THE THIRD REDUCTION OF GIUSEPPE PIAZZI'S STAR CATALOGUE

E. Proverbio
Astronomical Observatory - Cagliari, Italy

Abstract

The star observations carried out by Giuseppe Piazzi with Ramsden's large altazimuth circle, which he began in 1792, led to the realization of a 1st and 2nd Catalogue, published by Piazzi in Palermo in 1803 and 1814.

During 1845, the original astronomical observations in Piazzi's catalogue, included in "La storia celeste of the Palermo Observatory from 1792 to 1814", which had been kept at the Brera Observatory in Milan, were published in Vienna.

The publication of these observational data revealed a series of errors, real or presumed, which cast doubt on the reliability of the Palermo Catalogue.

Towards the end of the last century, upon the suggestion of Giovanni Schiaparelli, work on the reduction of Piazzi's catalogue was once again taken up for the purpose of producing an independent catalogue based on the original observations. This work, carried out by Francesco Porro, led to the production of a corrected catalogue purged of systematic and accidental errors.

The third fundamental star catalogue of Palermo may represent the basis for the final reduction of the great Palermo Catalogue of 7646 stars.

G. Piazzi's 1st and 2nd Catalogues

In the second half of the 18th century, if we exclude Tobias Mayer's brilliant activity, positional astronomy and research for the realization of fixed star catalogues were basically dominated by the English and French schools. It is no accident that Giuseppe Piazzi(1), during his visit to France and England between 1787 and 1789 for the purpose of improving his knowledge in the field of practical astronomy commissioned the famous Ramsden to build for him a 5 foot

S. Débarbat et al. (eds.), Mapping the Sky, 75–86.

focal length transit instrument and the large altazimuth circle(2) with which he was to begin his long series of observations at the Palermo Astronomical Observatory starting from 1792(3). Piazzi published a first list of mean declinations for 1795.0 of 34 stars observed with the instrument from 1791 to 1794(4), and 1803 marked the appearance of his first catalogue of 6748 stars in D and RA, based on observations carried out between 1792 and 1802(5). Piazzi based the calculation of the right ascensions of this catalogue on the positions of the 36 stars of Maskelyne's catalogue(6), and those of the declinations on the Observatory's latitude of 38°6'45".5. However, since he was in doubt as to the precision of Maskelyne's catalogue and to the values of the precession constant and latitude adopted, he decided to intensify the observation of a limited number of stars and the Sun in the period 1803-05 for the purpose of arriving at the determination of an absolute catalogue. This led to the realization of a basic catalogue of 120 stars and a second catalogue of 100(7), which made up the basis of Piazzi's second great catalogue of 7646 stars, based on observations carried out from 1792 to 1813(8). Piazzi's second catalogue was rightly appreciated at the time of its appearance(9), even though Piazzi himself was aware of the fact that it could not be considered as having been the last word, and that a new, more meticulous and rigorous reduction had to be undertaken. In a letter dated 3 October 1818, addressed to his close friend Barnaba Oriani, director of the Milan Observatory, Piazzi stated: "Mi viene un'idea. Il vostro bravo Carlini avrebbe egli agio di trattare le mie osservazioni, come Bessel ha trattato quelle di Bradley?"(10). There is no evidence to show that Oriani paid any attention to Piazzi's suggestion, but he did work actively for the publication of all the original observations carried out by Piazzi and his collaborators from 1792 to 1813. A copy of these observations, which constitute the "Storia Celeste del R. Osservatorio di Palermo", had been sent to Oriani after various attempts at publishing them(11) in May 1816(12) and July 1817(13). Because these observations could not be published by the Istituto di Scienze e Lettere di Milano(14), and following Piazzi's refusal to accept the proposal of the University of Cambridge to publish his original observations in England(15), the copy of these observations became the property of Oriani and, following his death, was willed to the Brera Observatory(16).

A further attempt to publish the observations at the Reale Accademia delle Scienze di Napoli(17) failed in 1827, just after Piazzi's death. It is known that on the insistence of Argelander these observations were finally published by C. L. Littrow in the Annalen of the Vienna Observatory between 1845 and 1849 on the basis of the manuscript conserved at the Brera Observatory(18).

