others that I spare the reader in order not to be too long, it seems to result clearly that […] comets don't have to distress us more than the appearance of other celestial bodies […] because of their very low density, they are not as

> important as other bodies are […] their appearances are a consequence of their periodical revolutions [*around the Sun*], and they cannot be regarded otherwise than as simply curiosity objects […] their annoying influence arises only against astronomers, as they are obliged to observe them painstakingly during the night, and to make long and tiring calculations on them during the day ...[29]

Halley's comet was observed at Palermo Observatory by the above-mentioned assistant Martina, but the observations remained unpublished until 1855.[30] It appears surprising that, after the publication of the related article, no result of the comet's observation was published. This means that Cacciatore probably did not observe the comet, and it was unacceptable that the contribution of the Palermo Observatory was restricted to the observations carried out by an assistant. No publication was therefore issued. Conscious of the importance of filling this gap, Ragona (see below) found in a manuscript the few data recorded by Martina and decided to publish them in 1855.

However, these clues reveal the lack of regular work at Palermo Observatory during Cacciatore's direction: even in an important case like Halley's comet, it might happen that the results remained unpublished.

For the sake of completeness, it must be noted that, until 1850s, the instrument used for cometary observations was the famous 5-foot Ramsden Circle, the main telescope of Palermo Observatory from its establishment.[31] The observations generally consisted in recording the following data: celestial coordinates, sidereal time, weather conditions, diameter of the head and extension of the tail; no indication was given about the brightness of the comets. The method for carrying out observations is described in 1831 by the Assistant Martina:

> The method I have applied to carry our these observations is the same applied by the Director […] Once the azimuthal circle is fixed in a position near the azimuth of the comet, the vertical circle is moved until the comet position is framed in the crosswire, and the sidereal time is recorded. By the same method, also the position of a well-known star is measured, in order to calculate the errors in azimuth and zenith distance.[32]

For measuring celestial coordinates, the circle was generally used, even if its accuracy was not so high as expected: as it was made of metal, it was strongly affected by thermal expansion, especially in the hot season.[33]

## *3. Ragona's inventory of comets observations in Sicily*

After the death of Niccolò Cacciatore in 1841, his son Gaetano (1814-1889) succeeded him as Director of Palermo Observatory.[34] Gaetano, however, was interested more in politics than in astronomy. He was involved in the anti-Bourbon revolutionary activity of 1848, whose failure consequently led to his removal from the post of Director. He was replaced by Domenico Ragona (1820-1892) (**Figure 3**), who procured from the Bourbon Government permission to renew the obsolete equipment of the Observatory, dating back to Piazzi's time. Ragona's appointment as Director of Palermo Observatory was a successful attempt to relaunch astronomical research in Sicily. In the 1850s he was sent to Berlin Observatory to practice astronomy and he acquired two excellent instruments made in Germany: a Meridian Circle by Pistor & Martins in Berlin (destined to replace the old transit instrument by Ramsden) and an equatorial refractor of 250 mm aperture, by the renowned firm of Merz in Munich. Moreover, in 1855 he started to publish the *Giornale astronomico e meteorologico*, reporting detailed information on the activity of Palermo Observatory and, in general, on the astronomical events of those years.

Ragona was the first to try to make an inventory of comet observations in Sicily. In 1854 he published a booklet[35] on the second comet of that year, adding a note[36] reporting cometary observations recorded at Palermo Observatory and throughout Sicily. He listed just the "observed" comets, meaning those whose positions had been determined and data had been published. He was surprised by the results of his survey: "Having looked so hard for them, I find just twelve comets observed from 1793 to 1854 while, in this time interval, 113 comets were observed in Europe, 23 of them discovered in Italy".[37]

Ragona's inventory[38] is quite complete, lacking only the observations of the comet of 1831, but it covers only the years after the establishment of the Observatory. It is interesting to remark that he states that two non-telescopic comets were discovered (in the sense of being observed for the first time) in Sicily. The first one is the aforementioned comet of 1807, observed in Castrogiovanni (Enna) by the Augustinian monk Friar Parisi, but Ragona errs in reporting that the second comet of 1792 was discovered in Sicily; he states that it was observed at the same time at Palermo Observatory by Niccolò Carioti, one of Piazzi's assistants, and in Spain by the famous French comet-discoverer Pierre Méchain (1744-1804).[39] This can be regarded as an attempt, be it either unintentional or on purpose, of promoting Sicilian astronomy: from Piazzi's time until then, no discovery had been recorded at Palermo Observatory and its maintenance by the almost bankrupt Bourbon Government, after the establishment of the majestic Naples Observatory, appears to be financially unjustifiable - and explicable only as a respectful but onerous preservation of Piazzi's memory. Adding new trophies could therefore reinforce the scientific value of the institution which Ragona was heading. However, the need for new scientific recognition for Sicilian astronomy was felt not only by the director of Palermo Observatory but also by the local intellectual class, and a good opportunity seemed to occur a little later, as shown below.

The examination of Ragona's list confirms that only bright comets were "observed" at Palermo Observatory. Since no information is recorded about the apparent magnitude of the twelve comets, we may infer this deduction from their absolute magnitude: actually, nine comets of twelve had an absolute magnitude lower than 5.5, the remaining three between 6 and 7.[40] This is probably due to the fact that the Circle was an instrument intended for astrometry and consequently had a small (3-inch aperture) telescope, "good but not excellent" in Piazzi's words.[41] At that time, two other instruments were installed at Palermo Observatory: a transit instrument by Ramsden, used for meridian observations and an equatorial telescope by Troughton, acquired by Piazzi in 1809 thanks to a King's prize to recognize his scientific achievements. This instrument, though suitable for comet seeking, was almost never used by Piazzi and his first two successors, probably because the hour ring was broken during the shipment and, though repaired, it was no longer reliable.

Ragona decided to reuse the equatorial and applied special devices and expedients to correct its defects;[42] with the Troughton equatorial he was able to observe celestial objects up to almost the absolute magnitude 8. In seven years, from 1854 to 1860, he recorded the positions of six comets – a good rate in comparison with the twelve records of the preceding sixty years – and probably would have continued to pay attention to these celestial bodies, if his destiny did not change (see below).

### *4. An amateur's contribution: the strange case of Tomasi's comet*

Before the years 1857-1859, when the instruments commissioned by Ragona in Germany were delivered, the best telescopes in Palermo were located in the private observatory belonging to Prince Giulio Tomasi di Lampedusa (1815-1885), who was an active amateur astronomer.[43] Amateur astronomy was cultivated in Sicily, but it was less widespread than elsewhere. Piazzi mentions some Sicilian non-professional astronomers in his chronicle of astronomy in Sicily,[44] and a few others could be added, usually priests and noblemen. In past centuries, regular astronomical observations had been carried out in Sicily by Francesco Maurolico (1494-1575) and Giovan Battista Odierna (1597-1660), the latter considered by Piazzi the leading Sicilian astronomer of the modern age.[45] Moreover, there had been various interesting figures committed to gnomonics as the large number of Sicilian sundials confirms.[46] However, the private observatory of the Prince of

Lampedusa was really a remarkable exception.[47] It was built in a villa near Palermo and was very well equipped with a good Merz refractor of 115 mm aperture, a small equatorial by Lerebours & Secretan, both generally used for comet observations, and many other instruments.[48] The Prince was a good observer and his high-quality telescopes allowed him to obtain results comparable with those of professional astronomers.[49] In 1857, while observing the comet Bruhns (1857II),[50] he found another comet. He suspected it could be a new comet and, as usual, he sent the results of his observations to the *Giornale Officiale di Sicilia* together with a short report:

> Since 14 [April] [...] in my observatory I have been observing a telescopic comet, which I believed to be the Bruhns' comet. Nevertheless [...] I suspected that the comet observed by me was a new one [...] The Bruhns' comet [...] was seen by me yesterday night for the first time, therefore I don't doubt that the one observed on the night of the 13th was a new comet. [...] In my first observations I have used an equatorial comet-seeker, then I have measured in a better way the position of the comet through the circular micrometer of my Munich refractor. [...] I could not say if this comet has been already observed by others ...[51]

Ragona calculated an ephemeris of the comet observed by the Prince, compared it with those of D'Arrest's (1857I) and Bruhns' (1857II) comets, and published the results in the *Giornale Officiale di Sicilia*:[52] the comparison seemed to confirm the discovery of a third comet.

