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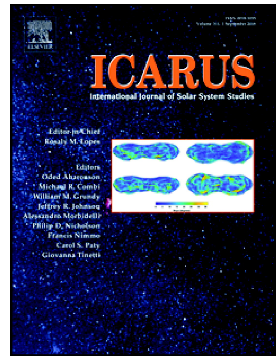

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NEW AND IMPROVED ORBITS OF HISTORICAL COMETS: LATE 4TH AND 5TH CENTURY.

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Abstract:

Since as early as the 19th century, many scholars have devoted themselves to the calculation of sets of orbital elements for particular historical comets. In many cases, these studies have led to proposing orbits that have given satisfactory answers to contemporary observations or later reports about these celestial bodies. As new records or improved translations of existing sources appear, the already calculated orbits can be refined, or even new ones can be achieved. In this paper we focus on historical observations from Eastern and European countries in the late 4th and 5th centuries to suggest new determinations of orbital elements for some of these comets, or, where appropriate, to discuss or improve existing ones. We will also carry out a separate study of comets from the years AD422-423 and AD467, which have been suggested as the parent comets of the Kreutz system of sungrazer comets.

Keywords: Comets, Data Reduction Techniques, Orbit Determination.

1. INTRODUCTION

Over the years, and as soon as in the 19th century, many attempts were made to derive cometary orbits from ancient and medieval observations. An interesting article on the possibilities of achieving reliable results using historical sources has recently been published in this same journal (Neuhäuser et al., 2021). They started from a well established orbit of comet 1P/Halley (Yeomans and Kiang, 1981) and successfully refined its orbital parameters for the 760 AD return. Moreover they also researched the possibility of obtaining, for that passage, an orbit just considering historical sources. A task that has been successfully accomplished probably also thanks to the information contained in the Chronicle of Zuqnin accurately translated and analyzed in every detail. Conversely we have no parameters to compare and the historical data of comets presented in this work are generally less accurate so that the final results should be considered as a good approximation of what could be the real orbit of each of them.

Focusing on the available historical data, the most remarkable are the ones from Asia, because astronomers from this part of the world carried out a systematic program of observations of celestial phenomena, providing most of the data used by several authors over the last decades to calculate tentative orbits for a significant number of comets. Since the study of sources turns out to be a fundamental factor, the publication of new translations and documents has always been a fundamental issue and many scholars have devoted their studies to this aim. This is illustrated by the pioneering efforts of Pingré (1783) and Williams (1871), then afterward in the 20th century, those of Ho Peng Yoke (1962), and even more recently by Pankenier et al. (2008). The translations and interpretations of different authors over time have led to submit orbits that are not always compatible with each other, although new translations from sources from the Far East could help to solve this issue. In some of these cases, the study of European sources, scarcely used by previous authors, may help to clarify inconsistencies.

As previously stated, ancient observations from other parts of the world, such as Europe or North Africa, have always played a secondary, if not irrelevant, role, firstly because they are far fewer and less systematic. Secondly, in the case of European observations, until approximately the 15th century and with rare exceptions, the observations of celestial phenomena were merely descriptive, because most of them are found in narrative works of non-scientific nature, such as chronicles, Easter calendars or, later in the Middle Ages, institutional or personal diaries. These observations used to record celestial phenomena that had attracted attention, although in some cases they served as a pretext to reinforce certain social or political contemporary events. This latter case would introduce another element of inaccuracy since a chronicler would go to change the date of an astronomical phenomenon only to make it coincide with the event that he wished to highlight.

The purpose of this paper is to review some comets observed during the late 4th and the 5th century in light of all the data so far available, both Asian and European, and also discuss the results obtained by different authors. Where appropriate, we propose a more suitable orbit for the observations. Also, possible connections with the Kreutz Sungrazer system of comets are analysed for a specific set of comets.

Our intention is not to make a complete compilation of all the known sources for each comet, since this work has already been carried out regarding the Eastern and also the Western sources (Kronk, 1999) that were available at the time of the publication. Western reports are more likely to be expanded. The authors themselves are working on an exhaustive compilation of the European ones (Sicoli et al, in prep) that will summarize and add new data to the already gathered by previous authors. Thus, to avoid repetitions with already published works, we will offer for each comet only a summary of the most representative sources, providing the necessary references so that the reader can access to the compilations or the original sources. The translation of a text will only be provided if it is used in the discussion of a particular characteristic that influenced the calculation or the improvement of the orbit. In the same way, we will avoid explanations about Eastern astronomy which can be found, for example, in Needham (1959) and Sun & Kistemaker (1997), with short summaries also in Stephenson (1994), Xu et al. (2000), Pankenier et al. (2008) and Neuhäuser et al (2021), among others. Appendix A, at the end of the paper, includes all Lunar Mansions, constellations and other Chinese asterisms mentioned in this article as in Pankenier et al. (2008)

An overview of Astronomy in Europe in late antiquity and early Middle Ages can be found in Eastwood (2007) or McCluskey (1998).

The paper is structured including an introductory section dedicated to briefly discussing the historical-scientific context of 5th-century Europe as well as the main sources used. Then, we will jointly study the comets of the years AD422-423 and AD467, whose relevance in the field of the Kreutz Sungrazer system will be commented. Finally, we will consider individually the comets of the years AD400, AD418 and AD442. In Appendix B we provide the positions employed for obtaining the orbits proposed in Table 8.

2. EUROPEAN CONTEXT AND GENERAL SOURCES

In the first place, we need to highlight that we are considering the European area in a very general way, including not only the territories that make up today's Europe, but also those that belonged to the Roman Empire. In this way, we will consider as "European" sources those from Armenia, the Roman province of Syria, or North Africa.

The 5th century in Europe began with the definitive split of the Roman Empire, after the death of Theodosius in AD395, replaced by a series of independent kingdoms frequently opposed with each other, that did not succeed in restoring the ancient empire. The Western Roman Empire suffered continuous convulsions that lead to its fragmentation into numerous kingdoms, ruled by sovereigns of Germanic origin, after a series of disasters such as the sack of Rome in AD410 by the Goths of Alaric, that of Carthage in AD439, and the deposition of the last Roman emperor, Romulus Augustus in AD476. This event is the traditional beginning of the Middle Ages.

The Eastern Empire maintained certain stability during the 5th century. Successive emperors were able to ward off the invasions of barbarians. The incursion of the Huns, which caused serious problems in the Western Empire, was avoided by paying tribute until Attila's death in AD453, and the Ostrogoths were diverted to Italy. At the end of the 5th century, the barbarian invasions no longer seemed an obvious risk to the stability of the near-east territory. The involved historical episodes were narrated by the chroniclers of the time, occasionally relating them to the most relevant astronomical phenomena of the century.

Regarding the astronomical records, our guideline has been the first volume of Kronk's Cometography (Kronk, 1999) and then, we have searched either in the compilations provided by other authors, in the case of Eastern sources, or the original sources for the European ones. Cometary catalogues previous to the 20th century such as Pingre (1783), Biot (1843), or Williams (1871) have also been consulted.

For the Eastern reports, we refer to three geographical areas: China, Japan, and Korea, and the compilations provided by Ho Peng Yoke (1962), and the papers of Hasegawa (1979, 1980, 1995, 2001,2002). We consider in particular the work of Pankenier, et al (2008), where they corrected some errors of dating and provide careful and updated translations of Eastern records.

Concerning Chinese documents, the *Sung shu* (AD489) is quite a contemporary source and others, as the *Wei Shu* (AD572), *Jinshu* (AD635), or *Nan shi* (AD670) were written only a few decades after, providing also valuable astronomical data.

Japanese and Korean records are of minor interest throughout this century and only appear occasionally. We have used no records from Japan and only secondary sources from Korea, whose records come mainly from three official history books: *Amagasaki* (AD1145), *Goryeosa* (AD1451) and *Joseonwangjosillok* (AD1392-1863) described, for example, in Yang et al (2005). These books cover long periods of time and contain astronomical phenomena that were systematically recorded by court astronomers.

In comparison, European data are scarce but many of them are contemporary to the specified events, which makes them very valuable. The problem with European records arises because, unlike Korean, Chinese and Japanese, no book of ancient astronomical records has been compiled so far, and the search of new records is hard because the accounts are found in chronicles, annals and diaries that have no astronomical function and some of them are neither systematically published nor even translated from Latin, Greek or, later in the Middle Ages, vernacular languages into English. Our search has provided several not yet used records, but unfortunately, only a few of them belong to the period that we are going to study in this paper.

Considering this, our main European source for the 5th century has been the *Monumenta Germaniae Historica* (*MGH*), together with other lesser-known documents from Spain, Portugal and Italy, obtained from both collections and particular sources. *Monumenta Germaniae Historica* is a comprehensive series of primary sources, including chronicles and archives, mainly from Germany although many others are also included (Britain, Czech lands, Poland, Austria, France, Nederland, Italy, Spain, etc.). More information can be found at http:// http://www.mgh.de (in German and English).

A further problem is how the scribes referred to the assorted astronomical phenomena since, being non-specialized literature, the same description can be associated with different events (Dall'Olmo (1980). See also the comments in Neuhäuser et al (2021a)) so the context must be carefully examined. In addition, the dates for what apparently were the same events sometimes are given in different years in diverse sources, for the most part likely due to copying errors, since the manuscripts currently available are later copies of the originals. Again, the study of the context and the origin of the manuscript is, in these cases, essential to distinguish between the different possibilities. It is also important to consider the peculiarities of each calendar when dealing with particular authors. For example, in the chronicle of Michael the Syrian, the employed Seleucid calendar, starts on October 1 instead of January 1.

The day on which an event occurred could also be uncertain because of the differences in the timing of the start of the day. The Church day, derived from the Jewish beginning of the day at sunset, began at vespers but the civil day, based on the Roman day started at midnight. Thus, events that happened between sunset and midnight could differ by one day depending on the system used.

3. OVERVIEW ON 5TH-CENTURY COMETS

In this paper, we are going to focus on comets from the 5th century, although we also include a single comet from the end of the 4th century.

Along the 5th century, we find several references to comets in manuscripts, some of them contemporary. Not in all cases we have enough data to derive a set of orbital elements, but it is possible for some of them and, in fact, there are published orbits that have been accepted by the astronomical community (see the websites of the MPC

https://minorplanetcenter.net/db_search or JPL https://ssd.jpl.nasa.gov/tools/sbdb_query.html)
A very practical summary of how Eastern sources provided astronomical data can be seen in Neuhäuser et al (2021). In particular, see their section 1.3 for further explanations. We shall simply emphasize that cometary references appear with great difference in the details, depending on each case. At best, the tracking of the comet may include the apparent path or even one or several more or less accurate positions, the magnitude, and details about the length or appearance of the tail. Usually, the most detailed descriptions come from Chinese sources and, in this case, the position is given relative to surrounding constellations or asterisms over the celestial sphere, that may contain few or many stars. Thus, with few exceptions, the provided cometary position is always relative. In addition, the names of 28 lunar mansions (LM henceforth) are often used, being identified by their determinative star. With reference to the LM, we must point out that, although they bear the same name than some asterisms, they represent the right ascension ranges from the determinative star of one LM to the next (Sun & Kistemaker (1997)) For a complete list of the LMs, constellations and asterism and their determinative stars, see, e.g., Ho (1962) or Pankenier et al. (2008).
Summing up, the orbits derived from medieval observations are inevitably affected by a certain inaccuracy, which in some cases can be reduced if independent descriptions of the phenomenon are considered, especially if they are contemporary and come from different observation sites. Considering this, although the European observations are not as detailed as the one from China, we will see that sometimes they do provide relevant data to compute a feasible cometary orbit especially when reports are written by observers who presumably were eyewitnesses. In this way, we have been able to calculate and / or improve the orbits of various comets of this century. For clarity, we present all of them in Table 1, along with the currently published orbit, when available. Comets of years AD422, AD423 and AD467, not included in this table, will be discussed separately and in detail in the following subsection 3.1.

T (UT)	ω	Ω	*i*	*q*	*e*	*Author*
400 Feb 25	47	38	32	0.21	1.0	Hasegawa (2002)
400 Feb 27	39	37	41	0.16	1.0	(Sicoli, this paper)
400 Feb 28.2	64.7	39.5	48.6	0.325	1.0	Kronk (2021)
418 Oct 5	240	310	110	0.35	1.0	Kronk (2009)
418 Sep 8	253	66	75	0.10	1.0	(Sicoli, this paper)
442 Dec. 15	178	271	106	1.53	1.0	Hasegawa (2002)
442 Dec. 21	176	274	117	1.75	1.0	(Sicoli, this paper)

Table 1: Published and proposed orbits for late 4th and 5th-century comets (referred to J2000.0). Angular variables are expressed in degrees and *q* is given in au.