Critical Analysis of Piazzi's Second Catalogue

The publication of Piazzi's "Storia Celeste" had been encouraged by the outstanding astronomers of the time, among whom Bessel and F.W. Struve(19), for the express purpose of arriving at a revision of the second catalogue with the use of the new reducing methods introduced by Bessel himself. In fact, Argelander had already observed that the right ascensions, and thus the values of parameter n in Bessel's formula

$$\alpha = t + (\Delta t + m) + n \tan \delta + c \sec \delta ,$$

relating to the group of stars in Piazzi's fundamental catalogue of 220 stars that he had examined, presented a systematic error which he attributed to an error in the azimuths of the meridian mark on the transit instrument with which Nicolo Cacciatore observed the right ascensions of the fundamental stars and of the Sun in the period 1803-05(20). F.W. Struve reached the same conclusion, indicating for Piazzi's catalogue an error in the right ascension of the type $0.131 \tan \delta$ (21).

But perhaps the most complete and accurate analysis of Piazzi's catalogue was made by Arthur Auwers, who not only confirmed the existence of the errors found by Argelander and Struve, but who also pointed out the existence of diurnal variations in right ascension and in n attributed to thermal effects(22).

Auwers' research is limited to an analysis of the positions of 46 fundamental stars of the Palermo catalogue and, as G. Schiaparelli acutely observes(23), the same magistral work by Auwers contains several mistakes and questionable analytical procedures, such as that of supposing the existence of an empirical relation of the type $m = n \tan \phi$ (ϕ = latitude of Palermo) in Piazzi's right ascension system. But Auwers' note did have the merit of definitely pointing up the lack of homogeneity in Piazzi's catalogue and proved the necessity of further revising it.

According to the testimony of Francesco Porro(24), about twenty years after the publication of Auwers' note, Ludwig Struve, in 1884, pointed "all'opportunità che la nuova riduzione del Piazzi sia intrapresa"(25). Struve himself certainly intended to undertake this arduous task but, as he confessed to Porro, other, more pressing chores kept him from it. Several years later, when it occurred to him to resume the job, he found that it was already in other hands(26).

In fact, Francesco Porro, who in 1884 had had occasion to discuss the revision of Piazzi' catalogue during his visit to Struve's study in Milan, had decided then and there to put all his efforts into this great task, which he must certainly have discussed with his venerated teacher Giovanni Schiaparelli. The latter, as can be seen from the

correspondence made public by Porro, was himself about to undertake the redefinition of a right ascension catalogue for Piazzi's 220 fundamental stars. But, being well advanced in years and realizing he did not have "molta speranza di vedere la fine" of the work, Schiaparelli invited Porro to "condurre la ricerca a termine", and gave him all the material and plan for the work of reducing the catalogue he had already elaborated(27). It is interesting to observe, as a confirmation of the importance that was then attributed to a new reduction of Piazzi's observations, that more or less at the same time, in 1889, Lewis Boss too "attempted to secure means for a new reduction of Piazzi's observations and was only deterred by a notification from Professor Newcomb that he was about to engage in this work, an intention he subsequently abandoned"(28).

At that time the fundamental problem arose, which particularly characterized Schiaparelli's reflections and original proposal, namely whether the new catalogue constructed from Piazzi's and Cacciatore's observations should be based on a system of fundamental coordinates independent of these observations or if it should be considered possible to derive a system of absolute right ascension from the same observational material. Schiaparelli's proposal, expressed already in 1893, to "conservare a Piazzi l'onore di aver fatto un catalogo di posizioni fondamentali non troppo inferiore in merito a quello di Bradley"(29), was based on the opinion that it would be more opportune in that epoch to try to "ridurre almeno le ascensioni rette delle 220 stelle fondamentali (observed by Cacciatore 1803-05) indipendentemente da qualsiasi base estranea", rather than trust to the positions of the stars, still quite uncertain, of even the most recent fundamental catalogues, such as those given in Bradley's new catalogue and calculated by Auwers(30). Auwers expressed himself differently. Although he recognized that "une reconstruction soigné et exacte du grand catalogue pour 1900 sera sans doute une travail de plus importants qu'on puisse entreprende dans l'astronomie"(31), Auwers was still of the opinion that it would be more convenient, at least at the beginning, to plan the work "sélon le modèle de ma nouvelle réduction du Catalogue de Mayer jusqu'au point dont on fixera la position la plus convenable après quelques annèes(32).

