

CIENCIAS

MEDIEVAL COMETS EUROPEAN AND MIDDLE EASTERN PERSPECTIVE

PIERO SICOLI ROBERTO GORELLI MARÍA JOSÉ MARTÍNEZ FRANCISCO J. MARCO





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European and Middle Eastern Perspective

Piero Sicoli Roberto Gorelli María José Martínez Francisco J. Marco



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Cover

Comet of 634 AD. This comet appeared during the Arab invasion of Syria, some time before the Muslim commander Khālid ibn al-Walīd conquered Damascus by treaty. (*art by M. Miani, 2022*)

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He works at the Osservatorio Astronomico Sormano (Italy) where he has discovered about fifty new asteroids and identified several hundred, including some PHA (potentially hazardous asteroids). Combining his passion for celestial mechanics and historical comets, he has tried to calculate some of their orbits. In 1999, asteroid (7866) Sicoli, discovered at Lowell Observatory in Arizona, was named after him.

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Roberto Gorelli worked in a public administration and is now retired. In the field of Astronomy he has worked for many years mainly on research on old texts for the retrieval of astronomical data of all types of astronomical objects and on meteoritical topics as meteorite observations, meteor showers, and discovery of meteorite craters. He is also involved in telescope observations of comets and asteroids and in recent years also of variable stars, especially extragalactic ones.

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Book summary

This book is intended to be the first volume in a series devoted to an in-depth study of medieval European and middle-east comet records. With the aim of covering the entire medieval period, widely understood as corresponding to the 5th to 15th centuries AD, this first volume deals with the 5th, 6th, and 7th centuries. The rest will follow until the period is completed.

Comet catalogs are a classic literary genre in the history of astronomy since before the 20th century. In them, the different authors presented reports of observations of different phenomena related to these celestial bodies but always presented a characteristic bias favorable to records from Asia, especially Chinese. This fact is understandable since, in those countries, there was a heritage of systematically writing chronicles of the successive reigns, pointing out astronomical events that, according to their traditions and beliefs, would influence the kingdom or the monarch in some way. This was not the case in Western countries, where we find fewer astronomical observations that are much more dispersed in works by different individual authors who often copy each other or, at least, tend to copy from the most prestigious ones.

As a result, to date, there has been no research dedicated to exhaustively studying European literary sources, searching for elements that allow expanding the historical databases on medieval comets, and, at the same time, carrying out astronomical analyses that allow in some cases, the improvement or even the proposal of a set of orbital elements associated with comets. Bernard of Chartres (sec. XII) taught us that the dwarves that arise on the shoulders of giants can see more of them and further away,even if they don't have a better view or a higher height. Following his lesson, the authors dedicate this catalog to Umberto Dall'Olmo (1925-1980) and Paolo Maffei (1926-2009)

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Foreword

The ancient observers of the night sky realized that, besides the fixed stars, a number of other bodies were moving; these bodies were the planets visible to the naked eye and the Moon, which was then considered a planet. The ancients also understood that those motions were somehow regular and predictable, and over time developed a kinematic picture of the heavens that was the first seed of the exact sciences.

From time to time, however, the unexpected apparition of a comet broke the order that was seemingly regulating the motions in the sky. Thus, comets were regarded as mysterious heavenly objects; the understanding of their nature and of their motion took a very long time, and led to important advancements of astronomy and exact sciences.

There are several historical examples of comets whose study substantially helped our understanding of the workings of the Solar System, even a long time after they had been discovered, and this is why it is worthwhile to collect and preserve as much as possible the records of comets of the past.

As an example, the study of the comet discovered on the night between 14 and 15 June 1770 by Charles Messier has been of fundamental importance for many developments of modern science. This comet was rapidly approaching the Earth, so much so that by 21 June had become visible to the naked eye, reaching the second magnitude three days later. It reached the minimum distance from the Earth on 1 July, at about six lunar distances, and after a few more days disappeared in the glare of the

Sun, from which it reappeared in early August. Messier then continued to observe it until the beginning of October.

However, the parabolic orbit that was customarily used at that time to compute the ephemerides for the comet turned out to be seriously inadequate to account for the entire set of observations. The Swedish astronomer Anders Lexell then stepped in, showing that the comet was on an elliptical orbit like comet Halley (the only other case known at the time), but with a much shorter period, 5.5 years instead of the 76 years of comet Halley. How was it possible that the comet, being on such a short period orbit, had not been seen at previous apparitions?