The case of the possible comet seen in AD498 deserves a mention. At the end of the 5th century, many reports of possible comets are found (Sicoli, et al. in prep), both in Eastern and Western sources. These testimonies are sometimes contradictory but considered as a whole, have allowed us to obtain an orbit that fit the historical and astronomical context. However, the authors consider that this result is not sufficiently accurate and we have decided not to include it in the paper.
As usual, to make estimations of the total visual absolute magnitude *H*, that of the coma, we use the well-known formula (Meeus, 1998):

$H = m - 5\log\Delta - 2.5n\log r$ (1)

Where *m* is the visual magnitude, Δ and *r* are the geocentric and heliocentric distances (in au), and *n* is the photometric index which is assumed as *n*=4 to provide the standard total magnitude H_{10}.

In some cases, it might be of interest to consider the brightness enhancement due to the scattering of sunlight (Marcus and Seargent, 1986). Marcus (2007) gives a modification of formula (1):

$H = m - 5\log\Delta - 2.5n\log r + 2.5\log\phi(\theta)$ (2)

being θ the scattering angle (180º-Phase Angle, defined as the angle between the Sun, the comet, and the observer) and $\phi(\theta)$a function defined by formula (1) in Marcus (2007) depending on several parameters given by g_f = 0.9, g_b = -0.6, k = 0.95, with δ_{90}=1 for a "usual" comet and δ_{90}=10 for a "dusty" Halley-like comet. Since the magnitudes have a certain degree of inaccuracy, because it is impossible to calculate them with reasonable accuracy from historical data, we did not believe it necessary to include all the possibilities for each comet. In particular, we have assumed a "normal" behavior for all comets rather than a Halley-like "dusty" behavior. Similarly, as a general rule we have not considered the "scattered magnitude" and, when we have, it has been specified in the footer of the figure.

Regarding the magnitude, it should be noted that as a general rule, European sources only mention comets while they show a significant brightness, and neglect them when they are no more remarkable celestial bodies. On the contrary, Asian sources may follow the comet until it is no longer visible to the naked eye. For this reason, except for individual cases in which the comet appeared in a very specific area of the celestial sphere, we will assume that, in the western countries, comets were not perceived until they reached magnitude 2, while in the Eastern sources we will generally consider a 3.5 magnitude. To support this assumption, we have consulted the exhaustive study carried out by Schaefer (1991, 1993) on the limits of vision in astronomy with the naked eye and, since we have no direct or extensive experience in observing comets, we requested additional help (personal communication) from a long-lasting comet observer (J.J. Chambó, see https://cometografia.es/) He considered highly unlikely the first detection of a comet of magnitude 4-5 and instead, recommended us to consider 3.5 as the mean magnitude value for the first detection" (Chambó 2020, personal communication,) Throughout the paper there are cases in which this mean value is varied for different reasons that are described in the text among which is a first detection in a well-known area of the sky, such as the Big Dipper, which could cause the comet to be detected with a fainter magnitude.

Sometimes the length of the tail also provides relevant information when deciding which orbit fits best the historical observations. This element has a high degree of uncertainty since the appearance of the tail depends on many factors, such as the relative position of the comet with respect to the Earth, its distance from the Sun, and the composition of the comet itself. However, estimates can be made using the formula developed by Kammerer (1994):

$logL = -0.26(\pm 0.01)H_e + 2.25(\pm 0.07)$ (3)

which provides the length of the tail in millions of kilometres, being H_e the heliocentric magnitude, $H_e = m - 5\log\Delta$. This formula was tested by the author considering about 2500 tail length estimates, but it should be used with caution and in any case only for comets at a distance less than 0.4au from the sun. The same formula (3) was later used by De Donà (1997) to simulate the longitude in degrees of the tail ψ:

$\sin\psi = \frac{L}{TF} sin\theta$ (4)

where TF is the linear distance from Earth to the end of the comet's tail. Nevertheless, we must bear in mind that the *n* variable may greatly vary from comet to comet, mainly for those approaching the Sun. In addition, there may be many more factors that affect the visibility or brightness of the comet, some of them irresolvable. In particular most manuscripts do not include meteorological data, so it must be assumed that the visibility conditions were always the most favorable, which may not always be true. This is why the estimated magnitudes should be taken with caution.

Through the paper, we use Julian dates and provide the elements in heliocentric ecliptic J2000.0. To obtain a best-fitted orbit we used *find_orb* (version Mar 17, 2019, projectpluto.com/find_orb.htm) and a computational package developed and owned by the Osservatorio Sormano. Unless otherwise is specified, star charts have been drawn using the program SkyMap Pro Version 11 by C.A. Mariott.

The integration of the orbital elements has been arranged using the Horizons Command-Line Interface from the JPL (see https://ssd.jpl.nasa.gov/horizons/ for details)

3.1. COMETS OF YEARS AD422-423 AND AD467

In this section, we will study the comets that were observed in the period between AD422 and AD423 and also the comet of AD467. The reason is that two of them, the one from February 423 and the one from AD467, could play a fundamental role in the origin and subsequent evolution of the systems of Kreutz sungrazer comets (Sekanina and Chodas, 2004, 2007).

The Eastern sources, all of them Chinese, provide numerous testimonies of cometary phenomena in the two-year period AD422-423. This abundance of data makes it rather difficult to distinguish among the different celestial bodies. We can consider three blocks corresponding to 3-4 different comets. For the sake of clarity, we are going to name each object from this period as:

i) A422, the one at the beginning of AD422.

ii) B422, the one at the end of AD422 and B423 the one at the beginning of AD423 (this latter is also known as X/423B1being this ~~is~~ the only one whose existence is currently accepted)

iii) C423 the one that appeared at the end of AD423 and the beginning of AD424.

In subsection 3.1.3 we will focus especially on comet B423, which has been appointed as a possible parent comet of the Kreutz Sungrazers family. In table 2 there is a list of our proposed set of orbital elements, for those comets whose orbits may be fitted.

Comet	T (UT)	ω	Ω	*i*	*q*	*e*
A422 [a]	422 Mar 6	344	203	34	0.96	1.0
A422 [b]	422 Feb 20.5	239	227	99	0.18	1.0
B423	423 Feb 3.5	149~~.56~~	315~~.45~~	71~~.29~~	0.47~~25~~	1.0
C423	424 Jan 19	247	300	122	0.54	1.0
467	467 Feb 5	85.1740	6.3254	144.5478	0.005388	0.999930

Table 2: Proposed orbits for comets in AD422-423 and AD467 (Marco & Martinez, this paper). The sources do not provide enough data to compute an orbit for B422 The superscripts a and b denote the two most probable orbits obtained by the authors for comet A422 (see explanation in text). The number of decimals given for the comet of the year 467 comes from the integration method that has been used to calculate the orbital elements (see explanation below in 3.1.3.2)

3.1.1 COMET A422

The exact period of visibility of this comet is unknown since three different sources report non-matching dates of appearance: March 16 in *Wei shu*, March 21 in *Nan shi* and March 26 in *Sung shu*. However, it is assumed that the comet was seen at least from the first to the last date, i.e., 10 days. All the sources coincide that it was first seen in XU [LM 11] and WEI [LM12], ~~both in Aquarius~~, and it is added that it pointed toward HEJIN, and swept HEGU (α Aquilae), implying a morning comet. HEJIN does not correspond to any star or asterism in Pankenier et al.(2008), from where we have taken the data, so we relied on Ho Peng Yoke's translation of the same paragraph, which indicates the motion of the comet towards the Milky Way and *Thien-Chin* (a large area around γ Cyg). The main European source, the *Chronicon Paschale* (written at the beginning of the 7th century), confirms the apparition of the comet in March and its visibility from Constantinople at least for 10 days and its morning visibility. It also describes a long tail: *in the early hours of the morning, a star with a very long white tail appeared in the sky for about 10 nights*.

No author has attempted to obtain an orbit for this comet, due to the limited information available. However, we believe that by combining all the existing data, a possible orbit can be reached. It should be remarked once again that the positions of the actual comet do not generally correspond to the determinative star that identifies the Chinese constellations or asterisms. We can only assume that the comet was near the referred celestial positions. In such cases, the usual method of approximation to an orbit is to compute different attempts which corrected in a feedback process, provide the best-suited set of orbital elements.

To this aim, we must consider not only the positions but also the dates on which the comet was visible. As an example, in this first case, we are going to develop in some detail the procedure that we have followed throughout the entire paper to obtain the proposed orbit. In the rest of the cases, to avoid repetitions, we will merely point out the data collected and the main characteristics that have allowed us to evaluate the set of orbital elements. Broadly speaking, for all the comets that appear in this paper, the steps outlined in the work of Neuhäuser et al. (2021) recently published in this same journal were followed.

The comet was seen in the 7th year of the *Taichang* reign period (AD416-423) of the Northern Wei dynasty, whose capital and possible site of observation in the period AD386-494 was Pingcheng (40º06'N 113º14'E). It is also reported that same year during the reign period of Emperor Wu of Song of the Southern Dynasties, with capital in Jiankang (32º02'N 118º47'E) between AD420–579.

Following the description from Eastern sources, an area of the sky in which the comet should have been perceived for the first time was identified, together with some further positions and the minimum period of time in which it was followed. According to this, the apparent path must have maintained an slowly changing ecliptic longitude, and an increasing ecliptic latitude. It was first seen in XU [LM 11] and WEI [LM12], whose determinative stars are respectively β Aqr and α Aqr, covering a RA range from 21h31m to 23h05m (J2000). Also, European sources give us the time when it was visible (10 days, which should be understood as the period in which the comet was a prominent element in the sky) and also that it was seen very early in the morning (after the cockcrow) in Constantinople. Taking into account the latitude of Constantinople and identifying the cockcrow with the astronomical twilight (around 5 in the morning), the declination of the comet must have been roughly between 0 and -30º

After its appearance in (or near) the constellation of Capricornus or Aquarius, it should have crossed subsequently the area around the constellations of Aquila, with the tail sweeping the brightest star Altair (HEGU, α Aquilae), then Sagitta, to disappear finally in Cygnus, covering an ecliptic latitude of about 45º-50°. In the first three rows of Table 3 are listed the apparent coordinates of the determinative stars of the Chinese constellations that appear in the texts and those of HEGU. The last three rows show the positions that we use after taking into account the previous considerations. Keeping in mind the uncertainties associated with this orbit, several sets of parabolic orbital elements were analysed and two of them were selected as the most probable (See table 2, comets A422[a] and A422[b]. See Figure 1 for the apparent path of both comets.) Also for a similar table for the rest of the comets in the paper see Table 9 in Appendix B.

Date (UT)		RA (J2000)		DEC(J2000)	
Day	Month	h	m	°	
		21	31	-05.0	XU[LM11]
		22	05	-00.3	WEI[LM12]
		19	49	+08.7	HEGU
16	March	22	05	-14.3	
21	March	19	46	+13.5	
26	March	19	13	+29.3	

Table 3: Comets A422. Dates, initial approximate positions and reference stars used in the computation of the orbital elements for A422a and A422b.

Formerly, we have verified that both comets meet the minimum expected visibility requirements: they could have been seen in the Chinese capitals in the period between March 16 and 26 and also that they could have been observed at dawn in Constantinople for a minimum period of 10 days, as indicated by the *Chronicon Paschale*.

