The 1054 Supernova as GRB: a binary-driven hypernova solution

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Abstract: The supernova of 1054 has been among the first galactic supernovae, whose remnant –the nebula included in the Messier Catalogue as M1- and observations –Chinese and European- have been correlated. The long visibility in daytime (23-30 days at least), and, mainly, its discovery as a noon fireball in Europe (11 april, 1054 in Belgium and Constantinoples) supports the observation of a very intense Gamma-Ray burst in optical band, producing air showers appearing as sparkling and changing rays around the bright source. The energetics of that phenomenon is reconsidered under the perspective of a binary-driven hypernova in three stages: first a CO-core of a massive star has a secondary neutron star orbiting at thousands Schwarzschild radii, second the CO-core star undergoes a supernova explosion, forming the pulsar and ejecting material, third the ejecta of the supernova crossing the neutron star fastly orbiting accreting onto it to a black hole, with the GeV emission from its diadosphere, the GRB itself.

Introduction: Supernova of 1054 historical data

The SN 1054 has been identified as the progenitor of the Crab Nebula (Messier 1 nebula) and as a supernova since the first correlations between the nebula and the 1054 event, proposed already by Hubble (1928).[1] Since then many prominent scholars have discussed the historical documents available either in Eastern Countries or in Europe.

We will focus first on European documents and secondarily on the Chinese and Japanese ones, widely known and acknowledged.

1. **Coins and accounts from Constantinoples**

A Numismatic thesis was based on the rarity of a coin of Constantine IX Monomachus (1042 June 11-1055 January 11) where it could have been represented the Supernova.[2]

[1] Virginia Trimble described in her PhD Thesis (1968) https://thesis.library.caltech.edu/1562/1/Trimble_vl_1968.pdf p. 33-37 an exhaustive historical background of the interpretation and progresses on the measures of the Crab from 1900 on.

[2] https://www.coinarchives.com/a/lotviewer.php?LotID=2365460&AucID=5803&Lot=24190&Val=4beeec12d35fd70d5b7b508cdfd84028 shows an exemplar with two stars on either shoulders of the emperor and one on his breastplate.

Fig. 1 Coin of Constantine IX Monomachus, with two stars on the shoulders and one in the breastplate.

Besides the *damnatio memoriae*, an hypothesis used to explain the rarity of that coin, which –if related with the Supernova- could have been minted only in half year over 14 of reign, and so it is expected to be found as 1/28 of the total, as it is. The presence of stars around the Emperor occurs also in other occasions as Alexius I Comnenus (1088-1118), and it is not related with astronomical events.[3]

Coin of Alexius Comnenus I (1088-1118), also with two stars on the shoulders.

The use of stars and crescents was frequent in antiquity,[4] and the tradition appeared in Byzanthium since three centuries before Christ. [5] So the presence of stars in the rare *histamenon*[6] (coin) of Constantine IX is not decisive, as already B. E. Schaefer (1995) pointed out.[7]

2. 11 april 1054, Diary of Ibn Butlān

The star appeared on 11 april 1054 (end of Hegira year 445) until april 1055.[8] He was from Baghdad, but at the time he was in Constantinoples. A plague in Egypt and Constantinoples was occurring at the same time.

3. 20 may 1054 The Rampona Chronicle (1425, from the Corpus Chronicorum Bononiensium)

Anno Christi ML8 Henricus tertius imperavit annis XL9. Hic primo venit Romam in mense maii. Cuius tempore fames et mortalitas fuit fere in universa terra. Et obscedit civitatem Tiburtinam diebus 3 mense iunii.[…] Tempore huius stella clarissima in circuitu prime lune ingress est, 13 Kalendas[Iunii] in nocte initio.

[3] Valerio Cerrone, expert of numismatic, private communication, 2024.

[4] https://www.coinbooks.org/v20/esylum_v20n40a29.html

[5] M. Markovitz, https://coinweek.com/star-crescent-ancient-coins/ 2017.