In the same newspaper the news of the discovery of the Tomasi's comet was announced with considerable emphasis:

> The first four months of this year have opened to the astronomers a large field of observations and studies, as three telescopic comets have appeared, all three almost at the same time, namely: first 1857 comet by D'Arrest, second 1857 comet by Bruhns, third 1857 comet by Tomasi. This third 1857 comet adds a new discovery to those by which Sicilian Astronomy has enriched the solar system with new celestial bodies, and the name of Giulio Tomasi, Prince of Lampedusa, will be remembered in the history of science. [...]. Indeed, this nobleman, who dedicates his free time to the contemplation of heaven's harmony, built a temple to Urania among the pleasures of the most beautiful country near Palermo, from where, in the night of 13 April, he could observe a comet, while looking for Bruhns' one. [...] now [...] from Sicily the news of the existence of a new comet reaches the astronomers. This discovery [...] reveals to the learned astronomers beyond the mountains the existence of a private observatory from where a man, respectable for social virtues, beneficent, modest, has given his name to the life of a celestial body. This is a large and earned recognition obtained by the Prince for many preoccupations, watching nights, studies, as he has reached the highest goal he could strive [...] we want to give to this noble man […] that praise which more competent referees will tribute to him, not only for his discovery, but also for his highest love for science.[53]

This amplification probably reveals the expectations of the Sicilian community from their compatriot astronomers. As stated above, since Piazzi's time, no other significant contributions to astronomy had come from Palermo: a scientific discovery, though coming from an amateur astronomer, would have shown a cultivated image of Sicily, contrasting the prejudices against its cultural backwardness.[54]

The comet Tomasi, however, was a big misunderstanding: it was not, indeed, a new comet, but the comet D'Arrest, still visible on the same days as the newly appeared comet Bruhns. There will never be a comet Tomasi,[55] as the Prince's contemporaries hopefully predicted, even if another strange accident occurred many years later.

In 1877, a mysterious letter dated 9 October by the Prince of Lampedusa was published in the *Giornale di Sicilia*. In this letter, the Prince claimed to have the priority in the discovery of the comet 1877 V, observed for the first time by a famous comet hunter, the astronomer Wilhelm Tempel (1821-1889), in Florence. The comet would have been observed by the Prince on 25 September while Tempel had discovered it on 2 October. Even if, a few days later, the Prince asserted that the letter was a fake, this event was so shocking for Tempel that he decided to interrupt forever his comets hunt; in 1885 he wrote to a friend: "I have not sought comets anymore and I have lost the wish to discover them since someone wanted to steal my last one of 1877 […] The Prince of Lampedusa, who died here a month ago, could testify to this fact."[56]

This puzzling incident, considered by the Prince as a trick played on him to injure his reputation,[57] reveals a curious insistence to attribute a comet discovery to Tomasi. However, Sicilian astronomy will make further contributions to the discovery of comets, as shown below.

*5. Early spectroscopic observations of comets in Palermo*

After the fall of the Kingdom of the two Sicilies, which was a consequence of the Expedition of the Thousand (1860), the process of political unification of Italy was almost achieved and the Kingdom of Italy was therefore proclaimed in 1861 – with the important exception of Rome, which was annexed in 1870. There was a remarkable investment by the new Government in Sicily, with Palermo planned as an important cultural pole in Southern Italy. Consequently, the University was endowed with laboratories, museums, libraries and other facilities while eminent scientists such as Stanislao Cannizzaro (1826-1910), Pietro Blaserna (1836-1918), Pietro Doderlein (1809-1896) and Gaetano Giorgio Gemmellaro (1832-1904), held respectively the chairs of chemistry, physics, natural sciences and geology. A special effort was made by the local intellectual class to give a new impulse to Palermo Observatory. They heartily recommended the Government to take measures for its recovery and they succeeded through a complex political manoeuvre. The result was the removal of Ragona, appointed Director of the modest Modena Observatory, the return of Gaetano Cacciatore, reintegrated in the directorship of Palermo Observatory for political reasons, and the appointment of Pietro Tacchini (1838-1905) as Adjoint Astronomer and with the implicit "mission" to act as a director.[58] In 1865 Tacchini installed the magnificent Merz refractor acquired by Ragona, which the latter had not the time to assemble and put in operation because of his removal; the instrument had excellent optics and was used for solar, planetary and cometary observations.[59]

Around the middle of the nineteenth century, the application of the new techniques of spectroscopy and photography led to the development of astrophysics. Once the laws of electromagnetic radiation were formulated in 1859, by studying the solar spectrum, and the theoretical structure of spectral analysis was established, it was natural to extend this research to other celestial bodies. Tacchini was among those scientists who immediately grasped the importance of spectroscopic research in astronomy.

Actually, Italian astronomers are rightfully considered pioneers in the application of spectroscopy to astronomy. In 1860 Giovan Battista Donati (1826-1873) paid attention for the first time to the spectra of some stars,[60] thus extending spectral analysis, hitherto limited to sunlight. In the years 1863-1872 Angelo Secchi (1818-1878) proposed an early spectral classification of stars, which became a reference for the following ones.[61] In the last quarter of the nineteenth century, Lorenzo Respighi (1824-1889), Pietro Tacchini (already mentioned), Giuseppe Lorenzoni (1843-1914) and Annibale Riccò (1844-1919) regularly used spectroscopic means for their early research on solar physics.

In Sicily, spectroscopic instruments were used from 1871 onwards, and thanks to Tacchini's and Riccò's spectroscopic observations, Palermo Observatory gained a reputation in the field of the astrophysical research. The main research line was solar physics, but some spectroscopic studies were also carried out on other astronomical objects, including comets.

In this context, it is worth recalling that Donati was the first to succeed in observing a cometary spectrum in Florence in 1864 (**Figure 4**). He observed the spectrum of the comet Tempel (1864 I) with a wide slit spectroscope and noted: "The spectrum of the comet looks like those produced by metals. Actually, the dark parts are larger than the luminous parts and one might say that these spectra are composed of three bright lines."[62]

Donati indicated approximately the position of the bright bands observed, included between the G and D Fraunhofer lines (λ4304-5890), in the yellow-green part of the solar spectrum. Two years later, at the Collegio Romano Observatory, Secchi, by carrying out early spectral studies on comet Tempel-Tuttle (1866 I), independently confirmed Donati's observations:

> I have found that [the spectrum] is composed of only three lines: one corresponding to the 2/5 of the distance between the Fraunhofer *b* and *f*, quite bright; its colour is *green* … the other two lines or rays are too short and faint to be able to measure accurately their positions. One, on the red side, is near the large main line, the other one is quite far on the violet side.[63]

Spectral analysis opened interesting perspectives on cometary astronomy, in the effort to measure, identify and interpret the spectral lines of comets, whose results were sometimes unclear. Though being minor works, the studies carried out at Palermo Observatory contributed to the scientific debate on the chemical-physical nature of comets, activated by the analogies and differences shown by their spectra. [64]

