

DO WE NEED TO REDATE THE BIRTH OF THE CRAB NEBULA?

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Abstract The most famous example of the use of ancient astronomical documents for solving important astrophysical problems is that of the explosion of the Supernova of 1054 and the associated birth of the Crab Nebula and PSR0531+21 in Taurus. Until now all informations about this event come from Chinese and Japanese documents and were used to determine the physical characteristics of the explosion. It has always been thought that there was no mention of the event in any European source. We have now found a definite mention of the explosion of the Supernova of 1054 in a Flemish chronicle and a more uncertain reference in a Roman chronicle of the time. An analysis of the documents sheds new light on the explosion which appears to have taken place a few months before the time reported in the oriental documents.

1. Introduction

The references in the oriental chronicles to the "guest star" of 1054 (Ho Peng Yoke, 1962; Clark and Stephenson, 1977, and their bibliography) have been until now the only historical evidence for a Type II galactic supernova, but for a possible connection between SN185 and PSR1509-58 (Thorsett, 1992). After SN1054, no supernova of this type visible from Earth has exploded in our Galaxy. Unfortunately, the references to the SN1054 event are few and until now only four Chinese and one Japanese independent sources have been considered. It has always been thought that there was no mention of the event in any Western source, but for a reference in an Arabic document (Brecher, Lieber and Lieber, 1978).

The greater part of the information of astrophysical interest was found in the Chinese sources. These records made possible to link the event with the explosion of the precursor of the Crab Nebula and pulsar. If we look at the translations provided by Clark and Stephenson (1977) and Wang (1987) of the five primary eastern sources, we will see that the data of greatest astrophysical interest (position -near to ζ Tauri-, date of first appearance -4th July 1054-, date of disappearance -17th April 1056-) come from two passages in the official history of the Sung dynasty, the *Sung-shih* (*Treatise on Astronomy*, Ch. 56, and *Annals*, Ch 12) written some 200 years after the event. Another Chinese source, the *K'i-tan-kuo-chih*, the history of the Kingdom of Liao written about 1350, refers only briefly to the appearance of the "guest star", but states that it happened near the time of a total eclipse of the Sun. Duyvendak (1942) has shown that the only important eclipse of the period in question occurred on 10th May 1054. The fourth Chinese source is the *Sung-hui-yan*, compiled by Chang The-hsiang in the fourteenth century. It refers the official report of the director of the Astronomical Bureau of the Sung court, Yang Weide, giving the same date for appearance and disappearance as *Sung-shih* and also the length of visibility in daylight (23 days).

It is commonly assumed that the date of the explosion is that reported by *Sung-shi*, who give the most detailed description of the event. Nevertheless, this information has to be used with caution, since none of the chinese documents contain eye-witness accounts of the event and all show evidence of mistakes and alterations. In fact, as has been observed by Ho Peng Yoke et al. (1970), the position in the sky of the event reported by *Sung-shih* is incompatible with the actual position of the Crab Nebula. Furthermore a deeper reading of the *Sung-shi* "Annals" related to the years 1054-1057 shows that the announcement of the "guest star" is not reported in the day of the discover but only when the object became invisible, nearly two years later. An other reason to doubt of the official report is the political situation of the Sung court in 1054. The winter was characterized by a long period of cold weather: the "Annals" report that many people died because of this reason and that a public distribution of remedies was performed. Then, on

march 1054 the Emperess died "in a dramatic way" and during spring a pestilence spreaded in the Empire. We can thus assume that the Sung court was in a period of crisis, as it is pointed also by other historical records, and it is likely that the Astronomical Bureau director Yang Weide had to be very careful before to release the announcement of a "guest star", that was believed to bring bad luck, since an astrological interpretation of the phenomenon was dangerous from a political point of view. An example of a similar behaviour is reported in the case of the SN 1006 (Clark and Stephenson, 1977). Actually, the transit of a bright comet (that was believed to bring good luck and that is confirmed by many independent sources) is announced on September 1054, but the contemporary presence of the "guest star", thought very unusual and thus surely impressive, is not reported. Furthermore the 1054 "guest star" is not reported on the Chapter 58 of the *Sung-shi* ("*Astronomical Treatise*"), where the most impressive astronomical phenomena of the Sung dynasty are summarized. These facts suggest that a sort of "censorship" had been performed on the Supernova. The sentence of Yang Weide, reported on the *Sung-hui-yan* about the announcement of the appearance of the "guest star" on 4th July 1054, cannot be assumed as an evidence that the event occurred in that date. Actually, it is a ritual formula and it is probably just a dramatization in direct speech of the same information reported in the *Sung-Shi*.