[6] https://en.wikipedia.org/wiki/Histamenon

[7] B. E. Schaefer, QJRAS, **36**, 377 (1995) https://articles.adsabs.harvard.edu/pdf/1995QJRAS..36..377S

[8] According to the Guidoboni's interpretation, Le Scienze, **292**, 24 (1992).

4. 11 april 1054, from Historia S. Petri Ecclesiae (Oudembourgh, Belgium)

Another western source for SN 1054, deeply delved by many scholars,[9] is the Tractatus de Ecclesia S. Petri Aldenburgensi,[10] in which is written *"…on the 18th day before the first of May, a Monday, around midday […] all over the World there appeared to men a circle in the sky of extraordinary brightness which lasted about half an hour.[11]"* The day was 11 april 1054, the very day and hour of death of the blessed pope Leo IX, the conclusion of this text is *Perhaps the Lord wished to say that he* [the Pope] *was worthy to received a crown in Heaven between those who love Him."*

Besides the obvious criticism about a typical agiographic language, in which the sphere of light is associated to the soul ascending into heaven of a saint at the moment of his death,[12] the description of the appearance at noon of a bright sphere of about 30 minutes may be considered astrophysically relevant.

5. 19 april 1054 from De Obitu Leonis

Elsewhere the death's date of pope Leo IX is 19 april, as the day in which he is celebrated as saint.[13]

The sphere of light appeared is described with rays sparkling from it, and the account was made by Libuinus' *De Obitu Leonis* "as along a path strewn with shining garments and lit by innumerable brilliant lamps".[14]

6. Chinese sources for 1054 Supernova

They are the most quoted, studied and discussed about all medieval and historical supernovae, and we refer to the account of Collins et al. (1999) which present widely the texts and their context, literary and historical. Chinese astronomers' duty was to observe and record carefully ordinary and extraordinary celestial events, and considering the corresponding omens. The explosion of the supernova could have occurred weeks to months before the commonly accepted date of 4th July 1054, according to Sung-dinasty celestial accounts *Sung-hui-yao* (compiled before 1184 by Li Tao, so a century later). There are two other sources quoting its appearance during a total eclipse, and the only one was on 10 may 1054.

6.1 Sung-hui-yao texts

Always the *Sung-hui-yao* accounts for a 23 days of daytime visibility, that we consider brighter than -5 magnitude, with a total visibility (brighter than +5.5 magnitude) until April 17,[15] 1056 (after data from two other accounts *Sung-shih* and *Wen-shien t'ung-k'ao*, with 615±15 days or $5.3 \cdot 10^7$ s.

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[9] V. F. Polcaro and A. Martocchia, IAUS 230, 264 (2006). https://articles.adsabs.harvard.edu/pdf/2006IAUS..230..264P

[10] Oudenbourg, presently in Belgium.

[11] Complete excerpt translated into English in Polcaro and Martocchia (2006).

[12] https://catalogo.beniculturali.it/detail/HistoricOrArtisticProperty/1200758832 St. Benedict sees the soul of St. Scholastica, his syster, going into heaven.

[13] https://www.treccani.it/enciclopedia/santo-leone-ix_(Enciclopedia-dei-Papi)/

[14] https://arxiv.org/pdf/astro-ph/9904285.pdf in Collins, et al. (1999), page 3. Libuinus describes in this way the soul of Leo being taken by angels up to heaven, and it is quoted by Watterich, J .M. 1862, Pontificum Romanorum qui fuerunt inde ab exeunte saeculo IX usque in finem XIII vitae, (Leipzig) 95, 176.

[15] 17 april in Collins et al. (1999) and in Polcaro and Martocchia (2005), 6 april in Stephenson and Green (2003) and in Murdin and Murdin (1985).