Lexell computed that in May 1767 the comet had passed rather close to Jupiter, so that the gravity of the planet had been able to strongly modify its orbit: before 1767 the comet was on an orbit of much larger perihelion distance, thus was impossible to see it from the Earth with the instruments available at the time. Moreover, Lexell computed that in 1779 the comet would come even closer to Jupiter and would be sent into an orbit of very large perihelion distance and period, thus becoming again invisible from the Earth.

Actually, the comet was not observed in 1782, as it should have been if it had remained in the orbit in which it had been discovered in 1770. Thus, Lexell had shown that the orbit of a celestial body can be changed by an encounter with a planet even within a very short time span, a concept that is still nowadays used in astrodynamics in order to change the orbit of a spacecraft in interplanetary space.

All these results by Lexell were obtained in the same decade in which the comet had been observed; but more was coming afterwards, showing that comet apparitions can have a great importance for the advancement of science even long after they have taken place.

In fact, about thirty years later Laplace dedicated a chapter of his Traité de Mécanique Céleste to Lexell's comet, introducing what is nowadays called the "spere of influence" of a planet, within which one can consider that the comet moves in a planetocentric orbit perturbed by the Sun, while outside it the motion is heliocentric, with the action of the planet considered as a perturbation.

But the story about this comet was not over. Around the half of the nineteenth century, Urbain Le Verrier reexamined the available observational record and concluded that it was not possible to reliably determine a unique orbit for that comet because the observations, although covering a few months, were nevertheless insufficient.

But this finding did not discourage Le Verrier, who realized that the orbits compatible with the observations were arranged on a line in the space of orbital elements, and could be expressed as a function of a single unknown parameter; outside a certain range of this parameter, the comet trajectory would have been



measurably different from the observed one. Essentially, Le Verrier had in this way introduced the modern concept of "line of variations" that is at the heart of the first software robots introduced at the end of the twentieth century to monitor the possibilities of impact with the Earth of newly discovered near-Earth asteroids.

In addition, Le Verrier computed the effects of the 1767 and 1779 encounters with Jupiter undergone by comet Lexell for the entire range of orbits that were compatible with the observations, obtaining a global view of all the possible encounter outcomes. According to his calculations, in 1779 the minimum distance of the comet from Jupiter could have been as small as less than three and a half radii of the planet from its centre; however, it could not become a temporary jovian satellite in any case. Among the post-1779 orbits, many were similar to the pre-1779 one, but other were very different; among the various possibilities, Le Verrier even found that the comet could have been transferred into a hyperbolic orbit, leaving forever the Solar System.

With such a wide range of possible outcomes for the 1779 encounter with Jupiter, Le Verrier had in fact evidenced the extreme sensitivity of the orbital evolution comet Lexell to even small changes in the initial conditions; this sensitivity is an essential ingredient of the modern concept of chaos, i.e. that small changes in the initial state of the system lead to large differences afterwards.

Le Verrier's computations probably represent the first instance of chaos in the scientific literature and it is interesting, in the light of the present book, that it was obtained re-examining comet observations taken many decades before.

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Introduction

Comets have always played an important role in the history of mankind. In all cultures their appearance, with very few exceptions, has always been considered an ominous sign. In the East, the figure most involved was the reigning monarch who «theoretically was responsible for the orderly functioning of the entire cosmos as well as that limited part of it that constituted human society» (Cullen 1991: 114). The appearance of a comet was then perceived as a sort of reflection on his morality, his failures and more generally on his ability to lead the country. In the West, the widespread opinion considered their appearance to be an omen of wars, famine and plague. Still at the beginning of the eighteenth century, the Jesuit Franciscus Reinzer (1661-1708), professor at Linz, claimed that rarely a comet appears in the sky if not to scourge the Earth, announcing and inflicting all sort of doom; then, he goes on resuming the saying of the vate: *nunquam coelo spectatum impunè cometen* for which its tail serves for a rod, its hair for weapons, its light acts as a threat and its heat as anger and vengeance (Reinzer 1709: 56; White 1887: 23).