Schiaparelli's preoccupations, repeated in a letter to Porro in February of 1896(33), were also supported by the criticisms that Lewis Boss and other astronomers had advanced regarding the accuracy of Bradley's fundamental system reduced by Auwers. These criticisms were later accepted by Boss himself, who observed in a letter to Porro in 1899 that he was inclined "to assign only a small weight to Bradley's observations", even though he spoke in favor of the possibility of reducing Piazzi's observations with reference to the determinations of

Bessel, Struve and Argelander and to the more recent catalogues by Pulkovo and Greenwich(34).

The conviction that it would be possible to construct a coherent right ascension system on the basis of the observations of the 220 stars in the Piazzi catalogue led Schiaparelli to lay out a most precise and complex plan for the reduction of these observations in 1896, and this plan constituted the foundation of the work undertaken by Francesco Porro(35).

The Foundations for a Third Piazzi Catalogue

Presumably it is in 1895 that we have the beginnings of the preliminary phase of organizing the practical activities for the revision of Piazzi's observations by Francesco Porro. Documents regarding the development of this phase and the next are however few and far between(36). From Schiaparelli's letters written in November 1895 and those of Auwers written in December of the same year to Porro it appears that the latter had not yet made any final decision as to the reduction plan(37). Not even in 1896, that is, at the time when Schiaparelli was preparing his "piano delle operazioni", had Porro defined with any clarity his choice of criteria and the objectives he intended to reach. In a letter previous to the one already cited, which has not come down to us, Auwers suggests to Porro to carry out the heavy preliminary work of reduction together with the American astronomer Herman Davis of the Columbia College Observatory, who had offered his help. On Schiaparelli's advice (letter dated November 1895), Porro accepted this offer and, after meeting with Davis in Europe (it is not known exactly when) they decided to proceed with the calculation of Bessel's special constants for all the 7646 stars in Piazzi's second catalogue(38). But the collaboration with Davis was interrupted immediately following a first exchange of constant values calculated in Turin and New York(39), and only in 1921 do we have the publication of the values of Bessel's special constants calculated by Porro in Turin in 1899 and 1900 with the collaboration of Vittorio Balbi, Azeglio Bemporad, Luigi Carnera, Luigi Volta and Luigi Gabba(40). It may be assumed that only in 1897-98 did Porro finally decide on a revision of the 1803-1805 observations on the basis of the plan set up by Schiaparelli. In fact, he communicated his executive plan to the Meeting of the Astronomical Society held in Budapest in 1898(41).

We do not know what the next steps were in the work of reducing the observations, according to Porro's plan. Porro himself confessed, however, that subsequent to his transfer from the University of Turin to the University of Genoa, which took place in 1901, the continuation of the task rested on his shoulders alone, "e quindi progredì lenta-

mente sino al termine del 1905", the year in which Porro was officially invited by the Argentine government to direct the La Plata Observatory(42).

Following his return to Italy in 1910, Porro published at the expense of the Argentine government, as stated already, the first volume of the "Fondamenti", that is, of the values of Bessel's special constants for all the stars included in Piazzi's second catalogue.

The calculation of the corrections and the subsequent derivation of the right ascensions of the new fundamental catalogue was carried out many years later. The reason for the delay in completing the reduction work is not known. It must certainly have been completed before 1930. In fact, during the meeting of the Classe di Scienze fisiche, matematiche e naturali of the Accademia d'Italia held on 21 March 1930, the proposal to publish Porro's reduction of Piazzi's star catalogue, carried out in line with Schiaparelli's views and plan, was announced(43).