From the Sung-hui-yao [Essentials of the Sung dynasty history] (Chapter 52)

"On the 1st year of the Chih-ho reign period, 7th month, 22nd day [August 27, 1054] ... Yang Wei-te said 'I humbly observe that a guest star has appeared. ***Above the star in question there is a faint glow, yellow in colour****. If one carefully examines the prognostications concerning the emperor, the interpretation is as follows: The fact that the guest star does not trespass against Pi and its brightness is full means that there is a person of great worth. I beg that this be handed over to the Bureau of Historiography'. All the Officials presented there congratulations and the Emperor ordered that it be sent to the Bureau of Historiography.*

"During the 3rd month of the 1st year of the Chia-yu reign period the Director of the Astronomical Bureau said, 'The guest star has vanished, which is an omen of the departure of the guest'. Earlier, during the 5th month in the 1st year of the Chih-ho reign period, the guest star appeared in the morning in the east guarding Tian-kuan. ***It was visible in the daytime, like Venus. It had pointed rays in the four directions and its colour was reddish-white. Altogether it was visible in daytime for 23 days****."*[16]

6.2 July 4, 1054 Sung-shih texts

From the Sung-shih [Annals, of the Sung Dynasty] (Astronomical Treatise, chapter 56).

"On the 1st year of the Chi-ho reign period, 5th month, chi-chou (day) [July 4, 1054], a guest star appeared approximately several inches to the south-east of Tian-kuan [Aldebaran]. After a year and more it gradually vanished."

From the Sung-shih (Chapter 9).

"On the first year of the Chia-wu reign period, 3rd month, xin-wei (day). The Director of the Astronomical Bureau reported that since the 5th month of the 1st year of the Chih-ho reign period, ***a guest star had appeared in the morning at the east, guarding Tian-kuan, and now [two years after its first appearance] it has vanished****".*

6.3 10 may 1054 (total solar eclipse) Ch'I-tan-kuo chih text (written in XIII century)

During the first year of the Chih-ho reign-period [1054] there was a solar eclipse at midday and a guest star appeared within the Mao [lunar mansion, the Pleiades]

6.4 10 may 1054 (total solar eclipse) Sung-shih hsin-pien text (prepared by K'o Wei-ch'I in XV century)

During the eight month [of the 23rd year of the Chung-his reign period, 1055] the King passed away… Previously there was a solar eclipse at midday and a guest star appeared within the Mao [lunar mansion, the Pleiades]. The Assistant Officer in the Bureau of Historiography, Liu I-shou, said "Isn't this an omen that [the King of Ch'I-tan] Hsin-tsung will die?" The prediction did come true. The same passage is give in Liao-shih-i.

7. 20-29 may 1054 Japanese source: Mei Getsuki

After the 2nd third of the 4th month, the second year in the Ten Ki period of Japan at the time of Chuou, a guest star appeared three times at the Hsiu Tsui (Turtle). It was seen in the east, with Ten Kwan Hsing, as big as Jupiter[17]*.*

[16] From the Sung-hui-yao [Essentials of the Sung dynasty history] (Chapter 52), reported in https://jila.colorado.edu/~ajsh/courses/astr2030_12/sn/sung.html

[17] Translation by Xi and Bo (1966) NASA TT F 388

In the middle of the ten-day period of the fourth Moon of the second year in the Ten-ki period, [between May 20-30, 1054] and in the following days, a guest-star was observed in the orbit of Orion. It was seen in the Eatern horizon. Its radiation resembled a comet with short rays in T'ieng-K'uang and it was about the size of Jupiter. [18]

8. **In the 446 after Hegira year: Arabic source (Ibn Butlān, Baghdad, then in Constantinoples)**

One of the well-known epidemics of our time is that which occurred when the spectacular star appeared in Gemini in the year 446 after the Hegira (from April 12, 1054 to April 1, 1055).[19]

9. **Irish Rosa Ela tower of fire; 24 april 1054**

A round tower of fire at Ros Ela [visible] for five hours of the day [feast of St. George, 24 april 1054][20],[21]

Comments on the accuracy of the dates and of the observations

Either the Chinese sources and the European ones have statements which appear in contradiction each other, if they are taken exactly as written, with their dates.