It is definitely more "philosophical" the interpretation of the abbot Diego Zunica (b. 1633), according to which the whole Nature is a mixture of good and evil: in the air doves fly and hawks stalk, zephyrs blow and typhoons rage; in the sea fierce monsters and innocent fish coexist; close to the sheepfolds the wolves frolic; in the midst of the glory of the lilies hemlocks sprout and where roses flourish snakes often nest; finally the sky itself does not vaunt complete innocence, since among its stars, a bloody comet sometimes mingles (Zunica 1700: 68- 69). Among the evil things that comets brought with their apparition, it was very popular the belief that they announced the death of

kings and princes and the changes of kingdoms. Valerio Castiglione, historiographer of the royal House of Savoy, recalling the death of the very young Duke Francesco Giacinto, which occurred on 4 October 1638, in the castle of Valentino (Turin), wrote that this sad event had been foretold by the fall of a salt shaker at the table and by a bearded comet seen towards the province of Asti (Tapparelli d'Azeglio 1863: 116). It seems that Alfonso VI (1643-1683), King of Portugal, after having launched a series of invectives against the comet of 1664, which was considered guilty of attempting on his life, he had even fired a gun at it (Baruffi 1835: 18). Louis XIV's brother, frightened by the appearance of a comet in 1680, overheard his courtiers talking about it in a lighthearted manner, turned to them and said: «You gentlemen talk about it with ease, you others are not princes» (Flammarion 1924: 303). Apparently, however, comets did not bother nobles of minor rank. The "Messagere Tirolese" of 16 July 1819, reports a conversation between an elderly Italian prince, worried about the appearance of the great comet of that year, and an impertinent Frenchman who, with a mocking tone, said: «tranquilisez vous, monseigneur, vous n'êtes pas un Prìnce à comete» (Don't worry, my lord, you are not such a Prince to make a comet concerned).

In the past, few men, even among the most erudite ones, could escape this conviction. One of them was the famous Florentine bishop Antonino Pierozzi (1389-1459). On the occasion of the appearance of comet Halley in 1456, he did not hide his perplexity: «one can not see why somebody should think such a thing, since - first of all comets rise on the same land inhabited by the poor, the rich and the king. Secondly, however, the comet has a natural cause, which does not aim at anything. It is therefore clear that it has no relationship with the death of anyone or to wars» (Garbini 1996: 444). Melchior of Parma (d.1520), a friar of the order of the Minors, in the Dialogo dell' anima (Dialogue of the Soul), to Microcosm who asks: «where does it come from that in the death of the princes and kings comets appear?» he replies with "doi resposte bone" (two good answers) of St. Bonaventure [born Giovanni Fidanza (~1218-1274)]. In the first one, he explains that the apparition of comets does not necessarily mean the death of Kings and Princes but, if it did, it would only be the result of a fortuitous coincidence. As experience shows, writes Melchior, Kings and Princes, are also dead in periods when comets are entirely missing. In the second answer, he clarifies that it cannot be the stars to influence the death of the powerful, being this prerogative assigned solely to the "divine commandment". The Spanish Benedictine Benito Jerónimo Feijoo (1676-1764), who defined the comet as a "bragging of the sky", wrote: «perhaps they wanted to make it a bugbear for the sovereigns, to depress their vanity, on the consideration that they have less to worry about on the earth, than other men; but the monarchs have, down here, enough enemies to fear, without it being necessary to contain them that the brilliant agitations of the sky concur with the vapours of the earth. The ambition of neighbours, the complaints of subordinates, the annoyances of governing, such are the comets that monarchs must fear».



From the above point of view, some of the most outstanding figures of the ancient world, mentioning comets in their works, considered them as carriers of misfortunes or dire warnings. Orosio (died c. 423), in his Historiae adversus paganos, closely bounds the heavenly signs with the history of mankind. Hydatius (c. 400-c. 469), in his Chronicle covering the years from 379 to 469 AD, follows the same approach. Gregory of Tours (538-594), in the Historia Francorum, devotes numerous lines to the "wonders" and "signs" such as: strong storms devastating regions, moon darkened and comets preceding pestilence and destruction. Finally, the encyclopedist Isidore of Seville (560-636), who is considered as a point of connection between the ancient and medieval world, tries to give a "scientific" explanation for all natural phenomena against superstition. In the third book (of twenty) of his Etymologies, he points out the difference between the concepts of Astrology and Astronomy. About this latter, he says: «concern itself with the turning of the heavens, the rising, setting, and motion of the stars, and where the constellations get their names» (Barney et al. 2006: 99). However, in De Natura Rerum he did not deprive comets of their mystical and ominous meaning: «A comet (cometa) is a star, so named because it spreads out the 'hair' (coma) of its light. When this type of star appears it signifies plaque, famine or war» (Barney et al. 2006: 105).