Palermo Observatory participated in this debate, not only by carrying out observations, but also through Tacchini's work as editor of the *Memorie della Società degli Spettroscopisti*:[65] In the years 1874-1888, more than forty articles on spectroscopic observations of comets and cometary physics appeared in this journal,[66] both from Italian and foreign astronomers, thus contributing to the development and diffusion of cometary theories.[67]

The main questions on cometary spectra discussed at that time are very well summarized by Secchi:

> 1. Is the spectrum of the comet [when it has] just appeared identical to that developed later by the comet at its maximum brightness? 2. Have all [comets] the same [spectral] bands, not only at the same positions, but also with the same intensity? 3. What is the influence of sunlight? 4. Is this polarized?[68]

The astronomers of Palermo Observatory entered the debate in 1874. Spectroscopic as well as visual observations (**Figure 5**) of Coggia's comet (1874 III) were carried out by Tacchini, who reported:

> The bright lines observed in the spectrum of the comet were four; compared to the solar spectrum they corresponded to the following positions in the scale of Angström 6770, 5620, 5110, 4800. The positions of these lines cannot be considered exact […] but it is clear that the last three correspond to the carbon spectrum.[69]

Tacchini's results were in agreement with Secchi's spectral observations of the preceding comet (Winnecke, 1874 II)[70] and confirmed those obtained in 1868 by William Huggins (1824-1910), who had identified Donati's three bright bands as carbon spectral lines.[71] Moreover, together with the physicist Giuseppe Pisati (1842-1891), Tacchini also investigated the polarization of cometary light, an observation which had given controversial results,[72] and they observed the presence of a strong linear polarization:

> Once a biquartz polariscope was applied to the refractor, some tracks of polarization were immediately visible, but weak; when we applied a Nicol [prism] and rotated it, the light appeared strongly polarized and we find that […] the light was polarized along a plane passing through the Sun.[73]

Spectroscopic studies of many comets were carried out in the 1880s at Palermo Observatory by Annibale Riccò (**Figure 6**) (see Appendix A). [74] In those years, new spectral lines were observed in cometary spectra and the astronomers were puzzled by their identification, as well as by their appearing and disappearing and their changing intensity.[75] Riccò described carefully his spectral observations of the great comet of 1881, the first comet to be successfully photographed both visually and spectroscopically.[76] He identified three superposed spectra (**Figure 7**):

> … a continuum spectrum, complete, bright, but limited in height, almost linear, another one composed of three zones or bands standing out [from] a third spectrum, continuum, very faint, which is constituted like a background.[77]

Riccò attributed the three spectra respectively to the nucleus, the coma and the tail of the comet and deduced that the nucleus was made by particles of solid or liquid matter, reflecting the solar light and emitting gases or vapors forming the coma; he advanced also the hypothesis that the tail was formed by the condensation of those gases into minuscule liquid or solid particles. Unfortunately, Riccò did not possess a micrometric scale spectroscope to carry out accurate measurements of the positions of the spectral bands, and he tried to remedy this by comparing the cometary spectral lines with those of sodium and indium produced by an alcohol lamp, properly prepared, placed in front of the objective-lens of the refractor.[78] He estimated the positions approximately and calculated the wavelength, concluding that the emission spectrum was a typical cometary spectrum, with hydrocarbon lines. Riccò also reported the important discoveries resulting from the first comet spectrogram obtained by Huggins who, in the ultraviolet region, had observed new lines revealing the presence of cyanogen and nitrogen.[79] In July 1881 Riccò had the opportunity to examine the spectrum of Schaeberle's comet, and remarked that it showed the usual three bands, but the intense short continuum observed in the spectrum of the previous comet - and attributed to the nucleus - was here less evident and even irregular, and its intensity varied from day to day.[80]

In 1882 Riccò observed the spectrum of Wells' comet and noticed that it appeared less sharpened than the cometary spectrum observed in 1881; just a narrow continuum was observable, while the usual carbon emission lines appeared like faint swellings in the continuum, so that 'the impression was that of a usual cometary spectrum in its early stage.'[81]

On that occasion, for the first time, astronomers observed sodium in a cometary spectrum[82] and they realized that the spectrum changed while the comet approached perihelion. Bernhard Hasselberg (1848-1922), at Pulkovo Observatory, explained this phenomenon with the evaporation of sodium provoked by the increasing temperature due to solar heat combined with the action of electric discharges produced by the Sun on the comet surface.[83]

The great comet which appeared in September 1882 offered the possibility of making very good observations of its spectrum, and this time Riccò was able to notice the presence of sodium lines too:

> … the very intense linear spectrum of the nucleus [was a] continuum from the far red, which is very bright, to the violet […] It is crossed by the D line of sodium, very intense, wide and long. […] In the linear spectrum there are three maxima in brightness: one in the orange red […] another one in the green and the last one in the blue.[84]

He observed other faint emission lines – whose positions he could not determine, as his spectroscope lacked a micrometric scale - and the Fraunhofer lines of the reflected sunlight. Having observed the comet and its spectrum for many days (**Figure 8** and **Figure 9**), he noted the variability in the intensity of the lines and the continuum and, correspondingly, in the colour of the comet head. Riccò concluded:

> There has been, therefore, a gradual decrease of the sodium vapors […] until their disappearance; while the hydrocarbon bands, firstly in their early stage, increased in extension […] Correspondingly, the head of the comet, which was reddish, became white, then bluish. […] the difference of colour was so marked that the vanishing of the yellow vapors of sodium must have been its main reason.[85]

Riccò found his results concordant with Hasselberg's hypothesis about the hydrocarbon emission screened by the sodium vapors:

> The dissolving of the sodium vapors by the solar heat, when the comet is at perihelion, produces the dissimulation, so to speak, of the hydrocarbon spectrum; then, it becomes again visible when the comet is so far away from the Sun that the sodium vapors can re-condense.[86]

Hasselberg mentioned Riccò's observations in his papers to reinforce his hypothesis:

> … the beautiful observations of Mr. Riccò in Palermo allow us to examine the evolving phases of the spectrum from day to day. Thus, the disappearance of the sodium lines can be fixed quite exactly to the first days of October, while their weakening in the preceding days was accompanied by a remarkable increase of the usual spectrum of hydrocarbons, which at last was the only one visible.[87]

In 1883 Riccò looked again for the presence of sodium in the spectrum of Brooks' comet, but he found no trace of this element, just the usual cometary bands and a faint linear continuum from the nucleus. A few months later, he had the opportunity to observe the spectrum of Pons-Brooks' comet and remarked the same variability in the intensity of its spectral bands as in the great September comet of 1882; this variability became evident in conjunction with an increase of brightness of the comet, a phenomenon which lasted a few days.

Riccò compared his observations with those of Vogel and Hasselberg, who had also remarked this variability, and with his own observations of the great comet of 1882 and concluded that the spectral band in the blue was more bright than the yellow band (usually the brightest) when the comets increased their brightness for a few days.[88] Riccò simply gave a phenomenological description here, without giving a physical interpretation as in his observations of 1882 – and this was to be his attitude hereafter. He made the same descriptions in 1886, when he carried out spectroscopic observations of Barnard-Hartwig's comet, recording the presence of the hydrocarbon bands on a faint continuum from the nucleus, and in 1888, when he observed the spectrum of Sawerthal's comet, just describing it and remarking that the usual carbon bands were very faint compared to the other cometary spectra he had observed.