Not all the sources have the same accountability, and they are text written in the present form more than a century after the events.

Following the approach of Shklovsky (1968)[22], the Japanese observations in may would have been in the rising phase of the Surpernova, before its brightness maximum, while the Chinese ones (of the 4th July) are after the peak, and the solar conjunction (may 27) during which no observations were possible, at 7° from the Sun itself.

The accountability of the Chinese astronomers was not doubted, nor the Japanese accounts, related in Kyoto, the medieval capital of Japan, but the accuracy of the dates was discussed by many scholars, admitting shifts of a whole month or more. His propositional calendar was Japanese observations end of June 1054, in the pre-maximum phase (like Jupiter and closer to the Sun in the eastern horizon, at dawn), and Chinese at the maximum (July 4th 1054), until April 17, 1056, 21 months later, when it disappeared to the naked eye.

Shklovsky did not report any European sources, but how the European sources could be relevant?

The Rampona chronicle[23] seems to refer to the 20 may, with a short visibility at dusk on the western sky, where the astronomers expected to see the new Moon. The Obitus Leonis presents the cohincidence between the brilliant orb in the sky and the very hour (noon) of the death of Leo IX. The Belgian (Alderburgensis) chronicle also refers about midday, in the date of the death of Leo IX, computed wrongly at 11 april, instead of 19 april.

If the maximum brightness occurred around midday, in April, the following days also in Eastern countries the star should have been spotted.

[18] Text reported by Shlovsky, Supernovae, London 1968, p. 52.

[19] From P. and L. Murden, Supernovae, Cambridge (1985) p. 8.

[20] Filipovic, et al. EJST **19** 149 (2021)

[21] R. F. Stephenson and D. A. Green, JAHH, **6**, 46-52 (2003).

[22] Supernovae, Wiley & Sons, London (1968), p.49-57.

[23] Gathered in Bononia, Italy, by Ludovico Antonio Muratori in XV century, upon manuscripts then existant.

So it is possible that the event has been seen firstly very luminous in daytime, but not in April, more reliably near the solar conjunction, occurring on May 27.

Before May 27 the Supernova could have been seen after sunset, after that date before sunrise.

There is another piece of the puzzle that does not fit with this picture: the visibility during the total solar eclipse of May 10, 1054. This date is the only one computable with celestial mechanics.

To be visible in the total eclipse, and noticed as new star, and not as a planet, an object should have at least apparent magnitude 0 or -1. The recognition has to be realized during a short period of time: 2 minutes typically.

The new object was located near the Pleiades, which are difficultly visible during a total solar eclipse, because it is a group of 3-4 magnitudes stars, at the limit of visibility in our polluted night skyes... If this account is true, the new star was already visible in the evening sky since May 10, as luminous as Vega.

Reliably the eclipse preceeded the Supernova, but at the redaction of the document such difference was eliminated, because of the same "sign" of the omens by the two events.

Moreover there are some discrepancies between the observation's positions of the new star: the Rampona chronicle posed it near the position of the New Moon for the epoch (correct if 20 may). The Chinese chronicles posed the star South East of Aldebaran, while the Crab is North East of it, or near the Pleiades, which are farther than Orion with respect to M1 SN remnant.