All these facts point to the presence of a single chinese independent source: the Yang Weide's report to the court on 17th April 1057, when the supernova disappeared. However, it is easy to prove that this report has been manipulated because of political reasons: in fact it announces that the "guest star" of 1054 appeared South-East of "Tien Guan" (i.e. ζ Tauri), while the Crab is North-East of this star and no professional astronomer can mistake the North with the South.

The Japanese source, the *Meigetsuki*, the diary of the courtier Fujidara Sadaie (written in 1230), is scarcely useful to clarify the date of the event, since it gives us the date of 29th May 1054; but on that day the Crab was in conjunction with the Sun.

Finally the arabic document discovered by Brecher et al. (1978), a chronicle of the Middle East epidemic of 1054 written by the christian arabic scholar Ibn Butlan, first dates the appearance of the supernova in the year 446 of the Egira, then in the year 445 E. This apparent contradiction has been interpreted by Brecher et al. (1978) as a copyist's error. We will see later a better explanation.

Thus it is of the greatest importance that we analyze every historical source that can give any further information that might help to date the event and thus assist a greater understanding of the phenomenon.

2. The European chronicles

Contrary to the common assumption, we believe that the explosion of the Supernova of 1054 was noted in European medieval chronicles. We shall present and discuss the evidence of two contemporary writers which, though very different in style of presentation, are both of equal interest, not least for the history of western thought in early Latin middle ages.

The first text that we have discovered belongs to the *Tractatus de ecclesia S. Petri Aldeburgensi*, written by a monk or a clerk of the church of St. Peter in the town of Oudenburg (in present-day Belgium). The anonymous Flemish author is a first-hand witness of the event he describes and he provides a detailed report of a striking heavenly phenomenon happened in 1054. It also gives evidences of the connection made between this phenomenon and the death of Leo IX. This is the text in full:

And the most blessed Pope Leo, after the beginning of the construction of the aforementioned church of St. Peter, in the following year, on the 18th day before the first of May (i.e. 14th April 1054), a Monday, around midday, happily departed this world. And at the same hour as his leaving of the flesh, not only in Rome, where his body lies, but also all over the world there appeared to men a circle in the sky of extraordinary brightness which lasted for about half an hour. Perhaps the Lord wished to say that he [the Pope] was worthy to receive a crown in Heaven between those who love Him.

(*Qui beatissimus pontifex Leo post initium constructionis praefati templi sancti Petri sequenti anno 18 Kal. Maii, feria 2, circa meridiem feliciter migravit a seculo. Et in ipsa hora transitus sui a corpore non solum Romae, ubi corpus eius iacuit, verum etiam in toto orbe terrarum circulus ezimiae claritatis hominibus apparuit in coelo per spatium fere mediae horae, Domino fortasse demonstrante, quod ipse coronam inter diligentes se percipere dignus esset in caelo.* p.868)

The English translation introduce some risks of misunderstanding in the interpretation of the Latin text. First of all, one should notice that the terms *circulus* and *corona* have a meaning which is not exactly the same as "circle" and "crown": both English terms can suggest that the Flemish observer saw a bright ring in the sky. On the contrary, the Latin terms mean something different. Let us start with *corona*. In this context the author is clearly referring to the "aureole" that was attributed to the Blessed in Heaven. We must free our mind from the Renaissance images of the Blessed where the aureole was represented as a halo, i.e. as a bright ring surrounding their heads. As one can see from the medieval paintings, this image does not hold for the Middle Ages. Furthermore, Honorius of Autun, writing in the XIIth century, describes how these aureoles were depicted at his time: they seemed like "round shields" since their function was thought to be that of divine protection. The other term (*circulus*), similarly to its English counterpart ("circle"), can mean both the circumference of a circular plane figure and its area. The fact that *corona* was conceived as a bright disk (or shield) makes us understand that also *circulus* in this context must mean the same object. In conclusion, the Flemish chronicler saw a bright disk in the sky, and not a halo. Furthermore, we can observe that in this document, the author describes the phenomenon in neutral terms, unaffected by any set of beliefs: the disk-like shape, the intense brightness and the duration of the phenomenon are all elements common to very different cultures. The author separates the description of the phenomenon from his cautious (*fortasse*) symbolic interpretation, showing a clear awareness of the different levels of discourse. The second text does not refer *explicitly* to any unusual celestial phenomenon. It describes the death of Pope Leo IX, on 19th April 1054, and the miracles that occurred at that time and afterwards. The writer is a certain Libuinus who describes himself as a subdeacon and servant of the late Pope (*De obitu* p.177). The aim of the document was to demonstrate the sanctity of Leo IX with a view, perhaps, to the process of sanctification that did indeed take place subsequently. It is in this context that Libuinus refers, with the vagueness typical of so many other contemporary chronicles, to the evidence of some men who had seen something unusual :

Now I shall tell of the wonderful things that it has pleased God to perform: at the hour when the Prelate gave up his soul to Christ, the bell of the church of St. Peter began to sound, though none of those present had touched it. A man named Albert and five other people from Todi say that, at the same time, they saw something that looked like a road decorated with wonderful adornments and shining with innumerable lamps, along which his soul was led to heaven by angels.