About the nature of comets, at least until most of the sixteenth century, there was an almost unanimous agreement around the thesis that Aristotle had expressed in his Meteorology, about two millennia before. The Philosopher, after refuting various hypothesis on the origin of comets, including that of the so-called Pythagoreans, according to which the comet is: «just one of the planets that appears only at long intervals of time», exposes his theory of earthly exhalations: the moist ones, namely vapours, form clouds and then rain, snow, sources of rivers, dew and frost; the dry ones, namely steamy substance, rise higher, condense and, between the layer of fire and the beginning of the space permeated by the ether, within the sublunar sphere, catch on fire forming shooting stars, comets and what we now call the northern lights. Probably if the cosmology of the Stagirite, based on the opposition between the four elements and the ether and the dichotomy terrestrial corruptibility vs celestial incorruptibility, had not been adopted by both Christian and Muslim culture, meteors, comets and northern lights would have been observed and recorded with systematicity and attention at least as much as those dedicated to the planets. It was only in the last quarter of the sixteenth century that accurate observations of the great comet of 1577 allowed Tycho Brahe to demolish this false theory. Moreover, a century later, Edmund Halley, in the opening of Newton's Principia (1687), could state: «Now it is clear to us what is the curved path of the terrible comets; now we are not (longer) surprised by the phenomena of the bearded stars». If Newton's discovery of the laws governing the motion of comets and Halley's intuition on the periodicity of one of them had finally torn the veil of mystery that surrounded them, much more difficult was to eradicate people's prejudices.

Today we tend to look at these fears with benevolent detachment, but judging them with hasty superficiality would be a mistake. Mario Rigutti (1997: 50), in one of his essays, invited us not to smile «at the thousands of stories of misfortune and death that have accompanied the appearance of comets in the skies of distant centuries». A judgment that closely resembles that of Charles Singer (1959: 1), according to which: «It therefore behoves the historian of science to be very charitable, very forbearing, very humble, in his judgements and presentations of those who have gone before him. He needs to remember that he is dealing with the work of erring and imperfect human beings, each of whom had, like himself, at best but a partial view of truth, but many of whom had a sweep of genius far beyond his own».

Evidently, this volume and the others for later centuries, do not claim to be exhaustive because the amount of texts not yet published is still remarkable, and it is expected that new mentions of comets will appear in the future. In this sense, the present work is intended to be an effort to reconcile observations of comets from such different cultures by combining, in particular, the Western and Middle Eastern literature with the rich and diligent heritage of the Far Eastern tradition. The aims of scholars have become more and more ambitious, thanks to the work of historians who have compulsorily collected primary sources, or their best editions, in the most varied languages in order to translate them into what has been the common language of scholars throughout the ages: Greek, Latin, French, German and English. Therefore, it is reasonable to assume that re-reading Western and Middle Eastern sources may help to solve semantic problems, complete chronological gaps, clarify dates, or raise new questions about what has been transmitted from the Eastern annals. A case in point involves a recent paper to improve the orbital elements of Halley's comet during its appearance in 760 AD (Neuhäuser et al. 2021: 19).

Generally speaking, the present work follows the path of previous studies devoted to resuming, ordering and interpreting, in a systematic way, all original observational notes on comets in specific geographical areas and historical periods. Even so, the references are rather numerous, for which we refer to the final bibliography. We must, however, mention at least half a dozen treatises. From the past: Johannes Hevelius' *Cometographia* (1668), Stanisław Lubieniecki's *Theatrum cometicum* (1668), the two volumes of Alexandre Guy Pingré's *Cométographie* (1783 and 1784), and John Williams' *Observations of Comets* (1871), whose covers are reproduced on the next page. In more recent times: the first volume of Gary W. Kronk's *Cometography* (1999), and John T. Ramsey's work *A Descriptive Catalogue of Greco-Roman Comets from 500 B.C. to A.D. 400* (2008).





COMÉTOGRAPHIE T R À I T É historique et théorique

DES COMÈTES.

Par M. PINGRÉ, Chanoine Régulier & Bibliothécaire de Sainte-Generière, Chancelier de l'Université de Paris, de l'Académie Reyale des Sciences.





OBSERVATIONS OF COMETS,

FROM B.C. 611 TO A.D. 1640.

EXTRACTED FROM THE CHINESE ANNALS.

TRANSLATED, WITH INTRODUCTORY REMARKS,

An Appendir,

TABLES NECESSARY FOR REDUCING CHINESE TIME TO EUROPEAN RECENNING; AND A CHINESE CELESTIAL ATLAS.

JOHN WILLIAMS, F.S.A.