The Arabic source is also fairly accurate, because the author was a physician and also astrologer. He wanted to show the correlation between the spectacular star and the following plague, occurred either in Constantinoples (14000 deads) and in Egypt at the time *of midsummer when the Nile was low.*

As this spectacular star appeared in the sign of Gemini, which is the ascendant of Egypt, it caused the epidemic to break out in Old Cairo when the Nile was low, at the time of its appearance. Thus Ptolemy's prediction became true: Woe to the people of Egypt when one the comets appears threateningly in Gemini. Then when Saturn descended into the sign of Cancer, the destruction of Iraq, Mosul and Jazira was complete. […] And this confirmed the wisdom of Ptolemy in saying: when Saturn and Mars[24] *are in conjunction in the sign of Cancer, the world will be shaken.*

From the astrological mentions of Ibn Butlān we can verify the duration of the plague also from the positions of Saturn and Mars, while the star appeared in the sign of Gemini (which is the Taurus constellation because of the precession) at midsummer, when the Nile was low. With the offset Julian calendar ongoing, the real midsummer was about July 31st, instead of the 5th August. In any case after the summer solstice, occurring in Cancer on 15 June at that time. The Ibn Butlān datum seems to be more consistent with the Chinese observations of the 4th of July.

In the translation of Brecher at al. (Nature 273, 728-730,1978) reported in Stephenson and Green (2003),[25] this Arabic source is the only one trustable, beyond the Chinese ones and it is as following

One of the well-known epidemics of our time is that which occurred when the spectacular (athari) star (kawkab) appeared in Gemini in the year AH 446 (AD 1054 April 12- 1055 April 1). In the autumn of that year 14000 people were buried … in Constantinople… As this spectacular star appeared in the sign of Gemini which is the ascendant of

[24] That conjunction Saturn-Mars occurred on Jan 17, 1054 near 27 Psc (too far from Cancer sign even taking account of the precession). Saturn entered the Cancer sign in 1060, the plagues continued until the year 454 H (1062). Probably the conjunction mentioned by Ibn Butlān is the one of 23 February 1060, after a big appulse on October 6, 1059.

[25] Journal of Astronomical History and Heritage, **6**, 46-52 (2003)

Egypt, it caused the epidemic to break out in Fustat (old Cairo) when the Nile was low, at the time of its appearance in the year AH445 (AD 1053 April 23 – 1054 April 11).

The mention of both AH 445 and 446, probably is the reason why Guidoboni et al. taken 11 April 1054 as reference date. This early datation agreed with the other European sources, but imposed to explain why the Chinese postponed the announce of the discovery. Polcaro and Martocchia (2005) postulated a censorship due to the bad omen that the star and the eclipse would imply for the Emperor Renzong, who could have ordered himself the change of the dates to the astronomical bureau. Nevertheless Stephenson and Green (2003) are rather clear to say that none of the European accounts (besides the Arabic one) are viable, and the new star probably escaped notice in Europe because at the time astronomical knowledge was generally very limited. Moreover adjusting presumed dating errors, it has to be done with full care, in order to avoid playing some sort of "identification game". Some of the modern authors were anxious to demonstrate European priority in the observations of the Supernova.

Concluding these remark, the Chinese were indeed more acquainted with the sky aspect than European, and their observations were routinary. The legend of Hsi (Hi) and Ho, the first "royal" astronomers of China, beheaded after missing a prediction of a solar eclipse, means that the Astronomical bureau was a very serious task in the history of China, so it is complicate to explain 2 months, from April 11 to July 4, without any observation of the Supernova, unless the phenomenon was more complex than a Supernova...

If we put together all the chronicles, unlocking their accounted dates, we could obtain this picture Table A)

April, 11 1054	May 10, 1054	May 20, 1054	June 2, 1054 @ 11 UT	June 19-29, 1054	July 4, 1054	Midsummer 1054	April 6 or 17, 1056
Spectacular star in Gem	Mag. 0 (first appear)	Mag. -1 after sunset	Mag. -12 30 min. GRB air shower?	Mag. -2 pre-max	Mag. -5+23d daytime	Spectacular star in Gemini	Mag. 5
446 Hegira year starts	Solar Eclipse, China	Italy Rampona Chronicle	Europe, South-noon	Japanese East	China East dawn	Constan-tinoples	China twilight

The picture of table A) implies to change the European dates, referred to Pope Leo IX, when the phenomenon was observed at noon time.