(Mira dicturus sum, quae Dominus in suis factis dignatus est: hora qua ezimius Praesul suam animam Christo commendavit, nullo ministrorum pulsante, a se ipsa Sancti Petri campana sonare coepit. Qua scilicet hora quidam, Albertus nomine, ceteri quinque de Tudertina urbe protestati sunt, vidisse se quasi stratam pallis fulgentibus adornatam et innumeris coruscantem lampadibus, qua anima eius ab angelis ducebatur ad coelum). (p. 178)

The subdeacon's text, semantically analysed, confirms the Flemish document, telling us that (1) someone saw something in the sky in Rome; (2) the essential character of what was seen was its brightness; (3) the description was given after the death of Leo IX (the six witnesses - perhaps pilgrims - mentioned by Libuinus could not, while they were watching the phenomenon, know that the Pope was dying); (4) since the Pope died during the day, it is reasonable to suppose that the phenomenon was visible in the daylight and (5) the phenomenon was interpreted by these people according to the religious imagination of the period. We can also see another example of this religious interpretation, again in references to Pope Leo IX, in the *Dialogues* of Abbot Desiderius of Montecassino.

3. Problems of datation

Some problems arise if we try to date the event precisely. A first discrepancy, contained in the two sources, concerns the day of the week. Both in Libuinus and in the Flemish text it is not possible to reconcile the date and the day of the week: Libuinus says that Leo IX died on a Wednesday, the anonymous Flemish writer indicates a Monday. Both are incorrect, since 19th April 1054, the actual date of the pope's death, was a Tuesday, and the 14th April (in the Flemish text) was a Thursday. If we accept a Monday 14th April as the exact indication of the day, then the phenomenon would have to date from the year 1057, i.e. definitely too late to be associated with the pope's death. The mistake in the Flemish source is perhaps to be attributed to the distance in time between the events described and the actual writing down of the text. Such chronological

inconsistencies are not unusual in the documents of this period. The discrepancy between the date of the death of Leo IX stated by Libuinus (19th April is confirmed by other sources) and the Flemish text (14th April) can be explained paleographically with the addition of a 'V' to the original date by some copyist or the first nineteenth-century editor of the *Tractatus de ecclesia S. Petri Aldenbrungensi* (Malou, 1840). This addition would transform the real date "XIII Kal. Maii" (the 13th day before the first of May, i.e. 19th April, according to the Roman way of dating) to the one we read in the *Tractatus*: "XVIII Kal. Maii" (14th April). This hypothesis cannot, however, be proved since the fourteenth-century manuscript, the source of the 1840 edition, has vanished. Thus we can only point out the error in the Flemish text, while sticking to the date independently attested by other contemporary sources (cf. *Liber Pontificalis*, II, p.275).

The exact date of the death of Leo IX, however is no proof that on precisely that day the heavenly phenomenon was visible. It is clear from both the texts that the link between this event and the death of Leo IX was made at a later date and it is likely that the memory of the witness only connected these two events "*a posteriori*". There is nevertheless a surprising detail in the Flemish description - the allusion to the hour of the death of Leo IX "*circa meridiem*". This detail is not mentioned in any other source and, more importantly, in none of the documents from the circles of the Roman Curia (*Liber Pontificalis* and Libuinus) which were very likely based on first-hand accounts of the pope's death. It is very unlikely that such a minute detail could be found out by a person who was probably very distant from Rome, when the Pope died and who was writing his history more than thirty years later. It is our belief that, when the anonymous Flemish chronicler was writing, the superimposition of the two events had already taken place. He merely transferred from one to the other the circumstances that had made the appearance of the bright disk noteworthy - that is, that it had been seen in broad daylight - "*circa meridiem*". Another piece of information of great interest in the Flemish text is the indication of the duration of the visibility of the shining circle - about half an hour (*per spatium fere mediae hora*).