The problem involved in the publication of the results of the reduction calculations of Piazzi's new catalogue was discussed in another meeting of the Classe di Scienze fisiche of the Accademia d'Italia and, at the meetings held on 3 January 1931, a commission composed of Porro and the directors of the astronomical observatories of Milan and Rome (Giuseppe Bianchi and Giuseppe Armellini), was appointed to examine the manuscript(44). It was, however, only during the meeting held on 15 January 1932 that it was decided to publish the second volume of the "Fondamenti della riduzione per un nuovo catalogo di stelle"(45). In Porro's work are given the final elements, that is, the values of diurnal variations of the corrections ($\Delta t + \underline{m}$) and $\underline{n}$, and the final values of the right ascensions of 415 stars in Piazzi's second catalogue observed in the period 1803-1805.

Piazzi's catalogue reduced by Porro according to instructions dictated by Schiaparelli is presented as an absolute catalogue in right ascensions of which the only element known with insufficient precision is the equinox. This problem is due to the fact of having excluded from the material examined the original observations of the Sun which, because of their imperfection, would have been quite difficult to correct. It must be added that Porro, in applying Schiaparelli's procedure, limited himself to calculating the right ascensions as a first approximation believing, as indeed Schiaparelli himself believed(46), that this approximation was more than sufficient to guarantee an accurate definition of the positions in right ascension.

We do not know if Porro intended to arrive at the reduction of the right ascensions as a second approximation, which rests on the hypothesis that over long periods the collimation error is to be considered not zero. In fact, Porro died in 1937, just a few years after

the publication of his catalogue.

More than fifty years have passed since the publication of the catalogue, and since we now have at our disposal quite accurate fundamental catalogues, it would not be out of the question to consider a reduction of Piazzi's new catalogue of 415 stars to these large catalogues. This is what Boss had in mind and what Schiaparelli had imagined but not carried out because of his diffidence towards Bradley's catalogue and other catalogues of the time which only with difficulty could be reduced to 1800.0(47).

If this were to be carried out, it would allow the reduction of Piazzi's entire large catalogue of 7646 stars to a system of sure positions and the determination of the proper motion in right ascension of the stars in this catalogue. In this way it might be possible to facilitate the reduction of the declinations of the catalogue into a fundamental system, a task that Porro had not envisaged. In this way the third reduction of Giuseppe Piazzi's star catalogue could be carried out in practice and in line with the value that the great astronomers of the 19th century attributed to this catalogue.

Bibliographical Notes

1) Giuseppe Piazzi was born in July of 1746 at Ponte in the Valtellina district, which at that time belonged to the Helvetic Confederation. He attended the Theatine schools and became a member of the Order, which he later abandoned in order to follow his vocation for the exact sciences. He was a professor of mathematics in Malta and Rome. In 1780 he was appointed Professor of Mathematics at the University of Palermo and subsequently became the director of the Palermo Observatory (cf., S. Scrofani, "Elogio di Giuseppe Piazzi", Giornale di Scienze Lettere ed Arte per la Sicilia, Tomo XVII, ANNO V, 1827).

2) H.C. King, "The History of the Telescope", New York, 1979, 148-69.

3) A detailed description of the instruments is given by Piazzi in the volume "Della Specola Astronomica de' Regi studi di Palermo, Libro IV", Palermo, 1792.

4) G. Piazzi, "Della Specola Astronomica, Libro V", Palermo, 1794, 198-208.

5) G. Piazzi, "Precipuarum Stellarum Inerrantium, etc.", Panormi, 1803.

6) Nevil Maskelyne, "Astronomical Observations Made at the R. Observatory at Greenwich in the Years 1765-69", London, 1774.

7) G. Piazzi, "Del R. Osservatorio di Palermo, Libro VI", Palermo, 1806.

8) G. Piazzi, "Precipuarum Stellarum Inerrantium Positiones Mediae ineunte seculo XIX, etc.", Panormi, 1814.

9) Robert Grant, in his "History of Physical Astronomy", London (1832) on referring to Piazzi's second catalogue, states: "this great work is justly considered to be one of the most important that has ever been executed by a single individual".

10) The letter is a part of the copious correspondence between Giuseppe Piazzi and Barnaba Oriani edited by G. Schiaparelli and G. Cacciatore (cf., "Corrispondenza astronomica fra Giuseppe Piazzi e Barnaba Oriani", Milano, 1875).