Riccò's last spectrum observed in Palermo was of Davidson's comet in 1889: in that year he succeeded Gaetano Cacciatore as director of the Observatory but, one year later, at the end of 1890, he left the town, being appointed director of the new Catania Observatory. Nobody continued spectroscopic research at Palermo Observatory, which suffered a serious scientific decline, being deprived of appropriate resources in terms of staff and instruments. The research work reverted to mere positional astronomy – but an unexpected result would come from this activity.

## *6. Last contribution: Zona's comet (1890 IV)*

Just before the end of the century, a comet was at last discovered in Sicily.[89] The discoverer was one of the most active comets observers at Palermo Observatory, the astronomer Temistocle Zona (1848-1910) (**Figure 10**). He arrived in Palermo in 1880 as second adjunct astronomer and, after Riccò's departure, he was appointed interim director and was in charge until 1898. Zona was not a spectroscopist and preferred to fall back on 'traditional' astronomy, by observing meteors, eclipses, comets. He carried out visual observations of many comets of the 1880s and was certainly the best comet hunter that Palermo Observatory has ever had. On 15 November 1890, he announced the discovery of a new comet, as usual, by telegrams to the editors of the main astronomical journals circulating in Europe and in America at that time, namely *Astronomische Nachrichten*[90] and *The Astronomical Journal.*[91] Later, he failed to discover another comet, C/1898 M1, which was observed by Michel Giacobini (1873-1938) at Nice Observatory a few hours earlier.[92] Zona was awarded the Donohoe Comet Medal in 1891[93] but the discovery of his comet had no particular echoes: nothing about this discovery is recorded in the archives of Palermo Observatory and, in the publications of the Observatory, just a short note by a student, Cesare Mattina who calculated the orbit of the new comet, was published later, in 1893.[94] Of course, comets were a minor topic for professional astronomers and the news was considered irrelevant; moreover, in those years, Palermo Observatory had lost its high reputation and it was in such drastic decline that, for example, no publications of the Observatory were issued for the year 1890. Hence, by then, the discovery of a comet, instead of being considered a success increasing the scientific value of Palermo Observatory, was a proof of the poor quality of the research carried out there, comparable to that of skilled amateurs.

Therefore, when the long-awaited discovery of a comet arrived at last, it passed almost unnoticed in Sicily. Things had changed. Palermo was becoming a capital of high society, with a remarkable economic development. In 1891-92 it was chosen by the Government to host the National Exhibition, a recognition for the flourishing season that the town was living from an architectural, artistic and cultural point of view. In 1897 the monumental Teatro Massimo was inaugurated, while cultured entrepreneurs like the Florio and Whitaker families animated the cultural life of the rising rich middle-class, promoting artistic expressions of the Art Nouveau (also known as Liberty), which marked the city planning of that time. Palermo did not need further recognition - least of all, scientific recognition. The location of the Observatory in the old city center was by then inappropriate for astronomical research, but the local intellectual class, who had been important and active supporters of the Observatory immediately after the political unification of Italy, were no longer interested in its development.

In the meantime, Catania was gaining a scientific reputation, with the establishment in 1890 of the first Italian astrophysical observatory, participating in the international astronomical enterprise of the *Carte du Ciel*. New horizons for astrometry and stellar spectral classification were opening: at the end of the century, comets observations had become irrevocably old-fashioned and restricted to amateurs. Their passage through the Sicilian sky, with modest or spectacular show, were regarded merely with curiosity, as is the case today.

**Note on Contributor**

Ileana Chinnici is a research astronomer at INAF-Palermo Astronomical Observatory. She graduated in Physics at Palermo University in 1992 and in 1994-95 spent one year at the Paris Observatory working on the Carte du Ciel (1887) archives. From 1996 to 2004 she has been Curator of the Palermo Observatory museum. From 2006 to 2012 she has been Chair of the Working Group "Archives" of Commission 41 (History of Astronomy) of the International Astronomical Union (IAU). Her main research topic is the history of astronomy in the nineteenth century, especially the birth of astrophysics.

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[1] Stephen J. Edberg and David H. Levy, *Observing Comets, Asteroids, Meteors and the Zodiacal Light* (Cambridge: Cambridge University Press, 1994), 14.

[2] Gary W. Kronk, *Cometography*, vol. 2 (Cambridge: Cambridge University Press, 2003), vii.

[3] Four minor comets had been previously observed elsewhere from 1801 to 1806; see: Kronk, *op. cit.* (ref. 2), 1-10.

[4] Niccolò Cacciatore, *Della Cometa apparsa in settembre del 1807. Osservazioni e risultati* (Palermo, 1808), 9.

[5] In the commendable book by Kronk, *Cometography* (ref. 2), 11, the author erroneously records 'Castro Giovanni' as the name of the observer, but this is the ancient name of Enna.

[6] Cacciatore, *op. cit.* (ref. 4).

[7] On Piazzi's life and activity, see, for instance: Giorgio Abetti, "Giuseppe Piazzi", in *Dictionary of Scientific Biography,* edited by Charles C. Gillespie, (New York: Charles Scribner's Sons, 1970-1978) vol. 10, 591-3.

[8] "La cometa qui si è cominciato a vederla li 20 settembre, ma non se ne sono intraprese le osservazioni che li 28. Nella città di Castrogiovanni scrive un agostiniano di averla ravvisata li 9. Osservazioni e calcoli si sono da me abbandonati al mio assistente, il quale vi lavora con impegno, ma non è giunto ancora a trovare una parabola che soddisfi. Quando si cesserà di vedere questa signorina, se gli occhi me lo permetteranno, che sono assai male ridotti, porrò io pure la mano al calcolo." *Corrispondenza Astronomica fra Giuseppe Piazzi e Barnaba Oriani*, edited by Gaetano Cacciatore and Giovanni Virginio Schiaparelli (Milano, 1874), 99.

[9] Cacciatore, *op. cit.* (ref. 4), 9.

[10] The judgment on Cacciatore's scientific activity cannot be but severe; see: Ileana Chinnici, 'Personaggi e vicende dell'Osservatorio Astronomico di Palermo attraverso l'Unità l'Italia', *Giornale di Astronomia,* 37 (2011), 2-9, p. 2.

[11] See: Ileana Chinnici and Giorgia Foderà Serio, "Cerere Ferdinandea. Palerme, 1er janvier 1801", *L'Astronomie*, 115 (2001), 2-16, p. 8.

[12] Giuseppe Piazzi, *Della Cometa del 1811 osservata nella Specola di Palermo dai 9. Settembre ai 11. Gennaro 1812* (Palermo, [1812]).

[13] "Forse vi sarà capitata la mia Memoria sulla cometa del 1811 e probabilmente non vi saranno andate a genio le mie congetture sulla formazione di tali corpi. Sono ardite, egli è vero, ma è ben difficile a dimostrarsi che la cose non possa essere come da me si è divisata. In tanto con questo mezzo io ho reso un non piccolo servizio […] la Sicilia, i di cui abitanti erano generalmente invasi da panici timori, sembra ormai tranquilla e persuasa di quanto da me si è scritto." *Corrispondenza astronomica* … (ref. 8), 102.

[14] "Non si sono trascurati calcoli, combinazioni, ed ogni sorte di argomenti, a togliere dalle menti nostre il timore che un giorno qualche cometa possa mettere sossopra la terra." Piazzi, *op. cit.* (ref. 12), 41.

[15] "… se egli è vero che le masse di questi corpi sono tenuissime [tanto che la maggior parte delle comete] probabilmente dopo una o due rivoluzioni intorno al sole cessa di esistere […] Forse l'urto di una cometa contro la terra non potrà cagionarvi maggiore disordine, che non possa farne un granello di arena contro uno scoglio." Piazzi, *op. cit.* (ref. 12), 41-42.