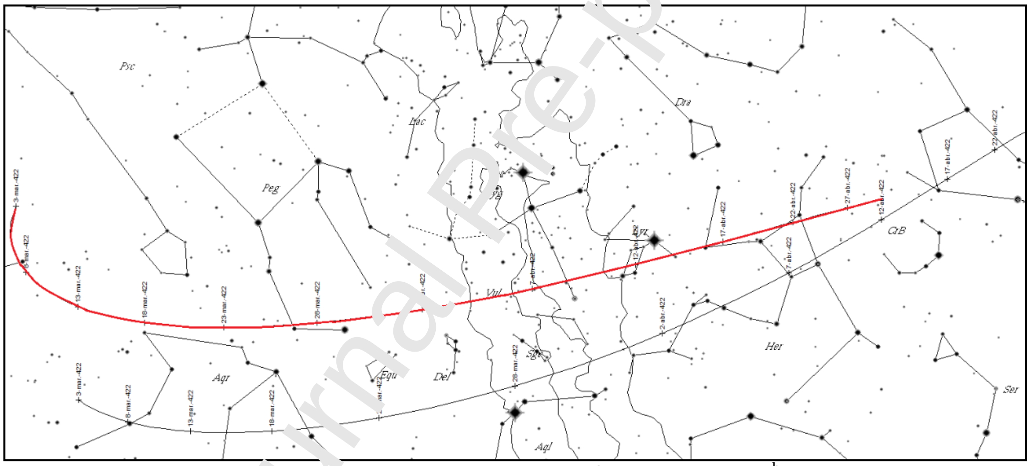

Figure 1: Apparent path of comet A422[a] (red) and A422[b] (black).

Finally, we introduced the visibility criteria related to the magnitude. In this case, since it is not possible to estimate the absolute magnitude of the comets from the date of their first visibility, we took a standard magnitude of $H_{10} = 6$ for both of them. As we can clearly see in Figure 2, both comets could have reached a magnitude visible to the naked eye as early as mid-February. In particular, A422[b] achieved its maximum magnitude on February 18. The difference between the two orbits obtained for the comet is that while A422[a] had a position on the celestial sphere that would have made it invisible in any of the three observation places, A422[b] would have been perfectly visible at sunset during the month of February. Furthermore, according to the *Chronicon Paschale*, the comet would have developed a long white tail in March and this may correspond to A422[a], but not to A422[b]. Dust tails are typically between 1 and 10 million kilometres long and according to the simulations calculated using (3) and (4), the comet's tail of A422a may have extended up to 60° in mid-March, while A422[b] would have only reached about 10°. From the obtained results, A422[b] is not compatible with the available historical observations, since the analysis of its magnitude and position shows that it could have been seen without any kind of difficulty long before and long after what the chronicles indicate. Due to all these considerations, our choice for the set of orbital elements was A422^{a}.

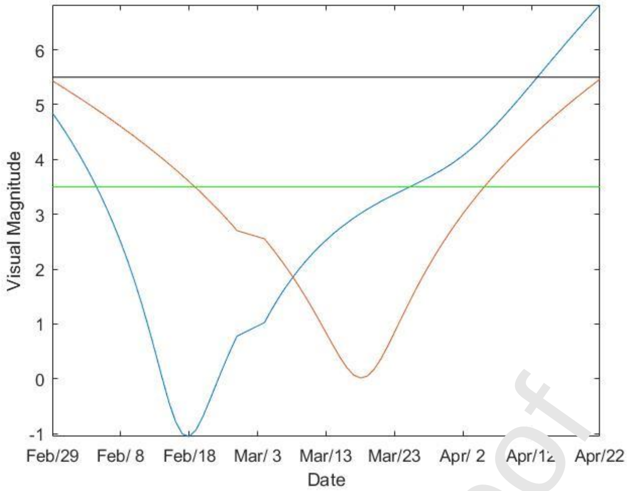

Figure 2: Magnitude comparison between the two possible comets. A422^{a} in red, A422^{b}in blue. Scattering is included. In all the magnitude graphs, the horizontal green and black lines represent the ideal limits of visual magnitude with which the comets could have been detected (green, 3.5) or would have stopped being tracked (red, 5.5) with the naked eye.

3.1.2 COMET C423

This is the last comet recorded by the Eastern sources for the year AD423. In this case, there are no Western reports that clearly pointing to its detection. Again, the two Chinese sources that mention this appearance are the *Song shu* and the *Wei Shu*, but the latter simply states the apparition of the comet at TUSIKONG during the 11thmonth (from December 19, AD423 to January 16, AD424) The longest records are the two versions from the *Song shu*. The first one asserts that on December 13, a star became fuzzy north of DI [LM3], with a tail of 4 zhang (40º) long pointing to the Northwest (towards WEI[LM6]). It penetrated SHETI and headed toward DAJIAO, growing longer each day by 6 to 7 chi (6-9º) and after more than 10 days, it was extinguished.

The second version is more explicit regarding the duration of the comet: in month 11, starting on December 19, AD423 it was in WEI [LM12], and in month 12, starting on January 17, AD424 it swept TIANCANG, after which it was extinguished.

The first version seems to refer to the appearance of the comet while approaching the sun. The size of 40º for the tail would then correspond to its maximum extension and not to the length at the time of its detection, which would have caused problems to explain why it was not seen before. For 10 days or a few more, between December 13-14 and December 25, the comet was reducing its solar elongation, and the tail was progressively lengthening. It pointed to DAJIAO (α Bootis) in the early days. Later, around December 25, when the tail developed further, it seemed to point to WEI[LM6], as the second version indicates. In this way, there is no contradiction between both versions and then, the comet was invisible due to its proximity to the sun (see figure 3)

The second version from the *Song shu* seems to track the comet when it became visible again, after the perihelion and shortly after dusk. At the latitude of Jiankang, this must have happened on January 10. Later, the comet lost its brightness until it was extinguished.

Using the calculated orbital elements from Table 2, the comet would agree to the reports from the *Song shu* and also with the path observed in the *Wei shu*, which claims that between December 19 and January 16 a broom star became fuzzy at TUSIKONG, while the computed orbit places the comet near this asterism on December 22-23.

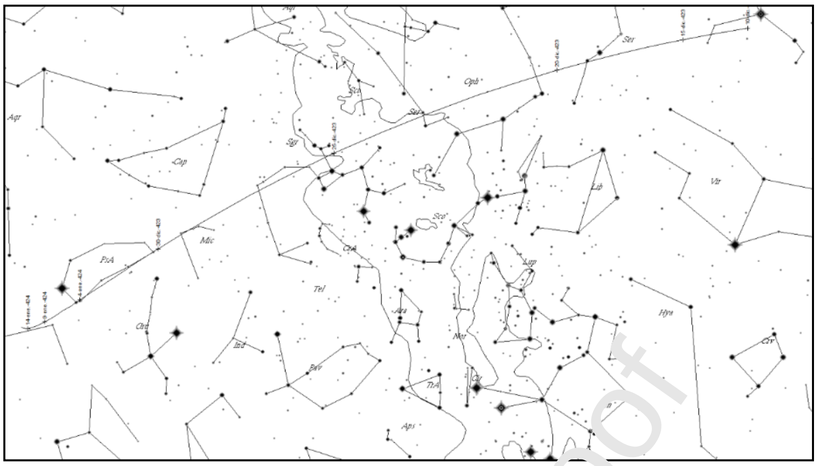

Figure 3: Apparent path of comet C423.

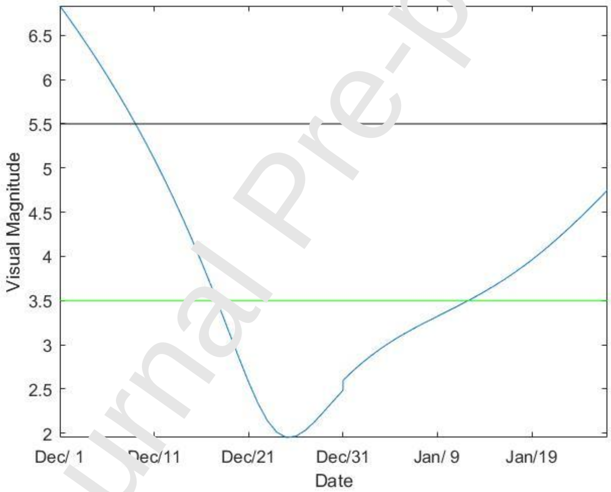

Figure 4: Magnitude curve of comet C423. A magnitude of H_{10}=6.41 has been computed

To study the magnitude in Figure 4, we have considered that the comet was detected when it reached a visual magnitude of 3.5, which provided a H_{10}=6.41. According to formulas (3) and (4), the tail could have reached up to 30º before becoming invisible, while after its reappearance it would have had more modest dimensions (maximum of about 10º) and it would have been gradually reduced.

3.1.3 POSSIBLE KREUTZ SUNGRAZING COMETS

The most recent review about Near-Sun comets was published by Jones et al. (2018) and it was amended by Sekanina (2019). In that paper, a classification of Near-Sun comets was proposed according to their distance to perihelion, distinguishing between Near-Sun comets, Sunskirting, Sungrazing and Sundiving (See Table 1 in Jones et al. (2018)), according to this distinction, the comets that we are going to deal with would be included in the Sungrazing group.

In this section, we are going to jointly consider the comets that were seen in the month of February in the years AD423 and AD467, because these celestial bodies are a fundamental part of the two scenarios that Sekanina and Chodas (2004, 2007) consider in the formation of the Kreutz Sungrazer comet system.

The information on these comets has been increased in the last years and several studies have been arranged regarding their origin. Most of near-Sun comets are members of one of the groups of dynamically related objects: Kreutz, Marsden, Kracht, or Meyer. Each particular group is assumed to have been created from a single parent comet from repeated fragmentation events. Experience seems to point that the Kreutz group (Kreutz 1888, 1891) is the one with the largest number of members, (85% of *SOHO*-discovered comets according to Jones et al. (2018)). Among its members, some of the most spectacular comets recorded in recent times are included, as C/1882 R1 (The Great Comet of 1882), C/1965S1 Ikeya-Seki, and recently, C/2011W3 Lovejoy.

The most comprehensive study of the creation and evolution of the Kreutz Comets system is that of Sekanina and Chodas (2007) and a preprint not yet published (Sekanina, 2021), but it is a problem that has been studied and has evolved with different authors, including Marsden (1967, 1989) and Sekanina and Chodas(2002, 2004, 2007, 2008) and to this day, this issue is still being the source of studies and controversies, as shown by the recent work of Fernández et al (2021) and again a non published preprint by Sekanina (2022). A brief outline according to these papers would include the perturbation and fragmentation of the parent comet sometime in the last 1000 years. These fragmentations wouldn't necessarily have happened near the perihelion (Sekanina and Chodas, 2002). In later papers, Sekanina and Chodas developed this idea giving rise to two scenarios in the framework of cascading fragmentation. Each scenario is restricted by a historical comet that could be a plausible candidate for X/1106C1 at its previous return to the Sun. They considered two constraints together, being the first the orbital similarity with C/1843 D1 and the second that the orbital period should be around 650 yr.

Sekanina and Chodas (2004, 2007). A very attractive idea was to identify Aristotle's comet in 372BC with the parent comet, but this linkage has not been clearly checked (Marsden 1967).

More precisely, the scenarios were composed by linking X/1106 C1 with a sungrazer from the 5th century. A first candidate was the comet of February 423 (our B423), following the suggestion of Hasegawa and Nakano (2001), with a probable perihelion on February 7. This assumption defined scenario A.

To define scenario B a new suitable candidate was needed and to select it England's (England, 2002) list of sungrazer suspects was used. He established a rank between 0 (not a sungrazer) and 10 (definitive sungrazer), depending on ten characteristics among which only the first seven are applicable for a context in the history of astronomy:

i Brightness. Sungrazer comets can be extremely bright near perihelion enabling the comet to be seen immediately before sunrise or after sunset, and sometimes even in broad daylight. A comet large enough to survive until a subsequent return (radius ~500 m according to Sekanina (2002)) should peak in brightness at perihelion and brighten and fade symmetrically, as did Ikeya-Seki. (Knight et al 2010)

ii Sudden appearance.

iii Discovery near the Sun, because of (i).

iv Position in the sky. They are most easily seen in the evening sky after sunset in the late winter and spring, and they are almost impossible to observe in the summer months.

v Tail length. These comets produce a very long tail (or tails) that rapidly shrink as the comet moves away from the Sun.

vi Short period of observation.

vii Characteristic motion across the sky. As stated in (iv), the best apparitions would happen between January and early May. The behaviour of a typical comet would then include a first sight in the evening sky at sunset and a path through Cetus, northern Eridanus and Orion, before fading. Comets at perihelion from September to November would appear in the morning sky near Virgo and Libra.