The approach is according the one of Shklovsky, to fit a Supernova light curve. Here the picture B):

April 11 or 19, 1054 @ 11 UT	May 10, 1054	May 20, 1054	June 2, 1054	June 19-29, 1054	July 4, 1054	Mid Summer	April 6 or 17, 1056
Mag. -12 (30 min only) (GRB, air shower?)	Mag. 0 (SN pre max1)	Mag. -1 after sunset	Solar conjunction	Mag. -2 SN pre-max	Mag. -5.5 SN max+23d daytime	Specta-cular star in Gemini	Mag.+ 5 limiting visibility
Europe, South- noon	Solar Eclipse, China	Italy Rampona Chronicle	invisible	Japanese East	China East dawn	Constan-tinoples	China, evening

Two interpretations of the account of Ibn Butlām are on the reference to the end of 445 after Hegira (April 11, 1054).[26] Being all secondary sources, moreover based on the report of Ibn Butlām account made by Abi Usaybia medical textbook *Uyun al-Anba fi tabaqat al-Atibba* in 1242, our position cannot be sharp on the date of the explosion.

The 11 april is present in the Aldenburgensis chronicle, and there are about 7 weeks from the first "prompt" to the SN maximum.

Another mention is the Irish one on April 24, provided that ordinary events like parhelia or pillars are excluded by such chronicles, the shift to the beginning of July is possible, because Ros Ela is a point Eastward of the abbey. Stephenson and Green do not consider this one a meaningful observation. Moreover a parhelion or a solar magnetic storm (rather normal) hypothesis would rule out the GRB (exceptional) .

The precision of the Chinese

Beyond the problems coming from censorship, or compilation many centuries after the event, the accuracy of the Chinese accounts is remarkable.

The position of the star is "some inches" South East of zeta Tauri, as it is the SN remnant now M1 or Crab nebula. None of the European sources mention other star as a reference, but only the vicinity of the Moon or the position of the new Moon (*in circuitu prime lune*) for the 20 may 1054 of Cronaca Rampona the Moon age was 10 days, so on the other side of the sky.

The timing of Chinese accounts is not univocal, but the accepted dates of July 4 1054 to April 6 1056 are reliable, along with the 23 days of daytime visibility,[27] with the addition of (corrected) Japanese accounts of 19-29 June, 1054, in the pre-maximum phase.

Some European accounts are probably related to the same astronomical event, whose memory remained in some manuscripts, used later to compile the chronicles.

23 days of daytime visibility and 21 months of whole visibility

The visibility in daytime of a star has been discussed widely by B. E. Schaefer with many technical notes on the sky brightness, and reported in other successive studies on the SN 1054 subject. The experience of one of us (Sigismondi) in daytime observations of Venus has been obtained mainly at the Vatican Obelisk meridian line, knowing the time and the altitude of the meridian passage of Venus. The planet was visible only knowing where to see. That's why we consider -5.4 magnitude, twice as brighter than Venus, as clearly visible in daytime. 23 days of daytime visibility imply that the SN reached magnitudes indeed brighter than -5.4, and the value of apparent magnitude-7 at maximum is reliable. The end of visibility on April 6, or better on April 17, occurred in twilight conditions, then the limiting magnitude of 5.5 (in a crowded stellar field) can be moved to mag. 5.

[26] Guidoboni, et al: Le Scienze **292**, 24 (1992), while this position is accepted by Collins et al. (1999) is not mentioned in a wider study on the historical context happening in Constantinoples, made by Filipovic et al., European Journal of Science and Technology, **17**, 147-160, (2021).