[16] "… non è congettura lontana dal vero, che tratto tratto [le comete] e si formino e si distruggano, e che quelle che si aspettavano e non sono ritornate, probabilmente già sciolte in vapori e consonte, abbiano servito di alimento alla formazione delle nuove che appajano." Piazzi, *op. cit.* (ref. 12), 41-42.

[17] Pierre Simon de Laplace, *Exposition du Système du Monde. Quatrième edition* (Paris, 1813), 152-4.

[18] William Herschel, "Astronomical Observations relating to the Construction of the Heavens", *Philosophical Transactions of the Royal Society of London*, 101 (1811), 269-336, p. 306.

[19] "Le vostre congetture sulla formazione delle comete sono molto ingegnose e s'accostano in parte alle idee date da Laplace nella quarta edizione della sua Exposition du Système du Monde ed alle idee di Herschel sull'origine delle nebulose." *Corrispondenza Astronomica* … (ref. 8), 104. It is worth mentioning here Laplace's hypothesis about the primitive cloud from which the bodies of the solar system originated and Herschel's hypothesis about the origin of nebulae as deriving from progressive condensation of luminous matter until they became stars.

[20] With the expulsion of the Jesuits form the Kingdom of the Two Sicilies in 1776, the educational system inevitably collapsed. In order to promote a new high-education system, Francesco D'Aquino (1718-1795), Prince of Caramanico, viceroy of Sicily, created the Academy of Royal Studies (later University of Palermo). Coming from the French Court, he had frequented Enlightenment circles in Paris and was an influential Freemason; he paid special attention to the scientific education and supported the establishment of a chair of astronomy in Palermo; see: Giuseppe Piazzi, *Sulle vicende dell'astronomia in Sicilia*, edited by Giorgia Foderà Serio (Palermo, 1990), 11-14. The failure to attract renowned scientists

to this chair clearly shows how little appeal it had at that time, because of the backward conditions of the sciences in Sicily.

[21] "Cacciatore ha pubblicato una piccola Memoria dell'ultima cometa di giugno. Se non avesse dato che i soli calcoli, avrebbe fatto assai meglio." *Corrispondenza Astronomica …* (ref. 8), 178.

[22] As usual, Cacciatore also sent the results of his observations to the astronomical journals of that time, namely *Astronomische Nachrichten* and *The Astronomical Journal* and sometimes to the Baron Franz Xaver von Zach (1754-1832), editor of the *Mönatlische Correspondenz*, one of the first international bulletins of astronomical news (for references, see Appendix A).

[23] Freemasonry could have played an important role. Piazzi was a Freemason and many important members of the Bourbons court were Freemasons too; see: Ruggiero di Castiglione, *La Massoneria nelle Due Sicilie*, vol. 5, (Roma: Gangemi Editore, 2014). After Piazzi's death, his main protector seems to have been the Lieutenant of Sicily, Antonino Lucchesi Palli (1781-1856), Prince of Campofranco, whose grandfather had been one of the most influent Piazzi's Freemason friends.

[24] Luigi Martina, *Osservazioni della Cometa apparsa in aprile 1830, fatte nel Real Osservatorio di Palermo* ([Palermo], [ca. 1830]). Martina was Niccolò's brother-in-law; he worked at Palermo Observatory as second assistant from 1811 to 1825, being appointed first assistant in 1826, at Piazzi's death, once Cacciatore became director. Errors in Martina's calculations of the Mean Time for the comet of 1830 were detected later and the corrected results published together with his observations of Halleys' comet; see: Domenico Ragona, "Due comete osservate negli anni 1830 e 1835 nel Reale Osservatorio di Palermo", *Giornale astronomico e meteorologico*, i (1855), 223.

[25] Innocenzo Cacciatore, *Osservazioni sulla cometa apparsa in gennaio 1831* (Palermo, 1831). Innocenzo was Cacciatore's older son and in 1831 he obtained the position of Assistant Piazzi, thus named after a legacy by the first director. This publication by Innocenzo includes a sort of defense of his father's observations, as in those years Niccolò was involved in harsh scientific and personal controversies with Domenico Scinà (1765-1837), professor of physics at the Palermo University; see: Orazio Cancila, *Storia dell'Università di Palermo* (Firenze: Editori Laterza, 2006), 321.

[26] See: Niccolò Cacciatore, *Sul modo di ridurre ad unico sistema le osservazioni meteorologiche: lettera a Giovanni Daniele …* (Palermo, 1832), 4.

[27] In the years 1830-1840 the philosophical theses of Positivism were already developing in France, but they would spread through the rest of Europe somewhat later, in the second half of the nineteenth century.

[28] "Il vicino ritorno della Cometa chiamata di Halley […] sembra che finalmente dovrà bandire per sempre li pregiudizi e gli spaventi che sogliono riprodursi ad ogni nuova apparizione di questi astri innocenti. […] grande purtroppo è il numero che nella società specolano sull'altrui debolezza […] e li loro avanzamenti fondano sull'altrui ignoranza. Ma anche la credulità spesse volte vergognosa e celata trovasi in tutte le classi. Le teste deboli sono di tutt'i tempi e in tutti i paesi. […] Perciò in ogni tempo, in ogni luogo, in qualunque sfera di società, vi saranno di coloro che vergognosi di loro ignoranza, non volendo mostrarsi tanto deboli […] temeranno occultamente gl'influssi delle comete; come tali altri presteranno fede alla ritmomanzia nei giuochi del lotto; altri alle forze occulte della jettatura; e altri consulteranno di buona fede l'avvenire nella scaltrezza degl'indovini, degli astrologi, e delle vecchie eremite. Ma l'astronomia fa ostinata guerra a tutti i pregiudizi [e combatte] l'impostura che profitta sempre dell'altrui ignoranza che tutto teme e della superstizione che tutto crede […] L'astronomia strappa sempre all'impostura la maschera del mistero […] e […] giovandosi della severità matematica, squarcia gli arcani veli delle cause occulte […] ed abitua l'uomo a non meravigliarsi di nulla, e ad estendere le sue idee negli spazi immensi dell'universo." Niccolò Cacciatore, "Riflessioni sull'imminente ritorno della Cometa di Halley; per la gente di buon senso del 1835", *Giornale di Scienze, Lettere e Arti per la Sicilia*, 149 (1835), 131-77, pp. 131-3.

[29] "Da queste riflessioni, e da tante e tante altre che per brevità risparmio al lettore, mi sembra risultarne evidentemente: […] Che le comete non debbono inquietarci né punto né poco, non più che l'apparizione degli altri astri […] Che esse per la loro pochissima densità non hanno in natura la stessa importanza degli altri corpi […] Che le loro apparizioni son conseguenza delle loro rivoluzioni periodiche, e non possono essere che oggetti di semplice curiosità […] Che la loro nojosa influenza si manifesta solamente contra gli astronomi, perché sono questi obbligati ad osservarle con assiduità in tempo di notte, ed a calcolarne con lungo e faticoso lavoro le osservazioni in tempo di giorno …" Cacciatore, *op. cit.* (ref. 28), 167-8.

[30] Ragona, *op. cit.* (ref. 24), 223.

[31] On the Ramsden's Palermo Circle, see: Ileana Chinnici, Giorgia Foderà Serio and Paolo Brenni, "The Ramsden Circle at the Palermo Astronomical Observatory", *SIS Bulletin*, 71 (2001), 2-10.