11) In a letter to Oriani dated 10 August 1814, Piazzi informs his friend that "In Napoli si pensa di intraprendere la stampa di tutte le mie osservazioni". But since these hopes were never realized Piazzi decided (letter dated 26 May 1815) to ask his friend to "vedere, se l'Istituto o qualche librajo di costì volesse incaricarsi di pubblicarla", (cf. "Corrispondenza astronomica" between Piazzi and Oriani, cit., 106-122).

12) "Eccovi la prima parte della Storia di questo Osservatorio", (letter from Piazzi to Oriani, 28 May 1816, in "Corrispondenza astronomica", cit., 133).

13) "Eccovi in 89 fogli la continuazione delle osservazioni fino al 1813, termine della mia esistenza astronomica, e dei lavori sui quali sono fondati i due Cataloghi e le altre mie bagatelle". (letter from Piazzi to Oriani, 21 July 1817, in "Corrispondenza astronomica", cit. 151).

14) Right up to the end Piazzi hoped that his observations would be published by Oriani at the Istituto Cesareo in Milan. It appears that the main obstacles to publication were administrative (see Oriani's letter to Piazzi dated 10 September 1821, in "Corrispondenza astronomica", cit. 185).

15) Letters from Piazzi to Oriani, 25 August and 3 December 1821 (cf. "Corrispondenza astronomica", cit., 183-84, 185-86).

16) "Lascio pure alla stessa specola la copia manoscritta delle osservazioni fatte a Palermo dall'astronomo Giuseppe Piazzi risposte in una scatola di latta" (cf. Testamento di Barnaba Oriani of 2 May 1832, at the Archivio dell'Osservatorio di Brera).

17) F. Visconti, "Breve Compendio delle opere astronomiche etc.", Atti R. Accademia delle Scienze, Napoli, 1832, 72-76.

18) "Storia Celeste del R. Osservatorio di Palermo dal 1792 al 1813", in Annalen der K. K. Sternwarte in Wien, Vols. IV-XII, 1845-1849.

19) See the Introduction by C.L. Littrow (Vols. IV, V) of the "Annalen", cit. in 18.

20) Argelander's first catalogue based on observations carried out at Abo were published in 1895 (cf., "DLX Stellarum Fixarum Positiones Mediae ineunte anno 1830, etc. adjecit Mag. Fredr. Giul. Aug. Argelander", Helsingfors, 1835.

21) F.G.W. Struve, "Stellarum fixarum imprimis duplicium et multiplicium Positiones Mediae pro Epoca 1830.0, etc.", Petropoli, 1852.

22) A. Auwers, "Reduction der Beobachtungen der Fundamentalsterne am Passageinstrument der Sternwarte zu Palermo in den Jahren 1803 bis 1805, etc.", Leipzig, 1866.

23) G. Schiaparelli, "Idea e piano delle operazioni da intraprendere per una nuova discussione delle osservazioni fatte a Palermo allo istrumento dei passaggi sulle stelle fondamentali del Catalogo di Piazzi, etc.", 1896, in: Fr. Porro, fondamenti delle riduzioni per un nuovo Catalogo di stelle dedotte dalle osservazioni di Giuseppe Piazzi a Palermo, Rome, 1933.

24) Francesco Porro was born in Cremona in 1861. In 1882 he was a student astronomer at the Brera Observatory in Milan. In December 1885 he was appointed astronomer at the Turin Observatory and was put in charge of the astronomy course at the University of Turin. He became professor of astronomy and director of the Turin Observatory in 1896. In 1901 he transferred to the University of Genoa. In 1906, upon the recommendation of G. Schiaparelli, he was

appointed director of the La Plata Astronomical Observatory in Argentina. He returned to Italy in 1910 and once again occupied his chair at the University of Genoa. He died in Genoa in 1937.

25) The quotation is given in: Fr. Porro, op. cit., 28. See Note 31.

26) Cf., letter from Struve to Porro dated 11 January 1900, in Fr. Porro, op. cit., 27.