No comet that meets all these characteristics is clearly identified as early as the 5th century, surely because of the lack of accurate descriptions and possible misunderstandings in the records. However, Sekanina and Chodas selected the comet of AD467, which is ranked as 5 in England's, the same as the comet of AD423 (see Table 4). It should be noted that Hasegawa and Nakano (2001) do not even consider the comet of AD467 among their list of potentially sungrazers, probably because they only use the Eastern sources ignoring the European in which characteristics do appear suggesting that this comet meets the appropriate conditions.

Sekanina and Chodas (2004) stated that scenario B fits better the early observations of sungrazer clusters observed in the 16th century, and suggested that the progenitor of the Kreutz system may have been observed as the comet of 214BC. This assumption, in addition, results to be quite consistent with the orbital distribution of the SOHO sungrazers. In his recent preprint, Sekanina (2021) considers these two scenarios again with B as regarded as the most probable and considers also other possibilities with different comets from the 4th century instead of the 5th century, although he points out that more experiments involving integration are necessary before reaching definitive conclusions.

In the next sections 3.1.3.1 and 3.1.3.2 we will consider the two historical comets defining these two scenarios under the historical and astronomical contexts that the historical sources provide. We will see that our conclusions note the fact that scenario B, which assumes that the comet of the year AD467 is the parent comet of the Kreutz Sungrazer system, is the most appropriate from all points of view.

Comet	Feb AD423 (B423)
Brightness	No special reference. *Saepe ardente* in *Marcellinus Chronicon*
Sudden appearance	Implicit in the text
Discovery near the Sun	*Became fuzzy in DONGBI*, circa 30º from the Sun (*Song shu, Nan shi*) *Emerged south of KUI*, circa 40º from the Sun (*Wei shu*)
Position in the sky	Seen in February, after sunset
Tail length	3 zhang long (30º), (*Wei shu*) 2 zhang long (20º), (*Song shu*)
Short period of observation	20 days , (*Song shu*)
Motion across the sky	Andromeda-Pegasus-Eridanus
Comet	**Feb AD467**
Brightness	Implicit in the text
Sudden appearance	Implicit in the text
Discovery near the Sun	Implicit in the text
Position in the sky	Seen in February, after Sunset in the evening, according to Theophanes Confessor, *Chronographia*
Tail length	*A white vapor was seen stretching half across the heaven from the SW to the SE* (*Nan shi*) * *Like a trumpet* in Theophanes Confessor, *Chronographia*
Short period of observation	*A sign appeared in the sky for 10 days in* Victor Tunnunensis, *Chronica* *A great sign appeared in the sky remaining visible for a few days* in *Chronicon Paschale*
Motion across the sky	No special reference. Appeared N of Libra.

Table 4: Comparison of England's list of Kreutz sungrazer comets characteristics for the February AD423 and February AD467 comets. (*) This report is not included in the work of Pankenier et al. (2008). We have used the translation provided by Ho (1962). Some authors have proposed that its description might correspond to an aurora, but the original text clearly states that "it was called a *chhang-kêng*" which is a type of comet with two tails.

3.1.3.1 COMET B423

The comet registered in February AD423 is one of those that have been postulated as a possible origin of the Kreutz Sungrazer system. The existence of records of another comet for December AD422 allows us to consider the assumption that both comets could actually be the same body, which we will discuss later.

The *Song shu*, *Wei shu* and the *Nan shi* date the appearance of a comet south of KUI [LM15] in the first month, between January 28 and February 25, or south of DONGBI [LM14] on February 13. The Western sources reported of the comet that heralded the death of Emperor Honorius (who died on August 15), so it seems logical to attribute these sightings to the comet detected by the Chinese astronomers in February. This comet has been the subject of much speculation and calculations (see table 5), including the possibility of an earlier visit of Comet Ryves (C/1931P1, https://ssd.jpl.nasa.gov/tools/sbdb_lookup.html#/?sstr=Ryves). Although this is a problem that is out of the scope of this paper, we would like to point out that the integration of the orbital elements of this comet is quite problematic (see, for instance, Sitarski, (2002)) when it goes back several centuries from its perihelion in AD1931, and we hope to discuss it in greater depth in a future study. Just for the purpose of this paper, we have integrated the orbit of Comet Ryves using the elements provided by JPL, up to the year AD423 and to this aim, we have considered a perihelion date of February 7, AD423.

T (UT)	ω	Ω	*i*	*q*	*E*	Author
3 Feb	264.00	310.60	42.94	1.1053	1.0	Zhou (1997)
26 Aug 1931	168.14	102.2776	169.2881	0.074924	0.999326	Sitarski (1985)
7 Feb 423	176.48	109.2[illegible]	127.93	0.007	0.9999	Sitarski*
3.5 Feb	149~~.56~~	315~~.45~~	71~~.29~~	0.47~~25~~	1.0	M&M This paper
7 Feb	77.97	356.9	143.17	0.007	1.0	H&N (2001)
7.5 Feb	82.12	2.65	144.18	0.00515	.9999379	Sekanina (2007)

Table 5: Different sets of orbital elements obtained by several authors for the comet of February AD423. Comet Ryves appears twice as Sitarski (1985) and being Sitarski* the integrated elements for the year AD423. M&M stands for Martínez and Marco, H&K for Hasegawa and Nakano. Sekanina's orbital set of elements corresponds to those obtained by Sekanina and Chodas (2007) listed in their Table 10.

As previously stated, we have studied the two scenarios proposed by Sekanina and Chodas. In this subsection, we will consider scenario A and in the next, scenario B. Following these authors, we integrate the orbit of C/1843D1 back to AD1106, adjusting and fixing its eccentricity to fit Hasegawa & Nakano's (2001) date for the perihelion time of X/1106C1, January 26. This is a common step in both scenarios. Next, we have adjusted the eccentricity again, so that after the integration of the orbit from AD1106 back to the 5^{th} century the comet fits the assumed perihelion time of the comet of AD423. This integration was then extended further into the past to provide a history of the orbital evolution. We obtained slightly different results from those by Sekanina and Chodas, because the historical data suggests that the date of the perihelion of the comet should be delayed a few days with respect to the one they used. However, this change does not affect their conclusions. The corresponding sets of elements are listed in Table 6. In this scenario, we were unable to identify the predicted pre-AD423 returns with any historical comet. The integrations in this and the next subsection have been arranged using the Horizons tool provided by the JPL (https://ssd.jpl.nasa.gov/horizons/) either with the web interface or with the command-line (primary) interface to Horizons.

	C/1843D1 (1)	X/1106C1 (2)	B423 (3)	Perihelion -308 (4)	Perihelion 1811 (5)
Osc ep. TDB	1843-Feb-27	1106-Dec-15	0423-Dec-15	-0308-Dec-15	1811-Dec-15
e	0.999914	0.999932	0.999933	0.999930	0.999931
q	0.005527	0.005600	0.005421	0.005615	0.005487
i	144.3548	144.4672	144.1235	143.9991	144.4731
node	3.5272	4.7200	1.9180	1.4087	5.5677
peri	82.6390	83.8083	81.5361	80.1854	84.3980
tp	2394259.411 (1843-Feb-27.9)	2125049.636 (1106-Jan-26.5)	1875595.382 (423-Feb-6)	1609142.006 (-0308-Aug-4)	2382540.108 (1811-Jan-15)
new e	0.999977839	0.9999306465	----	----	----

Table 6: (1) Original orbital elements from https://ssd.jpl.nasa.gov/sbdb.cgi?sstr=1843%20D1
(2) Orbital elements of X/1106C1 obtained from C/1843D1 after correcting e
(3) Orbital elements of B423 obtained from X/1106C1 after correcting e
(4) Orbital elements of B423 from (3) for the previous perihelion passage
(5) Orbital elements of X/1106C1 if not fragmented for the next perihelion passage

As for the historical data, the two available reports refer to the reign of Emperor Shao of Song of the Southern Dynasties, with capital in Jiankang, which is also assumed to be the place from where the observations were made. Different considerations lead to think that the comet of the year AD423 is not the parent comet of the Kreutz Sungrazing system, being the visual magnitude one of them (see figure 6). Considering a magnitude H_{10} = 6 the comet could have been visible to the naked eye from the end of January, its magnitude increasing quickly and with an elongation that would place it at all times (before and after its perihelion passage) to the East of the Sun. As can be seen in Figure 6, the comet would have reached such a magnitude to be a naked eye object even on the day of its perihelion passage (see (Schaefer, 1993) for further considerations about the limit of visibility of celestial bodies). Among all the available sources, only the *Wei shu* seems to refer to a possible observation before February 13, with the position of the tail sweeping the Milky Way, to the SE. This would mean that the tail should have reached a length of almost 100º that does not seem consistent with the historical observations since none of them mentions such a long tail.

In addition, we can carry out a rough simulation of the length of the tail, (in this case using Comet for Windows, by Seiichi Yoshida, http://www.aerith.net/project/comet.html, because formulas (3) and (4) are not suitable for a comet so close to the sun). If we start from a tail of length 0.1 au, the simulation of the comet's tail indicates that it remained below 10º. To reach the 30º mentioned by the Eastern sources the length of the tail should have been around 0.5au long.

We would have an analogous situation in Europe, from where at the end of January the comet would have been perfectly noticeable. On this occasion, it may be interesting to make a comparison between the elongations of comets and their magnitudes, which can be seen in figure 7. The integrated elements of the comet (in red) would provide visibility conditions that do not fit the observations, making the comet the brightest object in the sky except for the Sun and Moon, visible even in broad daylight.

Instead of a Kreutz Sungrazing comet, we propose a more modest comet in terms of magnitude, whose path also fits the observations (see figure 5). In this case, it would have reached the magnitude of 3.5 also in mid-January, but its magnitude and position close to the sun at twilight could have made it go unnoticed. Its tail would have swept the Milky Way in the NW, instead of the NE, in what could have been a transcription error from the ancient source.

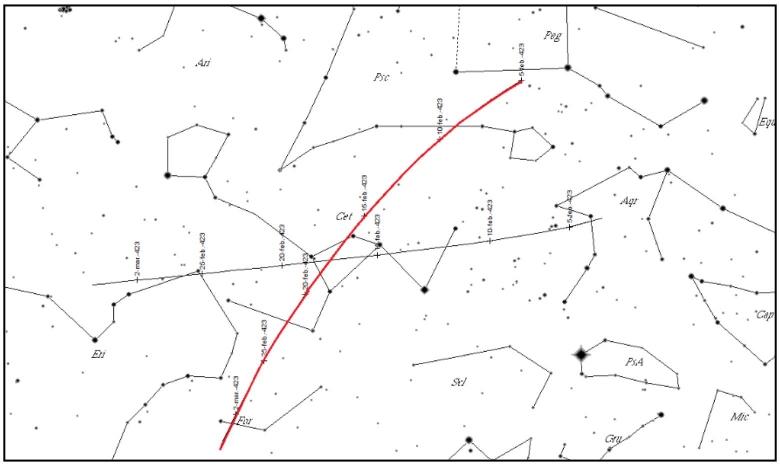

Figure 5: Apparent path of comet B423. In red, our proposed comet, listed in table 5, in black the comet obtained by integration from Table 6 whose path, at this graphical scale, is very similar to both the proposed by Sekanina and Hasegawa

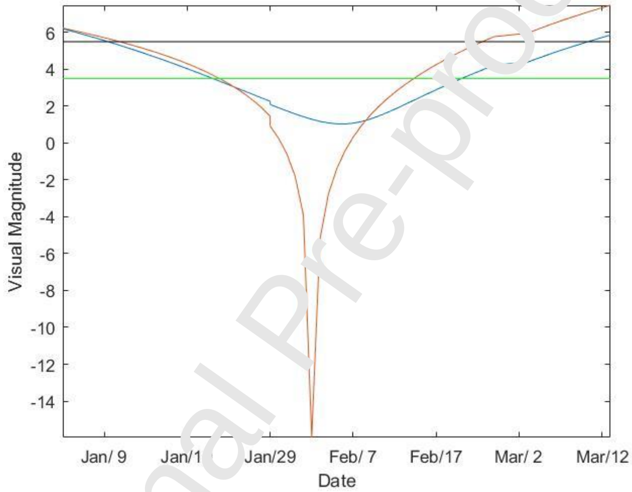

Figure 6: Comparison of the computed visual magnitude for the proposed comets of February 423. In red, the values for the orbit obtained after integration, given in Table 6. In blue, our proposed comet from Table 5.