[32] "Il metodo che ho tenuto nel fare le presenti osservazioni è quello stesso adoperato dal direttore […] Fissato cioè il cerchio azimutale ad un'azimuto [sic] prossimo alla Cometa, ne incontrava il passaggio all'intersezione de' fili col solo movimento del cerchio verticale, notandone l'istante al pendolo regolato sul tempo sidereo. Colla Cometa e collo stesso metodo osservava pure una stella ben conosciuta onde dedurne gli errori degli azimuti e delle distanze". Martina, *op. cit.* (ref. 24), 2.

[33] See: Chinnici, Foderà Serio, Brenni, *op. cit.* (ref. 31), 5.

[34] Niccolò, indeed, obtained permission for a large part of his family to work at the Observatory, covering different assignments (see also notes 22-23): this provoked the sarcastic comments of some contemporaries, like the physicist Domenico Scinà, who ironically defined the Cacciatore family as 'the new Cassini dynasty' thus ridiculing their scarce scientific production; [Domenico Scinà], *Lettera al signor Barone von Zach*, (Palermo, 1835), 22.

[35] Domenico Ragona, *Osservazioni sulla seconda cometa del 1854* (Palermo, 1854).

[36] *Ibid.*, 25-26.

[37] "Per quante ricerche avessi eseguito non trovo che sole dodici Comete, osservate dal 1793 al 1854, intervallo in cui sonosi osservate in Europa 113 Comete tra cui 23 scoperte in Italia …" (*ibid.*, 25). These data partially mismatch Kronk's catalogue (ref. 2), probably because they were extracted from different sources. However, Ragona's statistics sound like an implicit accusation of ineptitude against Niccolò Cacciatore and his family staff.

[38] Ragona later inserted two additional comet observations (1830 and 1835), excerpted from published and unpublished sources; see: Ragona, (ref. 24), 223.

[39] According to Kronk, the comet was discovered by the reverend Edward Gregory, who observed it for the first time on 8 January 1793, while Piazzi and Méchain observed it on 10 January; see: Gary W. Kronk, *Cometography*, vol. 1 (Cambridge: Cambridge University Press, 1999), 494-6. Kronk erroneously mentions Piazzi, but the observer of the comet on 10 January was Carioti, as stated by Piazzi himself, who observed the comet for the first time on 11; see: Giuseppe Piazzi, "Della cometa apparsa in gennajo 1793" in *Della Specola Astronomica de' Regj Studj di Palermo. Libro V. Parte I.* (Palermo, 1794), 1-30. This circumstance is erroneously reported also by Cacciatore: Niccolò Cacciatore, "Comete" in *Del Reale Osservatorio di Palermo. Libri vii, viii e ix.* (Palermo, 1826), 207-8, p. 207.

[40] Data extracted from Kronk, *op. cit.* (ref. 2)

[41] Giuseppe Piazzi, *Della Specola Astronomica de' Regj Studi di Palermo. Libri Quattro* (Palermo, 1792), 26.

[42] See: Domenico Ragona, "Osservazioni sulle stelle australi eseguite nel Reale Osservatorio di Palermo", *Giornale astronomico e meteorologico,* I (1855), 35-38.

[43] It is well-known that the figure of this nobleman inspired his great-grandson, the writer Giuseppe Tomasi di Lampedusa (1896-1957), in defining the profile of the protagonist of the novel "The Leopard" (1957).

[44] Giuseppe Piazzi, "Discorso preliminare sulla vicende dell'astronomia in Sicilia" in Piazzi, *op. cit.* (ref. 41), ix-xxxii.

[45] Ileana Chinnici, 'Giovan Battista Hodierna e l'astronomia', *Giornale di Astronomia,* 34 (2008), 10-17.

[46] Eight meridian lines and over 200 sundials have been recorded in Sicily (M. L. Tuscano, Personal communication, 2014).

[47] Another important exception, in the seventeenth century, was Odierna's 'specula'; in addition to his well-known contributions to astronomy (see, for instance: Giorgia Foderà Serio, Luigi Indorato and Pietro Nastasi, "Giovan Battista Hodierna [1597-1660] Observations of Nebulae and his Cosmology", *Journal for the History of Astronomy*, 16 [1985], 1-36), it is appropriate to recall, in this context, Odierna's booklet on the comet of 1652 (Giovan Battista Odierna, *La colomba volante: cometa nouamente comparsa mercoldì la note, delli 18. di decembre 1652*, [Palermo, 1653]), where the Sicilian priest adopted Galilean ideas on the origin of comets (erroneously considered as made of terrestrial materials and having linear trajectories), thus contributing to the spread of Galileo's theories. Incidentally, Odierna's observations of this comet are not mentioned in Kronk, *op. cit.* (ref. 39), 346-7, probably because Odierna's booklet had a limited circulation.

[48] Ileana Chinnici, "Gli strumenti del Gattopardo", *Giornale di Astronomia*, 23 (1997), 24-29.

[49] *Ibid.*, 27.

[50] The Bruhns' comet was not a new comet, but the Brorsen's comet of 1846 returned; see: Kronk, *op. cit.* (ref. 2), 248.

[51] "Fin dal giorno 14 [aprile] [...] nel mio osservatorio astronomico faceva delle osservazioni su di una cometa teloscopica, che giudicava fosse quella di Bruhns. Però [...] venni in sospetto, che quella da me osservata fosse una novella cometa [...] La cometa di Bruhns [...] fu da me veduta ieri sera per la prima volta, e quindi non dubitai più che fosse una nuova cometa, quella osservata la sera del 13. [...] Nelle prime osservazioni mi sono servito di un Cercatore di comete, montato parallatticamente, e poi fissai meglio la posizione della cometa col micrometro circolare del rifrattore di Monaco. [...] Non saprei dirle se questa cometa sia stata da altri osservata ..." *Giornale Officiale di Sicilia*, 18 April 1857.

[52] *Giornale Officiale di Sicilia*, 24 April 1857.

[53] "Agli astronomi larghissimo campo di osservazioni e di studi ha dischiuso il primo quadrimestre di questo anno, perciocchè tre comete telescopiche sono comparse, e tutte tre quasi contemporaneamente, cioè: 1ª Cometa del 57 di D'Arrest; 2ª Cometa del 57 di Bruhns; 3ª Cometa del 57 di Tomasi. E questa terza cometa telescopica del 1857 aggiunge una novella scoverta a quelle, con cui la sicola astronomia ha contribuito ad arricchire di nuovi corpi il sistema planetario, ed il nome di Giulio Tomasi, Principe di Lampedusa, sarà ricordato nella storia della scienza [...]. Perciocchè il nobiluomo, che dedica i suoi ozi alla contemplazione delle celesti armonie, come essi innalzava, fra le delizie della più amena campagna di Palermo, un tempio ad Urania, dal quale nella sera del 13 aprile gli era concesso di fissare lo sguardo in una cometa, mentr'egli per gl'interminati spazi del cielo ricercava l'altra di Bruhns. [...] ora [...] dalla Sicilia viene agli astronomi la notizia dell'esistenza di una cometa novella. La quale scoverta [...] rivela ai dotti astronomi di oltremonte la esistenza di un privato osservatorio, dal quale un uomo, rispettabile per sociali virtù, benefico, modesto ha consociato il suo nome alla vita di un astro. Ed è largo, e ad un tempo meritato compenso a tante cure, a tante veglie, a tanti studi, questo che il Principe di Lampedusa ottenne, perciocchè egli raggiunse la più alta meta, cui poteva aspirare [...] abbiam voluto rendere al nobil uomo quella lode, che più competenti giudici gli tributeranno larghissima non solo per la sua scoverta, ma benanco per lo amore grandissimo col quale coltiva la scienza." *Giornale Officiale di Sicilia*, 21 April 1857.