LONDON : Printed for the Zather ** STRANGEWAYS AND WALDEN. CASTLE STREET, LEICESTRE SQUARE 1871.

More specifically our research focused on retrieving extracts from annals, chronicles, manuscripts, and other sources on this topic recovered in Europe and the Middle East. For published work, where possible, we used the most recent edition and, in addition to the English translation, in most cases, we also reported the text in its original language. In this sense, therefore, this work should not be understood as a cometography stricto sensu, but rather as a list of historical comets independently confirmed in both Western and Eastern countries. A new interpretation of these texts has allowed us to compute a new orbit, for some particular comets, or alternatively to improve the already published one. These calculations took into account the reports obtained from the Chinese, Japanese or Korean observations For this reason, for each catalogued comet, we have provided a table with a brief summary, taken from the Eastern annals records,. The first column contains the reference texts from which we derived information. Columns two and three list dates and positions (*pinyin* spelling) by also crossing data from three different publications (Williams, 1871; Ho, 1962, and Pankenier et al. 2008). Finally, in the fourth column the determinative stars of the 28 Lunar Mansion "xiu" (see Stephenson 1997: 516-518; Sun and Kistemaker 1997: 114), and the approximate counterpart of the Western sky, are shown (see Ho 1962: 222-224; Sun and Kistemaker 1997: 147-191; Pankenier et al. 2008: 455-464; Stephenson and Green 2009: 35-51).

As we know, the term "comet" has sometimes been improperly used to indicate other types of celestial phenomena in the past. More frequently the opposite has happened when generic terms such as star, sign, portent, etc. have been used in its place (see, for example, Dall'Olmo, 1980). Moreover, in many cases, the chronicles refer, directly or indirectly, to a single primary source that is not always identifiable. This can be seen from the fact that some chronicles are very similar. The works gained prestige if they made reference to past authors famous for their wisdom, so that, on many occasions, the copyists transcribed the texts over and over again, although adapting them to their needs and not hesitating even to modify the dates to make them coincide with certain historical events that they wished to remark. In this process, not only voluntary changes were possible, but also the introduction of unwanted errors that could affect the meaning or data of the original text. For this reason, extreme precautions must be taken when working with historical treatises.

Since we can not report every single account, our choice was naturally to give priority to those chronologically closer to the event than to later chronicles. Those sources, in principle, are more reliable because they are less contaminated and sometimes contain first-hand testimonies. If no date is mentioned in the original document, this has been interpolated taking into account the events preceding and following the description of the cometary appearance. Further, the possible connection to comets already known in the literature was also checked based on the context. If the year reported in the source is clearly wrong, the comet has been related to the most



likely date; in any case, the year indicated by the chronicler (or the editor of the work) has been preserved, at the beginning of the description, by highlighting it in square brackets for any further investigations. As previously stated, according to the data obtained from the ancient texts, possible orbits have been calculated for some of the comets listed in this book. However, it should be emphasized that, due to the limited information available, the results thus obtained represent in good substance only an approximation of what could be the actual orbit. Some exceptions are those orbits based on previous returns of well-known comets such as 1P/Halley, 108P/Swift-Tuttle, or 12P/Pons-Brooks which are based on many accurate records and can even be improved based on trial-error methods. Comets preceded by the prefix X/ are instead those that, despite being well documented, do not have sufficient data to calculate an orbit (*see* Yeomans et al.,1997: 219; Marsden and Williams, 2005: 206). In addition to the officially recognized ones, our work has identified other comets, that deserve such a prefix. For these, we propose in brackets the new designation. In this first volume, as an example, those of the years 634 (X/634 S1) and 684 (X/684 Y1).

The first attempts to calculate orbits of historical comets were early in the second half of the eighteenth century mainly due to the translations of Oriental texts, finally available to Western scholars. Among the pioneering astronomers involved in the long and laborious calculations necessary for this type of computation, we should mention the names of Pierre Charles Le Monnier (1675-1757), Nicolaas Struyck (1686-1769), Alexandre-Gui Pingré (1711-1796), Heinrich Wilhelm Olbers (1758-1840), Johann Karl Burckhardt (1773-1825), Paul Auguste Ernest Laugier (1812-1872), John Russell Hind (1823-1895), Martinus Hoek (1834-1873), Lipót Schulhof (1847-1921), Giovanni Celoria (1863-1917), Andrew Claude de la Cherois Crommelin (1865-1939), Philip Herbert Cowell (1870-1949), Sinkiti Ogura (1884-1936), and Shigeru Kanda (1894-1974).

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