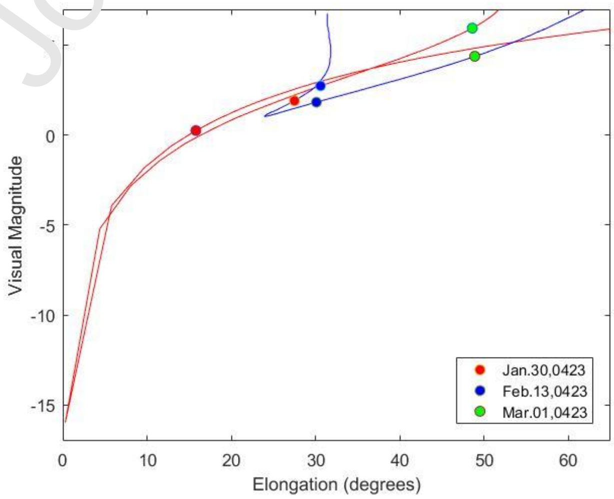

Figure 7: Elongation vs visual magnitude for the February 423 comet. In red the integrated comet from Table 6. In blue, our proposed comet from Table 5.

Finally, let us focus on Ryves comet, whose association with this comet was first proposed by Hasegawa (1979). We have already commented on the difficulties when integrating its orbital elements backwards for a long period of time. Nevertheless, we are going to consider the elements that appear in Table 5 to check if they fit the available observational data.
If we consider Sitarski's elements, integrated to AD423 and taking February 7 as the perihelion time, we see that before this date the comet would have been very easily observable from mid-January, in Aries and Pisces at dusk, and following a similar path to that obtained by Sekanina and Chodas. Therefore, it presents the same magnitude problems as this latter and could also be disregarded.
On the other hand, we could also consider the possibility that the comets seen at the end of the year AD422 (B422) and that of February AD423 (B423) were the same body. The Eastern sources seem to distinguish two different comets. For the comet of the year AD422, all sources agree that it began to be seen in SHI [LM13] (in one case in SHI and BI [LM14]). In particular, the *Wei shu*, a later text composed 150 years after the comet's passage, adds that *Swept* BEIDOU (Ursa Major) *and reached as far as the opening in the wall* [of ZIWEI]. From these descriptions it seems clear the presence of two distinct comets so, it is evident that they cannot correspond to the same one, since B422 was detected near Pegasus, moving progressively towards the north of the celestial sphere while B423, although it was found in a nearby area of the sky, had a displacement in the opposite direction. In fact, with the available data, it does not seem possible to propose an orbit for B422.

3.1.3.2 COMET AD467

Regarding this comet, the *Nan shi* states: *A white vapor was seen stretching half across the heaven from the SW to the SE* on February 6, AD467. This report is not included in the work of Pankenier et al. (2008); instead, we have used the translation provided by Ho Peng Yoke (1962).
Some authors have proposed that the description might correspond to an aurora, due to the reference to a single day, but the text goes on and clearly states that "it was called a *chhang-kêng*" which is a type of comet with two tails so, its translation as a comet seems evident. Some European sources seem to support this cometary hypothesis, among them, Victor Tunnunensis (see *Chronica* (1894)), who died circa AD570, mentions that a spear-like cloud appeared in the sky for forty days. This long period of visibility may be a transcription mistake and, as we will see later, this error may have some relevance in the discussion about the nature of the comet. The anonymous compiler of the *Chronicon Paschale* reduces the observation time to a few days and states that the tail was a straight line. Theophanes Confessor (see *Chronographia* (1839)), who lived during the 7th-8th century, specifies that the comet was visible in the evening. Much later chroniclers such as Gottfried of Viterbo (12th century, see Struve (1726)), Rolevink (15th century, see Struve (1726)) and Lycosthenes (1557) place the comet's appearance in the years AD434 and AD434-454 respectively, but they link it to a prodigy in Toulouse: the gushing of a stream of blood for a whole day in the city of Toulouse. This episode was possibly related to a geological phenomenon that actually happened (Alexandre, 1990) and it had been cited in the years AD467-468 by the only contemporary author Hydatius (who lived between AD395-470), (see Hydatius *Chronicon* (1845)). Although at first sight, this author does not seem to mention the comet, it is possible that he did it indirectly since he wrote that *at the time of the first year of Olympiad 312* (about AD468) *envoys returning from the king of the Goths*

brought back news of a number of portents seen in Gaul. (They said) that before their eyes . . .another sun, like the real one, seemed to have appeared immediately. . . at sunset; (…) and that at this time in the middle of the city of Tolosa blood had burst forth from the ground and flowed for an entire day (Burgess,1993).

As previously stated, it has been suggested that this comet may be part of the Kreutz group (see Sekanina and Chodas, (2007)). It would play a key role in their so-called scenario B in such a way that the comet of AD467 would correspond to a passage through the perihelion of the same fragment of the original parent comet that would be later observed as X/1106C1. In their paper, the perihelion passage would take place on Feb 1.5, AD467, but after the revision of the historical sources, we propose a new date T=Feb 5, AD467.

	C/1843 D1 (1)	X/1106C1 (2)	467 (3)	Perihelion -215 (4)	Perihelion 1764 (5)
Osc ep	1843-Feb-27	1106-Dec-15	467-Dec-15	-216-Dec-15	1764-Dec-15
TDB	0.999914	0.999932	0.999930	0.999930	0.999930
e	0.005527	0.005600	0.005338	0.005348	0.005376
q	144.3548	144.4672	144.5478	144.4612	144.4903
i	3.5272	4.7200	6.3254	5.2727	8.1360
node	82.6390	83.8083	85.1740	84.4516	86.5087
peri	2394259.411	2125049.636	1891563.778	1643198.464	2365616.455
tp	(1843-Feb-27.9)	(1106-Jan-26.5)	(467-Feb-5)	(-0215-Oct-31)	(1764-Sep-14)
new e	0.999977839	0.9999273655	----	----	----

Table 7: (1) Original orbital elements from https://ssd.jpl.nasa.gov/sbdb.cgi?sstr=1843%20D1
(2) Orbital elements of X/1106C1 obtained from C/1843D1 after correcting e
(3) Orbital elements of comet AD467 obtained from X/1106C1 after correcting e
(4) Orbital elements of comet AD467 from (3) for the previous perihelion passage
(5) Orbital elements of X/1106C1 if not fragmented for the next perihelion passage

We have tried to check whether the integrated set of orbital elements from Table 7 agrees to the recorded historical observations. In particular, the four-day displacement of the date of the perihelion passage would lead to the implementation of visibility conditions. With this assumption, the comet's tail could have been seen as a "white cloud" in the SW, after sunset, heading SE on February 6, and then it would have been seen as a "proper" comet for about a week after vanishing, as Chinese sources reported. That would explain both the "white cloud" that would not correspond to an aurora and the attribution that the same source makes of this object as a *chhang-kêng*. For Europe, we guess that the comet was seen only after the perihelion and for a very few days (namely 10).

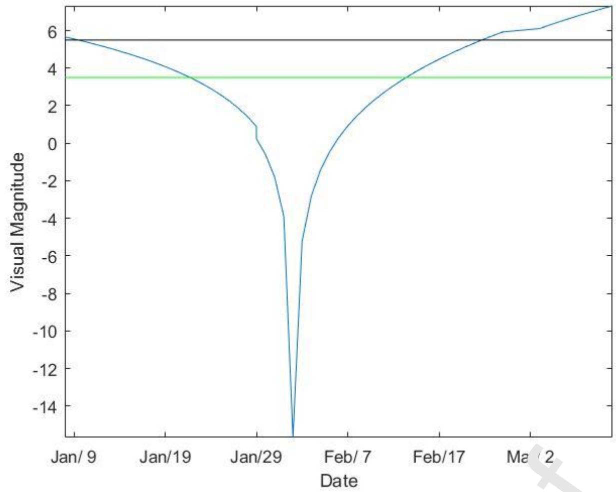

Figure 8: Evolution of the visual magnitude of AD467 comet

The previously mentioned Hydatius record might make sense in this context. In AD466 Euric had risen to power as a king of the Visigoths. The Goths were surely coming from an embassy from the capital of the kingdom in Tolosa (Nowadays Toulouse, France), from where the comet had just as bad observing conditions as in China. Hydatius mentions that a second sun like the real one appeared immediately after sunset. This description matches that of a sungrazer comet that would have been seen on a day very close to perihelion.

Estimating the magnitude of the comet is problematic since its discovery date must have been very close to its maximum brightness. However, taking as absolute magnitude H_{10} = 6 the comet could have reached a magnitude of -14 around the perihelion date and this magnitude would decrease very rapidly thereafter (see Figure 8).

As we have mentioned previously, a major problem in considering it a Kreutz-Sungrazer is Victor Tunnunesis's statement that extends the period of visibility of the comet up to 40 days. No contemporary author repeats this duration and, in fact, some sources such as the *Chronicon Paschale* reduces this period to a few days. The sources that we have consulted also contribute to the confusion since different durations have been found in the versions of the Tunnunensis' Chronica from the classic compilations: 40 days in *MGH* and 10 days in the version by Migne (1866). So, although it is not possible to be completely sure, the authors believe that the historical sources in general and Hydatius record in particular, provide sufficient indications to reinforce the hypothesis that the comet of AD467 was, indeed, a sungrazer.

In Sekanina and Chodas' scenario B the parent comet of AD1106 and AD467 was proposed to be the comet of 214 BCE but this attribution is very dubious from a historical point of view. The only two references that we have for this phenomenon only say that "*a bright star emerged in the west*" and *"a broom star appeared"*, without any further information. In our case, we have found no further observations for this latter comet, this does not imply that there are not, but rather highlights the scarcity of data for that time

As can be seen in table 7 we obtain similar results to the ones from Sekanina (2007). Had the parent comet not fragmented in AD1106, it would have returned to the Sun in AD1764 in scenario B. Again, no matching comet has so far been found for this return.

3.2 C/400 F1

This comet is referenced in many oriental chronicles, mainly Chinese and Korean. The oldest sources, *Song shu*, *Wei shu* and *Jinshu* coincide in pointing out its appearance on March 19 (from April 10 to May 9 in the *Wei shu*) in KUI [LM 15], its ascension to GEDAO and the west of ZIGONG. Its path gets near SANTAI, TAIWEI, DIZUO (α_1 Herculis, this could be a misprint. Actually, scholars agree it must refer to BAIDIZUO, a star close to β Leonis) and DUANMEN. The *Wei shu* is, in fact, more specific because it states that it trespassed on TAIYANGSHOU, rounded XIATAI and overran NANGONG, stepped in DIZUO then emerged (or as recently proposed "exit via") DUANMEN. The three sources agree about the comet entering the bowl of DOU (or BEIDOU).

Two much later Korean sources, *Jeungbomunheonbigo* (1908) and *Samguksagi* (1145), only state that there was a fuzzy star in KUI [LM15] and LOU [LM16]

On this occasion, the European sources are detailed and contemporary, so they should play a key role when providing a study as complete as possible about this comet. There is a significant number of European references (see Kronk (1999) and Sicoli et al. (in prep.)), but the most important source to consider is Claudian's record (c. 370-c. 404).

> *Then with these new portents their troubled minds link the signs of the past year and any omens that perchance peaceful days had neglected — showers of stones, bees swarming in strange places, furious fires destroying houses from no known cause, a comet — never seen in heaven without disaster — which first rose where Phoebus lifts his rosy morning beam and old Cepheus shines together with starry Cassiopeia, his spouse; then it withdrew little by little to the constellation of Lycaon's daughter* (Ursa Major) *and with its errant tail dimmed the stars of the Getic Wain until at last its dying fires grew feeble and vanished.*

There is some discrepancy on whether this comet appeared in AD400 or in AD402 (Pingré (1783), Barret (1978), (Hasegawa (1979), Kronk (1999, 2021)), or Ramsey (2006). The additional data about the many Moon eclipses to which Claudian refers in a previous paragraph does not help to clarify the issue: although native to Alexandria, it is assumed that this author spent most of his life at the court of Rome, and between AD400 and AD401 there were three total lunar eclipses visible there, so the allusion to constant lunar eclipses seen at the time of the comet could apply to either one. Considering the coincidence with the Eastern descriptions, we support the assumption that the fragment refers to the comet of the year AD400.

About the comet itself, Claudian seems to state that the comet appeared in the morning sky, near where the Sun rises, not far from Cepheus and Cassiopeia. We should not underestimate the reference to the tail of the comet that "dimmed" the stars of the Ursa Major because Claudian was an alleged eyewitness.