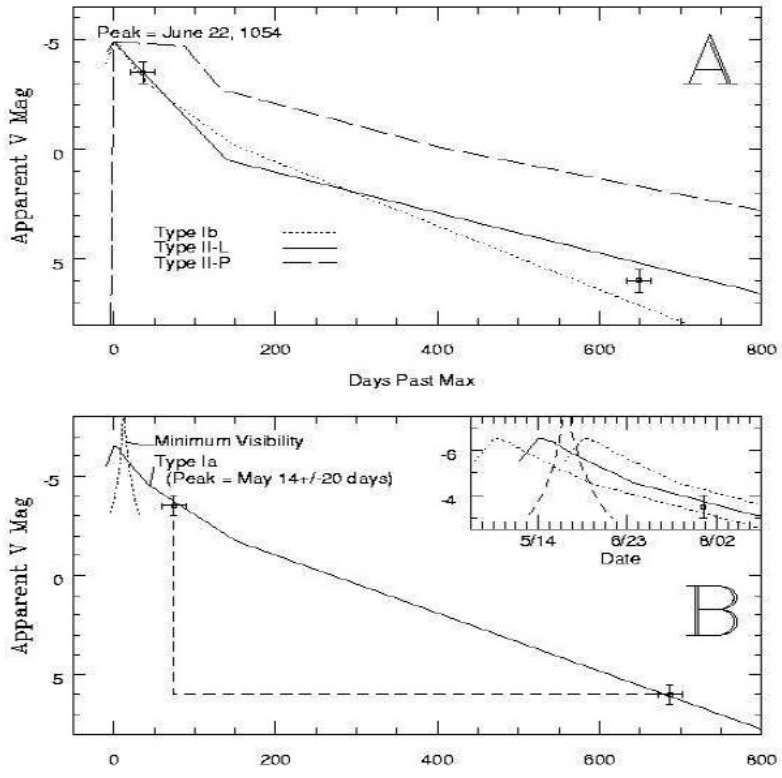
[27] Being the Sun's elongation increasing by 1° per day, the conditions of visibility of the Supernova increased during July and any dimming had to be intrinsic to the star (Stephenson and Green, 2003).

Fig. 3 The stellar field 14° wide, around M1, the Crab Nebula, with more than 30 stars as bright as magnitude +5.

The visibility of the star in nighttime is lost after two years, again not for all sources. Normally a star of +5.5 is at the limit of naked eye visibility. The “confusion limit” in a rich stellar field as this one can be also at a brighter level, if the closeness with zeta Tauri (+2.91) would have made the identification of the star more quick and certain.

Fit with supernovae lightcurves

Collins et al. (1999, fig.2) consider the either SN II-L (peak 22 June 1054) or SN Ia (peak May 14±20, 1054) for fitting the light curves and the 21 months of decay of 9 magnitudes.