4. Was the European 1054 heavenly phenomenon the Chinese 1054 "guest star"?

A possible explanation of the phenomenon described in the two aforementioned texts is an atmospheric effect, as a solar halo, or an auroral phenomenon though their descriptions in medieval chronicles are completely different. On the other hand, the fact that the event was visible at the same time in Rome and in Oudenburg put a lower limit on its distance from the Earth surface of 300 Km, ruling out the atmospheric effects. Auroral phenomena are marginally possible at this height, but the probability of such a phenomenon visible in broad daylight at Rome latitude is extremely low (Gregori, private communication). Thus, we can assume that the heavenly phenomenon reported in European chronicles was an astronomical one.

Despite of the disagreement of the day, it is thus reasonable to connect the texts we found to the 1054 "guest star", reported in the Eastern chronicles on 4th July 1054 AD. In fact, the proximity of the April 19, 1054 AD to the date of the conjunction of the Crab with the Sun (May 29) should have made the Supernova very difficult to see before beginning of July. On the other hand, the first luminosity peak, when the shock front reached the precursor atmosphere boundary, must have been bright enough to be easily visible in daytime. In order to check the faithfulness of the European sources and to explain the contradictory dates, we have calculated the position of the Crab Nebula in the sky at the different dates and in the different geographical sites referred to in the sources, with the help of the "Planetario" positional astronomy computer code developed by P. Massimino (1990). We found that, in middle April 1054 at noon, the Crab was 40 deg from the horizon and 80 deg from the meridian. Thus it was in a perfectly visible position apart from the light of the Sun. If the Supernova of 1054 was so bright as to outshine the diffused light of the Sun (that is, if it reached a visual magnitude less than -4, using the formula given by Shaefer, 1991), it is perfectly possible that the event was seen in a way similar to that described by the European chroniclers. In Oudenburg (50° 37' N, 3° 24' W), the situation was quite similar, but for the lower distance from the horizon, of about 33 deg. It is interesting to notice that the northern chronicle, written where, in our hypothesis, the event was lower on the horizon (and thus more adsorbed), describes it as a bright disk, while the Roman witness, whose atmospheric extinction was lower, gives a description of a much more luminous phenomenon. The situation changed little in the following weeks but, from the beginning of May, the position of the object moves so much towards the Sun that it could not have been seen unless its brightness was very much greater than currently envisaged by the supernova theory. In the last week of June, the object begins to move away from the Sun and once again becomes visible, assuming a magnitude compatible with that observed in supernovae.

From a deeper analysis of the arabic document discovered by Brecher et al. (1978), we have suggested that the Supernova of 1054 exploded probably on 12th April 1054 (Guidoboni et al., 1992). In fact the apparent contradiction between the two dates reported by Ibn Butlan is easily explained considering that the beginning of the year 446 E was noon of 12th April 1054. Furthermore, this day was a Monday: the Flemish author, writing many years after the event, should have forgotten the exact date but, being a monk, must have remembered the exact day of the week, since its life was scheduled on the base of a weekly time-table.

The difference in date from the Chinese chronicles can be explained if we remember that the "guest stars" were only considered by the Chinese astronomy in relation to the constellation in which they appeared, which determined their astrological significance. Thus it is possible that the date given in *Sung-shih* and *Sung-hui-yan* was the first date when it was possible to determine such a position, since it roughly coincides with the date of the chinese constellation (within which the position of the Crab Nebula lies) once again became clearly visible at night after its conjunction with the Sun. An alternative explanation is the manipulation of the data, since we have seen that all the Chinese documents shows signs of corrections that were probably made in 1057 by the head of the Astronomical Bureau himself, in order to improve its political standing.

5. Conclusion

Thus we can summarize our results as follows: the European chronicles show unequivocally that a bright object was seen in broad daylight in Rome and Oudenburg (Belgium) at least on middle of April 1054: this object was most probably the 1054 Supernova, because of the detailed description of the Flemish text, its reference to the fact that the object was visible "all over the world" and the lack of alternative explanations of the whole set of historical and physical data on the event.

If this reconstruction of events is correct, we must re-examine the classification of the Supernova of 1054. Given the brief period of intense brilliance, it has been hitherto classified as a "Type II Linear". If the date of the explosion should be put back by about three months, then the Supernova of 1054 ought to be seen as a "Type II Plateau" and the Crab Nebula and pulsar should be seen as an evolution of this type of object. The documents that we have discovered have, furthermore, an intrinsic importance for the history of scientific thought. They show how unwise it is to attribute the lack of information in European sources about astronomical phenomena of this type to the influence of Aristotle, still negligible in the culture of early Latin middle ages. In fact, although the occasional Latin translation of Arab astronomical texts was made, one can only talk of a real Aristotelian and Ptolemaic influence on the knowledge of medieval astronomy from the twelfth century. On addition, these documents make it possible to formulate new theories about medieval accounts of celestial phenomena, showing how what was not understood at the time lies concealed beneath the symbolic and religious interpretation of the day.

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