About forty years ago Hasegawa (1979) published an orbit that roughly matches the historical records shown. The weak point of his solution, as it was already pointed out by Kronk (1999), is that the comet does not crosses the bowl of BEIDOU, (asterism formed by stars α, β, γ, δ Ursae Majoris) although it passes in its proximity, going through its tail. Nevertheless, this orbit had not been reconsidered up to now. Considering that on rare occasions we find such a clear reference in a cometary position, on the basis of Eastern observations and Claudian's text, we independently calculated an alternative orbit that matches this particular condition and also agrees closely with the other records (see Table 1). During the writing of this paper, an update and improvement of the orbit initially obtained by Hasegawa was published also by Kronk (2021). We have included his results in this section and will comment on them together with our results.

According to all sources, on March 19 the comet was located in KUI [LM 15], in its southernmost zone close to LOU [LM16], becoming visible towards the Northeast before dawn with an estimated tail of 30 zhang long (about 30 degrees).
In these same days, the comet was also seen in the Middle East for which references can be found in Socrates Scholasticus, Philostorgius and Sozomene. In particular, the latter referring to the taking of Constantinople by Gainas, after having deposed and exiled Aurelian, mentions the appearance of a comet as a premonition for such an event: *Gaina intended to back off her oath and was planning to plunder the city when a huge comet appeared over the city foretelling this plot. The elongated comet quite reached the ground and it was said that by heart no one like it had appeared before*. Unfortunately, no other date has been mentioned by Eastern sources, making the work of those aiming to estimate an orbit complicated. In fact, even when several positions are mentioned none is accompanied by a precise date. This explains why, although the path in the sky followed by the comet is quite similar for the three orbits considered, as shown in Figure 9, its actual position, at a certain date remains uncertain. If we compare Kronk's orbit with our own, for example, we can see that the passage through the "bowl" of the Big Dipper occurred on April 2nd in the first case and on 6th in the second. In addition, Kronk's comet has an extremely slow initial motion but, at the beginning of the 3rd lunar month (April 10th) both paths and the positions of the comets are very close.

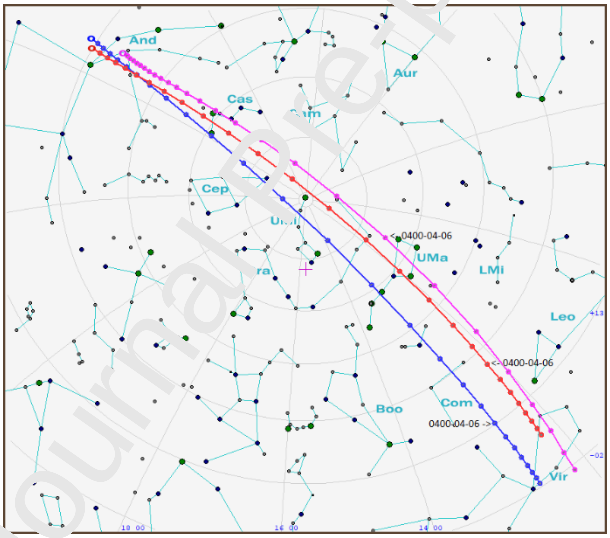

Figure 9: Apparent path of C/400 F1 from Mar. 18 (blank circle) to Apr. 13, 400 AD (1-day step). Hasegawa's orbit (blue), our (red) and Kronk (pink). Notice the difference around the UMa zone. Chart prepared using MAPPA2 (v. 5.8).

Since we do not have any data about the brightness of the comet, a calculation of its absolute magnitude H_{10} can only be inferred indirectly. According to Kronk (2021) the chance of discovering a comet, placed about 10º above the horizon, as in the case of C/400 F1, may be successful when its magnitude is not more than 2 or 3. Starting from this assumption and estimating its disappearance in the first days of the third lunar month (i.e. shortly after April 10) a value H_{10} = 4.8 seems quite reliable. Based on this result and considering our orbit, the scenario for C/400 F1 can be then recreated as follows: on March 19, at the time of its discovery, the comet, with a magnitude of around 1.5-2.0
was visible before dawn about 10º above the horizon to the Northeast.
A week later, gradually moving away from the horizon, it increased its brightness to magnitude 0.5, while developing a 25-30º tail. Probably in these days, the comet was

also observed in Constantinople as a "sword-shaped star" as reported by Philostorgius and "with elongated form that almost reached the ground" as said Sozomene. At the end of March, the comet moved towards the celestial pole, as stated by Claudian, came at the minimum distance from the Earth (about 16 million km) reaching at the same time, its peak of brightness with a negative magnitude, albeit slightly. After having transited in the "bowl" of UMa (Apr. 2) it went towards the tail of Leo (Apr. 8) and finally disappeared somewhere between the stars β and γ in Virgo a few days after the beginning of the third lunar month (Apr. 10), being now around 4th magnitude.
On the other hand, Kronk is aware that the magnitude of his proposed comet remains below the naked eye visibility (here considered 5.5) until early May and proposes that the comet was no longer observed for astronomical reasons (the full moon), or not astronomical ('dust rain'). Without neglecting this possibility, the comet that we propose would instead become unobservable around April 10, a date suits very well to the records (see Figure 10).

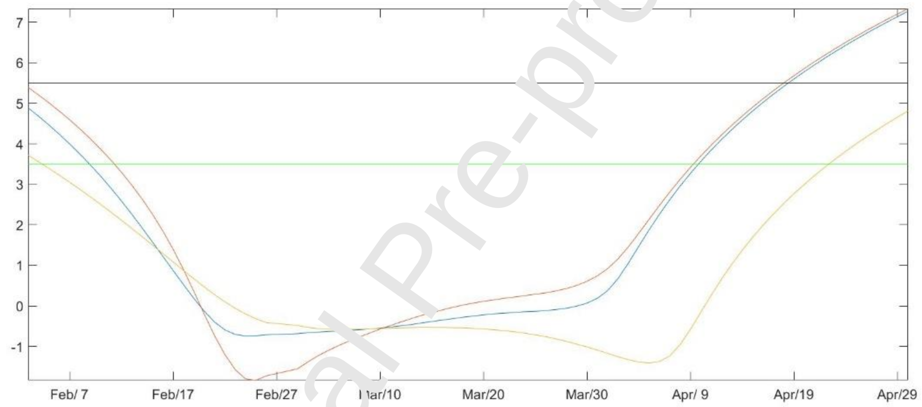

Figure 10: Calculated apparent magnitude for C/400F1. Where the dashed black line corresponds to the one calculated by Hasegawa and H_{10} = 5.9, red is ours and H_{10} = 4.8, blue is Kronk's and his proposed magnitude H_{10} =4.3. Scattering has been included. Horizontal red and green lines stand for magnitude 5.5 and 3.5 respectively.

Disregarding Hasegawa´s orbit and focusing only on proposed comets that confirm its passage through the bowl of Ursa Major, there is one remaining question: why the comet was not detected if it had a magnitude around1.5-2.0 in mid-February? To answer this question, it may be interesting to observe the relationship between elongation and magnitude (Figure 11). The two main observation sites must have been Pingcheng (40º06'N 113º14'E), capital of the Northern Wei dynasty in AD400, and Constantinople (41º 00'N 28º 58'E), and both cities have a similar latitude. The vertical line in Figure 11 at 10º marks the point from which it would be possible to detect the comet considering the latitudes and the epoch of the year in which the comet was observed (We consider this limit because it is the one indicated by Kronk in his paper, although 15º would be more appropriate from an observational point of view). Actually, from these latitudes, Kronk's comet would have been visible, very low after sunset, starting from mid-February and in early March also in the morning sky. On the contrary our proposed comet, being apparently closer to the Sun, would have been scarcely detectable before mid-March

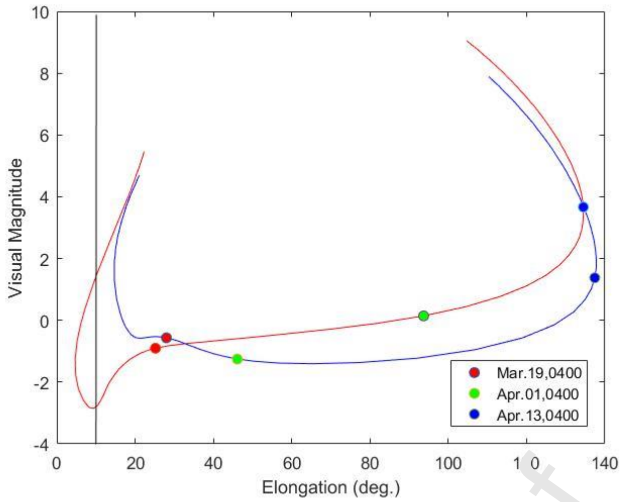

Figure 11: Calculated elongation-apparent magnitude for C/400F1 red is ours and H_{10} = 4.8, blue is Kronk's and his proposed magnitude H_{10} =4.3. Scattering has been included. Vertical line: 10 degrees elongation

Kronk (2021) also refers to the problem of the comet's tail, since in Chinese records a specific term *xingbo* is used for a comet that does not have a tail, although it follows from the same texts that it was developed later. Using equations (3) and (4) ~~proposed by Kammerer (1994)~~ we can obtain a modelling of the behaviour of the tail that the comet could develop, although considering, as we have already commented, that certain factors may influence the accuracy of this model. Bearing in mind that Kronk seems to use these equations in his article, we include the study for comparison. Both the comet proposed by Kronk and the one in this paper could have had a minimum tail length of around 10º long on March 19. The length of the tail would have been increasing until the end of March or the first days of April, with our comet in the vicinity of Ursa Major. It is at this moment when the *dimmed of the stars of the Lycaon's daughter* indicated by Claudian could have been produced while Kronk's comet would have reached a maximum on April 9, and then decreased quickly. Altogether and without claiming that the orbit cannot be improved, we think that the set of orbital elements proposed here for the comet of the year 400 adapts more naturally to the historical and astronomical data. However, Kronk's orbit remains as an equally valid alternative

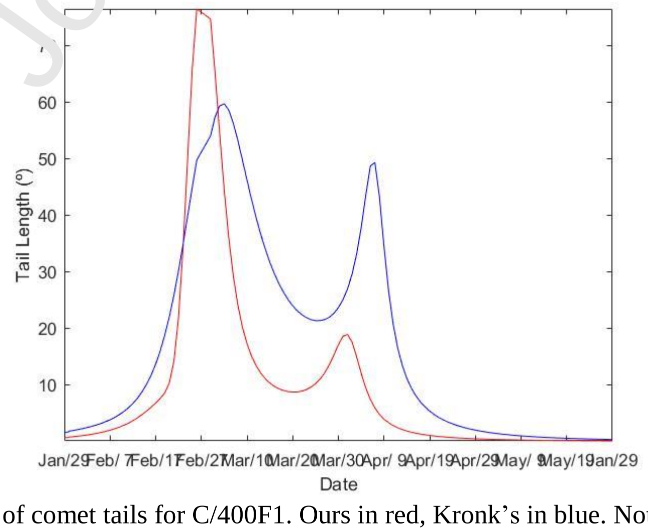

Figure 12: Behavior of comet tails for C/400F1. Ours in red, Kronk's in blue. Notice that our proposed comet was below the horizon in February.

3.3 C/418 M1

The main problem with the historical records for this year is that the existence of up to three different objects could be inferred from them, depending on how the observations are grouped (Kronk, 1999). Thus, concerning the Eastern sources, both the *Song shu* and the *Jin shu* coincide in stating that a star became fuzzy in the bowl of BEIDOU, although the former gives the date as July 6 and the latter June 24. Subsequently, on September 15, they affirm that a broom star emerged west of TAIWEI, its handle rising up from below the SHANGJIANG star. Its rays gradually grew to over 10 zhang in length, and then it proceeded to sweep BEIDOU, ZIWEI, and ZHONGTAI, without clarifying whether they refer to the same comet or another. The *Wei shu* ignores the June-July comet and only accounts October observations, stating that between October 16 and November 13 a long broom star became fuzzy in BEIDOU and overran ZIWEI, on day *xinyou* (November 12 instead of November 22, which seem to be a misprint in Pankenier et al. (2008)) it entered NANGONG, being followed for over 80 days.