27) Cf., letter from G. Schiaparelli to Fr. Porro of 8 November 1895, in Fr. Porro, op. cit., 34. Schiaparelli must have already calculated the Besselian constants necessary for the reduction of Piazzi's catalogue (see G. Schiaparelli, "Costanti generali besseliane calcolate di sei in sei ore per il periodo compreso tra il 31 luglio 1803 e il 2 novembre 1805", in Fr. Porro, op. cit., 155-276.

28) Cf., letter from Lewis Boss to Fr. Porro dated 14 April 1899, in Fr. Porro, op. cit., 36.

29) Cf., letter from G. Schiaparelli to Fr. Porro dated 20 February 1893, in Fr. Porro, op. cit., 24.

30) Cf., letter from Schiaparelli to Porro quoted in Note 35, 29 and 33. For Bradley's new catalogue see: A. Auwers, "Neue Reduction der Bradley'schen Beobachtungen aus den Jahren 1750-bis 1762", St. Petersburg, Erster Band, 1903, Zweiter Band, 1882, Dritter Band, 1838.

31) Cf., letter from A. Auwers to Fr. Porro dated 17 June 1888, in Fr. Porro, op. cit., 29.

32) Cf., letter from A. Auwers to Fr. Porro dated 2 December 1895, in Fr. Porro, op. cit., 31. For Mayer's catalogue, see: A. Auwers, "Tobias Mayer's Sternverzeichniss nach den Beobachtungen auf der Göttinger Sternwarte in den Jahren 1756 bis 1760", Leipzig, 1894.

33) Cf., letter from Schiaparelli to Fr. Porro dated 7 February 1896, in Fr. Porro, op. cit., 24.

34) Cf., letter quoted in Note 28, 37-38.

35) G. Schiaparelli, op. cit., in Note 23.

36) Of the correspondence between Francesco Porro and Giovanni Schiaparelli, Arthur Auwers, Lewis Boss and Ludwig Struve on the subject of revising Piazzi's and Cacciatore's observations, only the excerpts quoted in this work and published by Porro remain. Despite this author's patient research in the archives, the original letters have not been found.

37) This line of uncertainty seems to be borne out by the executive plan that Porro set up, presumably at the end of 1895. (Cf., Fr. Porro, op. cit., 34).

38) Cf., Fr. Porro, op. cit., 35.

39) Ibid., 36.

40) F. Porro, "Fondamenti delle riduzioni per un nuovo catalogo di stelle dedotto dalle osservazioni di Giuseppe Piazzi", Torino, 1911.
41) F. Porro, "Ueber den gegenwärtigen Stand der Berechnungen, welche in Turin und New York behufs einer neuen Reduction der Piazzischen Beobachtungen, etc.", Vierteljahrsschrift der Astronomischen Gesellschaft, 33, 1898.
42) F. Porro, op. cit. in Note 31.
43) Annuario R. Accademia d'Italia, Vol II, 1929-30, 394.
44) Annuario R. Accademia d'Italia, Vol III, 1930-31, 192, 210.
45) Annuario R. Accademia d'Italia, Vol IV, 1931-32, 270, 291.
46) Cf., Fr. Porro, op. cit. in Note 31, 47.
47) Ibid., 29-30.

Discussion:

EICHHORN What exactly was the nature of the data used in producing the new reduction, and what exactly are the data which constitute the result of the new reduction?

PROVERBIO The original material used for the new reduction of the Piazzi Catalogue was constituted by the observational data of Piazzi published in Vienna by C.L. Lettrow. The data published by Fr. Perro are the values of the m and n constants of the Bessel formula used in the reduction of the observational data and the final values of the RA of the FK5 stars of the Perro/Piazzi Catalogue.

MULHOLLAND In the past 24 hours, the name STRUVE has been mentioned several times. There have been six astronomers of that name, most of whom have done illustrious research in several domains. It would be a convenience if it were made explicity clear which one is being discussed.

PROVERBIO The Struve cited in the paper are F.G. Wilhelm Struve who in the "Stellarum fixarum etc." published in 1852 found evidence of a systamatic error in the second Piazzi catalogue and Ludwig Struve, who first discussed the revision of the second Piazzi's catalogue with Francesco Perro in 1884.