[54] Sicily did not enjoy a good reputation from a cultural point of view: in 1786 the mathematician Gregorio Fontana (1735-1803) wrote to the astronomer Barnaba Oriani (1752-1832), discouraging him from accepting the chair of astronomy in Palermo: " I would hardly recommend a Friend to accept this offer 1st for the climate; 2nd for the inhabitants; 3rd for the state of the sciences there (io stenterei a consigliare un Amico di accettare un tal partito 1° pel clima; 2° per gli abitanti; 3° per lo stato delle Scienze colà)." Piazzi, *op. cit.* (ref. 20), 14. About seventy years later, in spite of some attempts at reform of the public educational system, the situation had hardly changed.

[55] It is worth remarking that the novelist Giuseppe Tomasi di Lampedusa presents the protagonist of his novel as discoverer of two asteroids: this could be simultaneously a reference to the presumed discovery of a new comet by his great-grandfather, and a tribute to Palermo Observatory, where the first asteroid (Ceres) was discovered.

[56] "Non ho più cercato comete e non ho voglia di scoprirne da quando mi hanno voluto rubare l'ultima del 1877 [...] Il principe di Lampedusa, morto qui un mese fa, poteva testimoniare questo fatto." (Letter from W. Tempel to F. Fiaschi: Florence, 9 November 1885; Archivio di Stato di Firenze, Fondo Niccolò Nobili, fasc. 20, c. 131).

[57] Simone Bianchi and Ileana Chinnici, "L' 'arrubbatina' della cometa", *Giornale di Astronomia*, 40 (2014), 38-41. The riddle of the fake letter remains unsolved, because many documents related to the protagonists of this story have been lost or dispersed because of the world wars and the removal of the relevant archives.

[58] I. Chinnici (note 10), 4.

[59] See: Ileana Chinnici and Paolo Brenni, "The Palermo Merz Equatorial Telescope. An instrument, a manuscript, some drawings", *Nuncius*, 30 (2015), 228-279.

[60] John B. Hearnshaw, *The analysis of starlight* (Cambridge: Cambridge University Press, 1986), 52-54.

[61] *Ibid.*, 57-66.

[62] "Le spectre de la comète ressemble aux spectres produits par les métaux; en effet les parties noires y sont plus larges que les parties lumineuses, et on pourrait dire que ces spectres se composent de trois raies claires". Giovan Battista Donati, "Schreiben des Herrn Professors Donati, Directors der Sternwarte in

Florenza, an den Herausgeber", *Astronomische Nachrichten*, 62 (1864), 375-8, p. 378. All spectroscopic observations mentioned here refer to the head of the comets; prior to the beginning of the twentieth century the spectrum of the tails could not be well analyzed, although some comets showed spectacular tails, because this kind of spectral observation required special equipment, which was developed later (see: Polydore F. F. Swings, "Cometary Spectra", *Quarterly Journal of the Royal Astronomical Society*, 6 [1965], 28-69, pp. 31-32).

[63] "J'ai trouvé que [le spectre] est composé de trois rais seulement: une qui correspond à 2/5 de la distance entre b and f de Fraunhofer et est assez vive; sa couleur est verte […] les autres deux lignes ou raies sont trop petites et faibles pour en pouvoir fixer exactement la position. L'une est, du côté rouge, assez près de la large raie principale, l'autre assez eloignée du côté violet." Angelo Secchi, "Spectre de la comète de Tempel", *Comptes Rendus de l'Académie des Sciences*, 62 (1866), 210. The spectrum of the same comet was also described by William Huggins (see below) in a more detailed dissertation: William Huggins, "On the Spectrum of Comet I, 1866", *Proceedings of the Royal Society*, 15 (1866), 5-7). Huggins became a specialist in cometary spectral studies; see: Hearnshaw, *op. cit.* (ref. 61), 73.

[64] Cometary spectra were at first compared to those of planetary nebulae and the existence of a background continuum spectrum, sometimes observed, was also discussed, as well as the nature - self-luminous or reflected - of the cometary light; see: Swings, *op. cit.* (ref. 62), 29-30.

[65] In 1871 Tacchini established a scientific society of spectroscopists and, from 1872 to 1905, edited its *Memorie*, today considered the earliest astrophysical journal; see: Ileana Chinnici, "The 'Società degli Spettroscopisti Italiani': birth and evolution", *Annals of Science*, 65 (2008), 393-438.

[66] See: *Indice Generale delle Memorie della Società degli Spettroscopisti Italiani. vol. I a vol. XL*, 1872-1911 (Catania, 1912), 94-95.

[67] It should also be remembered that an Italian astronomer, Giovanni Virginio Schiaparelli (1835-1910), showed in 1866 the comet-meteor shower relationship; see: Giovanni V. Schiaparelli, *Note e riflessioni sulla teoria astronomica delle stelle cadenti* (Firenze, 1867). Moreover, in the 1870s a long debate arose on the origin of cometary tails; several hypotheses were developed about the nature of the repulsive force producing them, due either to radiation pressure or electric repulsion. An early classification of types of cometary tails was proposed by Theodor Bredichin (1831-1904), who divided the cometary tails into three classes, corresponding to their curvature and, consequently, to their chemical constitution: I-hydrogen; II-hydrocarbon; III-iron vapors; see: Tofigh Heidarzadeh, *A History of Physical Theories of Comets*, *From Aristotle to Whipple* (Dordrecht: Springer, 2008), 225-7. This is basically the modern typology of cometary tails, containing two classes: gas tails (Bredichin's I class) and dust tails (Bredichin's I-II classes).

[68] "1. E' lo spettro delle comete al loro comparire identico a quello che sviluppano appresso nella massima loro luce? 2. le sono in tutte le stesse non solo nel posto, ma anche nella intensità? 3. Che influenza vi ha la luce solare? 4. E' questa polarizzata?" Angelo Secchi, "Studi fisici sulle Comete del 1874", *Memorie della Società degli Spettroscopisti Italiani*, iii (1874), 117.

[69] "Le righe lucide osservate nello spettro della cometa furono quattro, che riportate su di uno spettro solare corrispondevano alle seguenti posizioni della scala di Angström 6770, 5620, 5110, 4800. Le posizioni di queste righe non si possono considerare esatte […] ma è chiaro che le tre ultime corrispondono allo spettro del carbonio." Pietro Tacchini, "Spettro della Cometa-Coggia e luce polarizzata. Osservazioni fatte a Palermo", *Memorie della Società degli Spettroscopisti Italiani*, iii (1874), 79. Tacchini was aware of a systematic error in his measurements – actually, they are about 40 nm average in excess of the exact values (see below). Applying this correction, the fourth line observed by Tacchini could be identified with the telluric [OI] line (λ6300) produced by the atmospheric airglow.

[70] Angelo Secchi, "Sullo spettro della Cometa Tempel", *Memorie della Società degli Spettroscopisti Italiani*, iii (1874), 29-30. The comet 1874 II was independently discovered also by Tempel (see: Kronk, *op. cit.* [ref. 2], 403): this explains the title of Secchi's article. Secchi remarked also that cometary spectra were similar, but not identical; see: Secchi, *op. cit.* (ref. 68).

[71] In 1868, by accurately comparing the spectrum of Winnecke's comet to laboratory spectra, Huggins identified the three bright bands observed by Donati as lines of carbon (see: William Huggins, "On the spectrum of Comet II, 1868", *Proceedings of the Royal Society*, 16 [1868], 481-2), today known as 'Swan bands' and attributed to molecular carbon (λ4380, 4740, 5165). On the identification of these carbon

bands, see: William Swan, “On the prismatic spectra of the flames of compounds of carbon and hydrogen”, *Transactions of the Royal Society of Edinburgh*, 21 (1857), 411–30.