Additional data is provided by the *Wei shu*, which states that in the twelfth month (between January 12 and February 10, 419AD) a broom star emerged from TIANJIN, entered TAIWEI, bisected BEIDOU, disrupted ZIGONG, trespassed on TIANBANG, again, the comet lasted for over 80 days. When it reached the Milky Way, it was extinguished. The two descriptions of the *Wei shu* seem to correspond to the same comet but shifted in time. In addition, the path of the comet coincides with that indicated by the two previous sources. We suspect that the *Wei shu* scribe mistook the month in both records. This would indeed be the same comet indicated by both the *Shong shu* and the *Jinshu* that was seen in the seventh month (18 August-15 September AD418). As we will see, this is also in accordance with the observations of the comet from Europe. If this were the case day *xinyou* would correspond to September 13 instead of November 12.

Once again, European sources can play a major role in this case, as they provide the testimony of the contemporary Byzantine historian Philostorgius (368 - c. 439 AD), who places the comet's appearance around the solar eclipse of July 19, 418 and provides details on the trajectory followed: *it arose first in the East, just where the sun rises at the equinox, and then passing across the lowest star in the constellation of the Bear, crossed gradually over to the west.* About its duration *for more than four months ... It began about midsummer, and continued till nearly the end of autumn,* concluding by pointing out that it was a precursor of wars and deaths. The rest of the non-contemporary European historians assign the duration of the phenomenon between three and seven months, highlighting the latter in the chronicle of Marcellin, who died in AD536, although this report has been the subject of some controversy (Kronk, 1999).

Authors such as Pingré (1783) and Hasegawa (1980) considered the existence of two distinct comets, one observed in June and the second in September. Kronk (1999) tends to assume a single comet and proposed consequently a parabolic orbit so that the apparent trajectory was able to satisfy all the positions recorded between June and September. Also, the description of Philostorgius seems to support the idea of a single comet from summer to late fall. However, we must try to reconcile this with the observations recorded in the *Jin shu* and *Song shu* where they clearly specify that a comet was seen in the bowl of BEIDOU in June / July and then refer to the September comet that appeared in TAIWEI (nearby Leo / Coma Berenices / Virgo) to later go up to BEIDOU and the circumpolar zone. Although the latter text could refer to the comet's tail (in this case, the tail could have reached a length of 150º) and not to the coma, it can be seen that the comet proposed by Kronk does not follow this path, nor would its tail adapt to the data (See Figure 16).

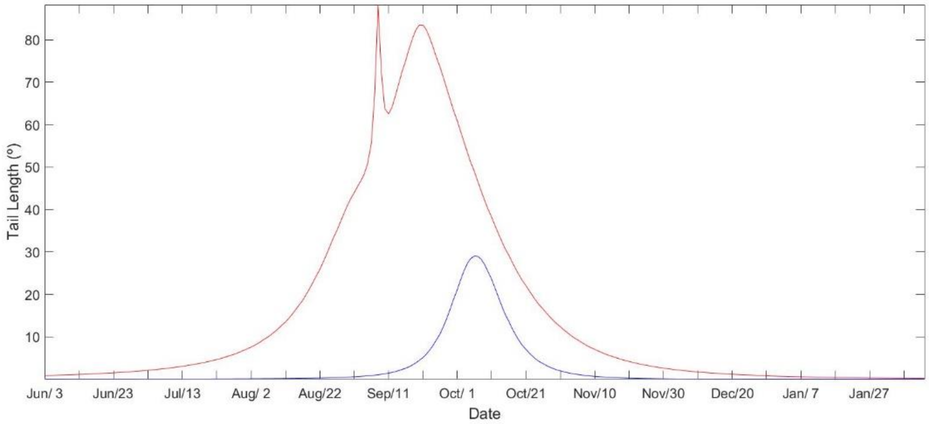

Figure 13: Behavior of comet tails for C/418M1. Ours in red, Kronk in blue using formulas (3) and (4). It should be taken into account that in the periods between September 23 and October 17 for Kronk's and August 27 and September 20 for ours, the comets were closer than 0.5 au to the sun and, therefore, formulas may lose accuracy.

Also, Zhou et al. (1997) proposed an alternative orbit, although the authors provided positions that were quite different from those observed. In this paper, we assume the existence of only one comet visible from July until late December, whose proposed orbit is listed in table 1 and the path may be seen in figure 14.

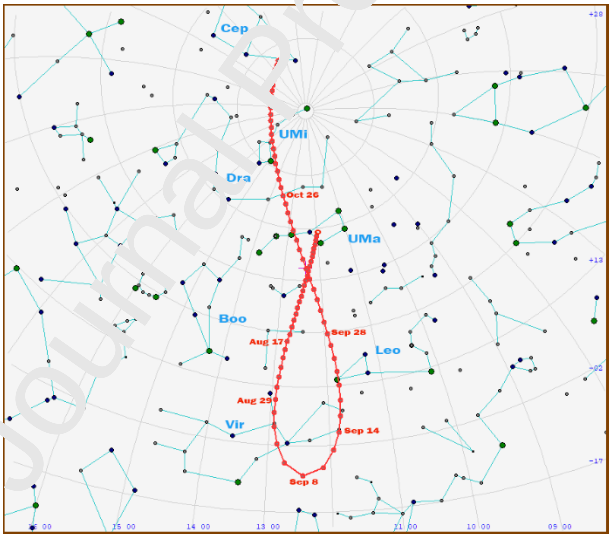

Figure 14: Apparent path of Comet C/418 M1, according to our orbit, from 6 July (blank circle) to 7 December 418 AD in 2-day intervals. Chart prepared using MAPPA2 (v. 5.8).

As can be seen, the comet that we describe would have appeared for the first time in Ursa Major and July 6 could have been an accurate date for this first detection. The proximity to the Sun would have made it invisible for a few days in September, being perhaps this the reason why some sources seem to consider two different comets. It emerged in TAIWEI around September 15, with its tail pointing from below the SHANGJIANG star. Unlike the comet suggested by Kronk, this one would return to a position close to the northern part of the celestial sphere, and its tail would sweep BEIDOU, ZIWEI, and ZHONGTAI in late September or early October. The comet that we submit could have remained visible, albeit with a low magnitude, until the end of

December (see Figure 15), although in November when it reached the vicinity of Cepheus and the Milky Way could have stopped to be tracked.

Although the detection in Europa could have been earlier, around the date of the eclipse of Sun in July, the first observation collected by Philostorgius would correspond to a position at the beginning of September, when the comet had its rising in the East cardinal point and from where it would move towards the stars of Ursa Major.

Another issue regarding the visibility of the comet should also be noted since if we consider the mean latitudes of Constantinople and Pingcheng, the comet proposed by Kronk would have had a period of invisibility due to its position with respect to the sun. This period would have been more or less long depending on the latitude, but in any case, it started at the beginning of October reaching up to mid-November or the beginning of December, when perhaps it could have been noticed at sunset, which contradicts the European data that they clearly state that the comet was seen *from midsummer to late fall*. In addition, Kronk has some concerns regarding the period of visibility of his published orbit. This period is assumed to range between the end of June and the month of November, so the requirements in terms of magnitude are very high. To fit this with the computed orbit, Kronk considers a magnitude H_{10} = 0.2, which would have allowed the visibility until November/December. But in this case, on June 24, the date of its first observation, the comet should have been at the limit of the naked eye (m_v = 5.5). That is a magnitude that, although not impossible, makes the discovery of a new celestial body very difficult. In general, it would be more logical to consider, for the first visibility, a magnitude of 3.5 or even less (Seargent, 2009), (Chambó, 2020). However, in this case and given that the constellation in which the comet first appeared is well known, we consider that it would be feasible that the comet would have been detected with a somewhat lower magnitude, around 4.5. Under this assumption, the authors have computed a H_{10} = -0.79 for Kronk's comet and H_{10} = 0.06 for the comet that we present. With these magnitudes, Kronk's comet would have reached a magnitude lower than -5 at the end of September and would have been visible until beyond February 419 (See the comparison in figure 15 and figure 13 for the difference in the behaviour of the tails).

In the case of the comet that we propose, its observation would have been compatible with a follow-up until the end of December, when it would have reached a magnitude greater than 5 and would have vanished, (see figure 15). In figure 16 the difference in visibility between both comets can be clearly seen. In this case, we have included a vertical line corresponding to an elongation of 15º which would be approximately the visibility limit for a latitude of 40.5º in the months of November-December. As shown in the figure, the comet would continue to be visible until its magnitude reached the naked eye limit, while Kronk's comet would have ceased to be visible much earlier due to its proximity to the sun.

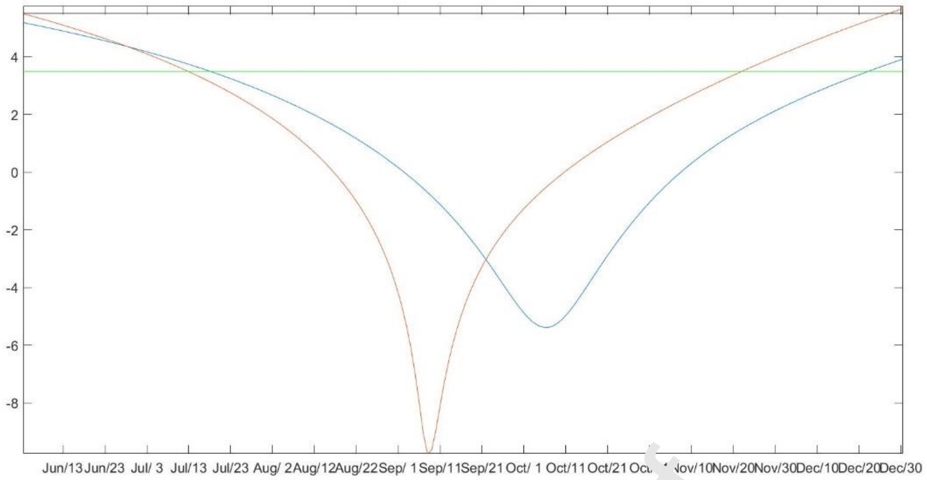

Figure 15: Calculated apparent magnitude for C/418M1. Where blue is the one calculated by Kronk and H_{10} = -0.79, red is the one we propose and H_{10} = 0.06. Scattering has been included.

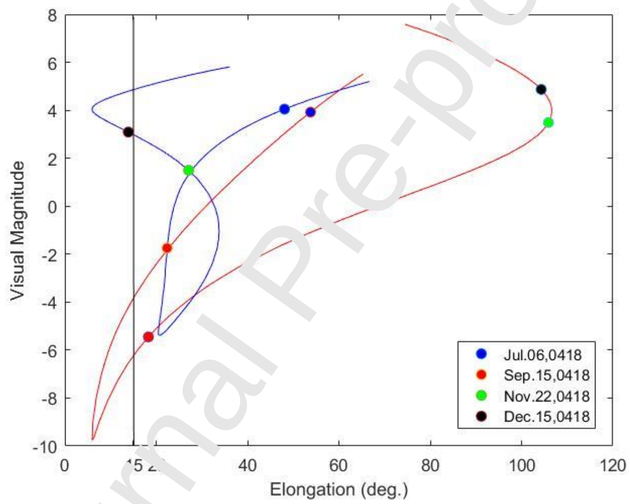

Figure 16: Calculated elongation-apparent magnitude for C/418M1, red is ours and H_{10} = 0.06, blue is Kronk's and his proposed magnitude H_{10} =-0.79. Scattering has been included. Vertical line:15 degrees elongation

3.4 *C/442V1*

Contemporary observations from Europe complement the slightly different versions from China according to which the comet was first seen sometime from October 20 to November 18, depending on the source, in BEIDOU (November 1 in *Nan shi* and with no specific date in *Song shu*) or TIANLAO (November 10 in *Wei shu*), in any case, the comet appeared in the Big Dipper. It entered WENCHANG, penetrated WUCHE and swept BI [LM 19], brushed TIANJIE, and passed TIANYUAN where it disappeared. The *Wei shu* provides a duration of 100 days and specifies that it passed between MAO [LM 18] and BI [LM 19], while *Nan shi* says that it disappeared the last month of winter. Combining the data, a duration of 100 days would have brought the comet's visibility to mid-February, near the beginning of the second month (February 15-March 16) very close to the spring equinox on March 20. Kronk does not collect the later translation of the *Nan shi* that does appear in Pankenier et al. (2008) book.