72 The first polarimetric observations of cometary light were carried out by François Arago (1786-1853) in 1858, while its variations were firstly remarked by Secchi in 1861; for a historical review of cometary polarimetric observations, see: Nikolai Kiselev and Vera Rosenbush, “Polarimetry of Comets: Progress and Problem”' in *Photopolarimetry in Remote Sensing*, edited by G. Videen, Y. Yatskiv and M. Mishchenko, NATO Science Series 161 (2004), 411-30, pp. 412-13. On the complicated polarization behavior of the comets, depending both on the wavelength and the scattering angle, see: K. S. Krishna Swamy, *Physics of Comets*, World Scientific Series in Astronomy and Astrophysics 161 (2010), 262-3.

73 “Applicato al cannocchiale un polariscopio a biquarzo si ebbero subito traccie [*sic*] di polarizzazione ma deboli; applicato invece un [prisma di] Nicol e fattolo girare, si vide la luce essere fortemente polarizzata, e si trovò che […] la luce era polarizzata in un piano passante pel Sole.” Tacchini, *op. cit.* (ref. 69). The polarization was observed also by other astronomers in Italy and abroad; see, for instance: Angelo Secchi, “Spettro della Cometa Coggia e luce polarizzata”, *Memorie della Società degli Spettroscopisti Italiani*, iii (1874), 77 and Arthur W. Wright, “Polariscopic observations of Coggia’s Comet”, *Memorie della Società degli Spettroscopisti Italiani*, iii-Appendix (1874), 60.

74 For observing cometary spectra, Riccò usually used a Clean’s spectroscope, made by the Browning company in London; the small spectroscope was attached to the large Merz refractor.

75 The intensity of the spectral lines varies from comet to comet and even within the same comet at different times or at different heliocentric distance (Swings effect); John C. Brandt and Robert D. Chapman, *Introduction to Comets*, (Cambridge: Cambridge University Press, 1982), 31.

76 The first spectrograms, obtained by Huggins and by Henry Draper (1837-1882), revealed the presence of emission lines in the ultraviolet part of the spectrum and confirmed the existence of a weak Fraunhofer spectrum due to reflected solar light; see: Swings, *op. cit.* (ref. 60), 31.

77 “… l’uno continuo, complete, vivace, ma di poca altezza, quasi lineare, l’altro formato da tre zone o bande spiccanti sovra un terzo spettro, continuo, assai debolmente luminoso, che costituisce come un fondo.” Annibale Riccò, “Relazione del primo Astronomo A. Riccò” in: Gaetano Cacciatore, “Sulla Cometa b 1881”, *Pubblicazioni del R. Osservatorio di Palermo*, *Anni 1880-1881* (Palermo, 1882), 19-32, p. 26.

78 He then repeated the observations and measured the line positions with a small direct-vision Browning spectroscope, equipped with a micrometric scale, lent by Ippolito Macagno, director of the Stazione Agraria, a local institution for supporting agricultural work; *ibid*., 28.

79 William Huggins, “Preliminary note on the Photographic Spectrum of Comet b 1881”, *Proceedings of the Royal Society*, 33 (1881), 1-4. Independently, the same results were obtained by Draper: Henry Draper, “Note on Photographs of the Spectrum of the Comet of June, 1881”, *American Journal of Science*, iii series, xxii (1881), 134-5.

80 Annibale Riccò, “Osservazioni della Cometa 1881 IV”, *Pubblicazioni del R. Osservatorio di Palermo, Anni 1880-81* (Palermo, 1882), 33.

81 “… l’impressione avuta fosse quella del solito spettro delle comete allo stato rudimentale.” Annibale Riccò, “Spettro della cometa Wells osservato a Palermo”, *Memorie della Società degli Spettroscopisti Italiani,* xi (1882), 76.

82 Sodium lines were observed in the spectrum of Wells comet by Nils C. Dunér (1839-1914) at Lund Observatory in Sweden, Bernard Hasselberg (see below) and Bredichin (already mentioned) at Pulkovo Observatory in Russia, and Hermann Carl Vogel (1841-1907) at Potsdam Observatory in Germany; see: *Memorie della Società degli Spettroscopisti Italiani*, xi (1882), 31-32; 73.

83 Hasselberg was the author of an important work on cometary spectra, published in the *Memoirs of the Imperial Academy of St. Petersburg*, xxviii (1881), resuming all spectral observations of comets and showing that cometary spectra belonged to one and the same spectral class, even if certain lines were sometimes invisible. He carried out several laboratory experiments on electric discharges in gaseous mixtures, trying to observe simultaneously the appearance of the sodium lines and the disappearance of the hydrocarbon bands; see: *Memorie della Società degli Spettroscopisti Italiani*, xi (1882), 32.

84 “… si ha lo spettro lineare del nucleo, vivissimo, continuo dal rosso estremo, che è assai splendido, al violetto […] E’ attraversato dalla riga D del sodio, fortissima, molto larga e lunga. […] Nello spettro lineare vi sono tre massimi di luce: uno nel rosso aranciato […] un altro nel verde, un altro nel bleu.” Annibale Riccò, ‘Osservazioni spettroscopiche della cometa Cruls fatte collo spettroscopio di Clean

applicato al rifrattore di 0$^{m}$25 nell'Osservatorio di Palermo', *Memorie della Società degli Spettroscopisti Italiani,* xi-Appendix (1882), 15-17, p. 15.

[85] "Si è avuta dunque una graduale diminuzione dei vapori di sodio […] fino a scomparire; mentre le bande degli idrocarburi, prima rudimentali, crebbero [in] estensione […] Simultaneamente la testa della cometa, che era rossiccia, divenne bianca, poi azzurrognola. […] la differenza di colore era tanto grande che certo lo svanire dei vapori gialli di sodio vi deve aver avuta la parte principale." *Ibid.*, 16.

[86] "Lo svolgersi dei vapori di sodio per il calore solare, allorché la cometa è al perielio, produce l'occultazione, per così dire, dello spettro degli idrocarburi; il quale poi ridiviene visibile all'allontanarsi della cometa dal sole, con che tornano a condensarsi i vapori di sodio." *Ibid.*

[87] "… les belles observations de Mr. Riccò à Palerme nous permettent d'étudier les différentes phases du spectre d'un jour à l'autre. Ainsi l'époque de la disparition des raies du sodium se peut fixer avec assez d'exactitude aux premiers jours du mois d'octobre, pendant que l'affaiblissement qu'elles ont éprouvé dans les jours précédents était accompagné d'un accroissement notable du spectre ordinaire des carbures d'hydrogène, qui finalement restait le seul visible" Bernhard Hasselberg, "Sullo spettro della Cometa Finlay. Settembre 1882." *Memorie della Società degli Spettroscopisti Italiani,* xi (1882), issue 11, 2.

[88] Riccò also mentions some spectral bands sometimes visible in the red, but as any information about their position is missing, their identification is unclear.

[89] Kronk, *op. cit.* (ref. 2), 658-60.

[90] Adalbert Krueger, "Entedeckung von zwei neuen Cometen", *Astronomische Nachrichten*, 126 (1890), 95.

[91] Benjamin A. Gould , "Comet *e*1890", *The Astronomical Journal*, 10 (1890), 101.

[92] Kronk, *op. cit.* (ref. 2), 748.

[93] "(Fifth) Award of the DONOHOE Comet-Medal (to Prof. T. ZONA)", *Publications of the Astronomical Society of the Pacific*, 3 (1891), 111.

[94] Cesare Mattina, "Ricerche sull'orbita definitiva della cometa 1890 IV", *Memorie della Società degli Spettroscopisti Italiani,* xxiv (1893), 91-95.