In Europe the comet does not seem to have been observed until December (in Hydatius, (1845)), preceding a universal plague (which, in fact, must have been local, since it is not mentioned in other sources) The available sources specify a period of visibility of some months.

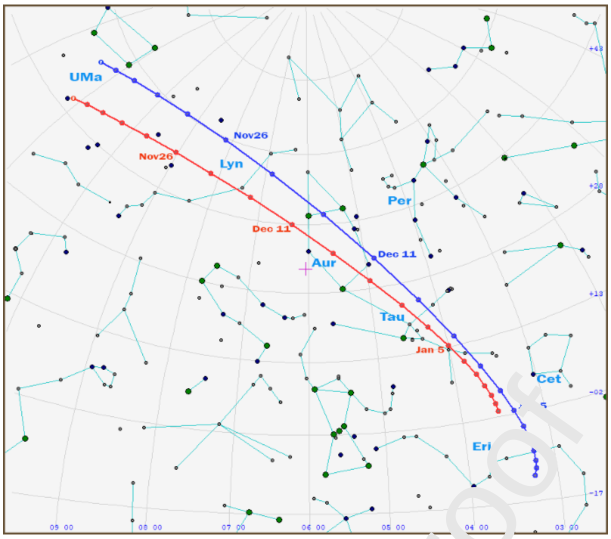

Figure 17: Apparent path of Comet X/442 V1, (red ours, blue Hasegawa) from 1 November 442 (blank circle) to 4 February 443 AD in 5-day intervals. Chart prepared using MAPPA2 (v. 5.8).

In this case, our proposal consists of a refinement of the orbit given by Hasegawa that results to be better adapted to the observation dates (see figure 17). The comparison of the paths shows that both comets would have been noticed in BEIDOU, being our comet closer to TIANLAO. Later, they would have evolved crossing WUCHE with a week of difference between them. Both would have passed between BI and MAO, with the tail sweeping BI, and finally, after crossing TIANJIE, they reached TIANYUAN where the comet would disappear in mid-January, according to Hasegawa's orbit, or a month later according to ours.

A no-minor issue regarding its magnitude is that the comet was detected in Europe by Hydatius (c. 400 - c. 469), an alleged eyewitness who, in addition, provides a duration of several months. Assuming a visual magnitude of 4 for October 31, Kronk calculates an absolute magnitude of 1.5. The same conditions for our comet provide an absolute magnitude of 0.33. In these cases (see figure 18), both comets would have been dim, although visible in the period considered.

After examining the historical context, we consider that these H_{10} values may be too pessimistic: at the time of discovery on 1st or 10th November, the comet must have been around a visual magnitude of 2.5 / 3.0. At the beginning of December, when it was first observed in the West, it should have been brighter, probably with a magnitude between 0 and 1. To deserve mention from Western sources, its magnitude must have remained at least above 2.5/ 3 throughout the period. At the end of February (a date which also corresponds to over 100 days of the Chinese) the comet must therefore still have been bright enough given that it was getting lower and lower on the horizon. On this basis we consider a value of H_{10} = -1 is quite consistent (See figure 18).

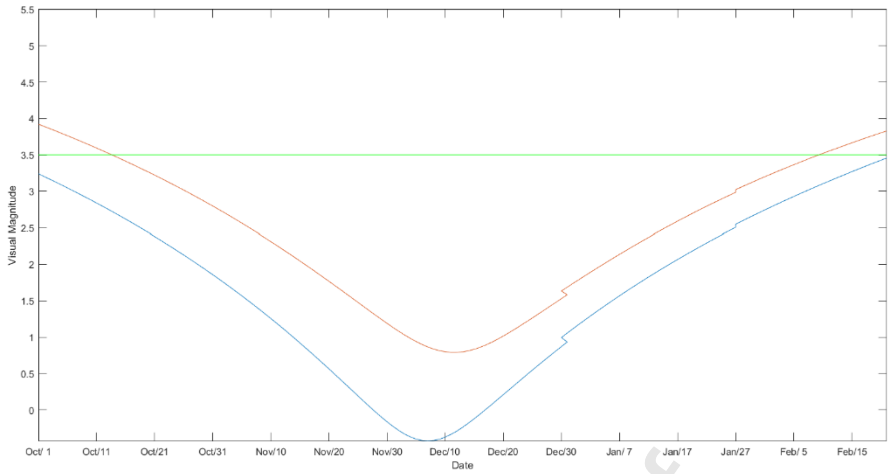

Figure 18: Calculated apparent magnitude for C/442V1. Where blue is the one calculated by Hasegawa, red is ours and H_{10} = -1 in both cases. (See text)

Name	T (UT)	ω	Ω	*i*	*q*	*e*	H_{10}
C/400F1	400 Feb 27	39	37	41	0.16	1.0	4.8
C/418M1	418 Sep 8	253	66	75	0.10	1.0	0.06
A422	422 Mar 6	344	203	34	0.96	1.0	6*
X/423B1	423 Feb 3.5	149	315	71	0.47	1.0	6*
C423	424 Jan 19	247	300	122	0.54	1.0	6.41
C/442V1	442 Dec. 21	176	274	117	1.75	1.0	-1
	467 Feb 5	85.1740	6.3254	144.5478	0.005388	0.999930	6*

Table 8: Proposed orbits for late 4th and 5th-century comets (referred to J2000.0). Angular variables are expressed in degrees and *q* is given in au. The asterisk after the absolute magnitude means that we have not found enough evidences to propose a reliable absolute magnitude and we have adopted a standard value to give an idea of the comet's brightness behaviour.

4. CONCLUSIONS

Based on historical sources from Europe and Eastern countries, especially China, we have provided in this paper new proposals or refinements of the orbital elements of some comets observed during the late 4th and 5th century (See the final conclusions in Table 8). 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 real orbit.

We discussed the orbit of comet C/400 F1, for which different authors had proposed orbits that were quite different and that presented problems in regard to discrepancies, mainly in terms of dating and magnitude, with historical data. The orbit we propose would solve these problems while being consistent with the historical interpretation. The case of the comet of the year 418 is also relevant, since different authors had suggested the existence of up to three different comets. We perform a reinterpretation of the data, giving a specific weight to those that come from Europe, so that we conclude the existence of a comet with an orbit completely different from the one already published but that adapts very well to the historical records while meets the astronomical requirements. For the comet of the year AD442 we do not suggest a change in the orbit, but only a modification in the light of the historical data collected, which, however, also implies a better adaptation to them.

Finally, we focused on the study of the Kreutz Sungrazers system. In this case, our intention was not to explain the origin of the Kreutz family of comets, which would require a much broader approach, with numerous calculations and integrations that are beyond the scope of this paper, but to examine the two proposals that Sekanina pursued in his cascading fragmentation hypothesis (Sekanina, 2007). With this perspective, we have concluded that scenario B is the most favorable one, involving the comet of the year AD467. The reasons for this choice are of two types, historical and astronomical. In the first case, it should be noted that scenario A implies a comet that would have been visible in Europe under very favorable conditions for a much longer period of time than was recorded. Nor do the eastern observations seem to agree with the simulation that we have carried out for this scenario. On the other hand, the assumption that the comet of the year 467 did belong to the Kreutz group does not require any additional assumption not already included in the records and is well adapted to both the astronomical and historical context.

Acknowledgements

The authors would like to express their gratitude to Professor D. Pankenier for his availability to answer questions about his studies, to J. Chambó, an experienced amateur comet observer, for his advice on the practice of cometary observations, and to A. Testa for his help in preparing fig. 9, 13 and 17. We also wish to thank Dr. Julio A. Fernandez and the anonymous referee for their valuable comments and contributions to the final version of this paper.

5. APPENDIX A

List of Chinese Lunar Mansions, constellations and asterisms that appear throughout the paper, as in Pankenier et al (2008) Notice that asterisms composed of several stars are identified by the first in order, according to the Chinese system. It is also worth noticing that scholars disagree in a few cases which star is the determinative star (compare Xu et al. (2000), Stephenson & Green (2002), or Sun & Kistemaker (1997)

The first column is the Chinese name, the middle column is the English translation and the third column corresponds to the determinative star. For a complete list see Pankenier et al (2008) and for a graphic representation of the sky see Ho Peng Yoke (1962)

CHINESE LUNAR MANSIONS		
DI [LM 3]	Root	α^1 Lib
WEI [LM 6]	Tail	μ Sco
XU [LM 11]	Emptiness	β Aqr
WEI [LM12]	Rooftop	α Aqr
SHI [LM 13]	Encampment	α Peg
DONGBI [LM14]	Eastern Wall	γ Peg
KUI [LM 15]	Swine	ζ And
LOU [LM 16]	Hillock	β Ari
MAO [LM 18]	Hairy Head	17 Tau
BI [LM 19]	Net	ε Tau
GUI[LM23]	Ghost	θ Cnc

CHINESE CONSTELLATIONS AND ASTERISM		
BEIDOU	Northern Dipper	α UMa
BADIZUO	White Emperor’s Throne	a star close to β Leo
DAJIAO	Great Horn	α Boo
DIZUO	Emperor’sThrone	α_1 Her
DUANMEN	Main Gate	between β and η Vir
GEDAO	Stepped Path	ϕ Cas
HEGU	River Drum	α Aql
NANGONG	South Palace	area near 92 and 93 Leo
SANTAI	Three Steps	ι, λ, ν UMa
SHANGJIANG		δ Leo (star)
SHETI	Left and Right Assistant Conductors	ο Boo, η Boo
TAIWEI	Grand Tenuity Enclosure or Privy Council	β Vir
TAIYANGSHOU		χ UMa
TIANBANG	Celestial Cudgel	ξ Dra
TIANCANG	Celestial Storehouse	ι Cet
TIANJIE	Celestial street	κ, ω Tau
TIANJIN	Celestial Ford	γ Cyg
TIANLAO	Celestial Dungeon	ω UMa,
TIANYUAN	Celestial Meadows	γ Eri
TUSIKONG	Butcher Shop	109 Her
WENCHANG	Celestial Secretariat	θ UMa
WUCHE	Five Chariots	ι Aur
XIATAI	Lower Step	ν UMa
XUANYUAN	Yellow Emperor	α Leo
ZHONGTAI	Middle Step	λUMa
ZIGONG	the circumpolar region	κ Dra
ZIWEI (ZIWEIYUAN)	Palace of Purple Tenuity	κ Dra

6. APPENDIX B

Comet	Date (UT)	RA hh mm	DEC °	Duration
C/400 F1	400 Mar. 18.5	00 21	+29.5	~ 1 month
	400 Mar. 27.5	00 30	+60.9	
	400 Mar 29.5	01 08	+80.7	
	400 Apr 7.5	12 11	+16.9	
C/418 M1	418 Jul 6.5	12 01	+56.5	> 3 months
	418 Sep 15.5	11 48	+04.2	
	418 Oct. 16.5	12 49	+56.9	
	418 Oct. 26.5	13 31	+67.1	
	418 Nov 12.5	16 40	+80.2	
A422	422 Mar 16.5	20 38	-20.6	~ 10 days
	422 Mar 21.5	19 29	+10.5	

	422 Mar 26.5	19 21	+28.1	
B423	423 Jan 30.5	22 49	+20.5	~ 1 month
	423 Feb 13.5	00 41	-05.4	
	423 Feb 23.5	02 28	-16.0	
C423	423 Dec 14.5	15 13	+23.9	~ 1 month
	423 Dec 16.5	14 53	+4.9	
	423 Dec 24.5	18 10	-20.6	
	424 Jan 10.5	23 22	-26.7	
C/442 V1	442 Nov 1.5	11 04	+45.7	~ 3 months
	442 Nov 10.5	10 38	+47.6	
	442 Dec 13.5	05 53	+39.7	
	443 Jan 16.5	03 41	+05.8	

Table 9. Date, approx. positions of the comets (coordinates in J2000) and period of visibility.

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HIGHLIGHTS

- The calculation of sets of orbital elements for particular historical comets has been a field of study widely treated by numerous authors.
- The discovery or improvement in the translations of historical sources can lead to propose orbits for some comets or improve existing ones
- We focus on historical observations from Eastern and European countries in the late 4th and 5th centuries to suggest new determinations of orbital elements for some of these comets, or, where appropriate, to discuss or improve existing ones.
- We will also carry out a study of comets of the 5th century that have been suggested as the parent comets of the Kreutz system of sungrazer comets.