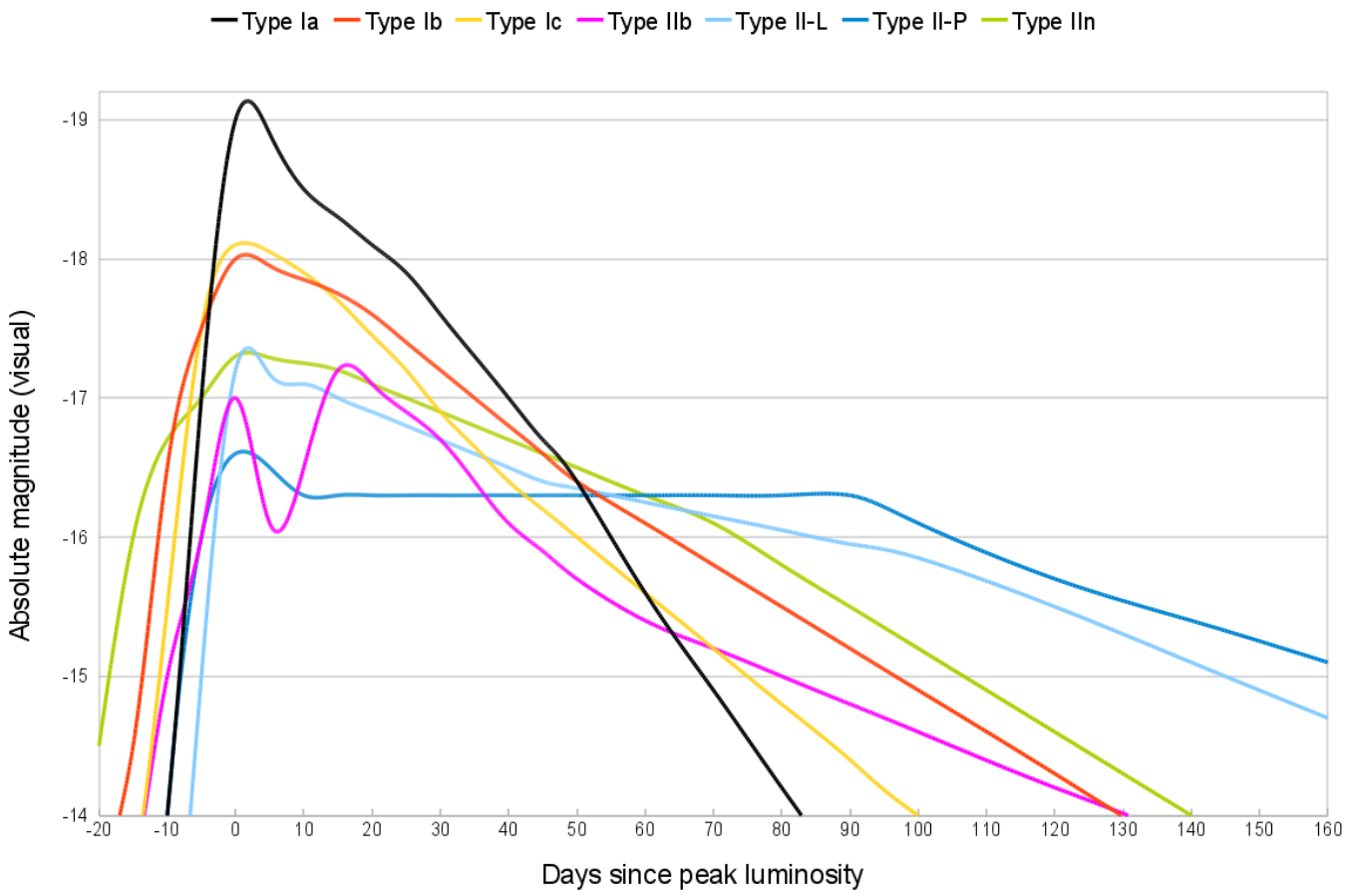


This approach extends the Shklovsky one (1968) which says that 23 days after the maximum the magnitude of the SN in NGC 1073 (Type I pec) the luminosity drops of 1.5 magnitudes, while after 650 days it drops of 11 magnitudes.

Shklovsky posed -3.5 the daytime visibility limit, and -5 the magnitude of the maximum, analogously posing to +6 the limiting visibility at night, again -5 is the maximum magnitude, 11 magnitudes brighter.

The limit for daytime visibility it is to rise at least of 1 magnitude, because Venus is difficult to be seen in daytime not knowing where it is exactly, obtaining a maximum luminosity of -6, which is compatible with a disappearance at mag. 5 after 650 days.

Not all the SNe light curves allow such fit.



This image shows light curves of the main supernova types, representative of peak brightness, rise times, and decay times. See Karttunen et al. for types Ia, Ib, II-L and II-P;[1] Modjaz et al. for types Ic and IIb;[2] and Nyholm et al. for type IIn.[3] (from Wikipedia, and links therein).

The thesis of Collins et al. (1999) of including European observations with their timings, was heavily criticized by Stephenson and Green (2003) and it seems ruled out now.[28]

[28] https://fr.wikipedia.org/wiki/SN_1054

Fit with a GRB lightcurve

The GRB 190114C lightcurve can be extended to 1000 years to get the Crab luminosities nowadays.

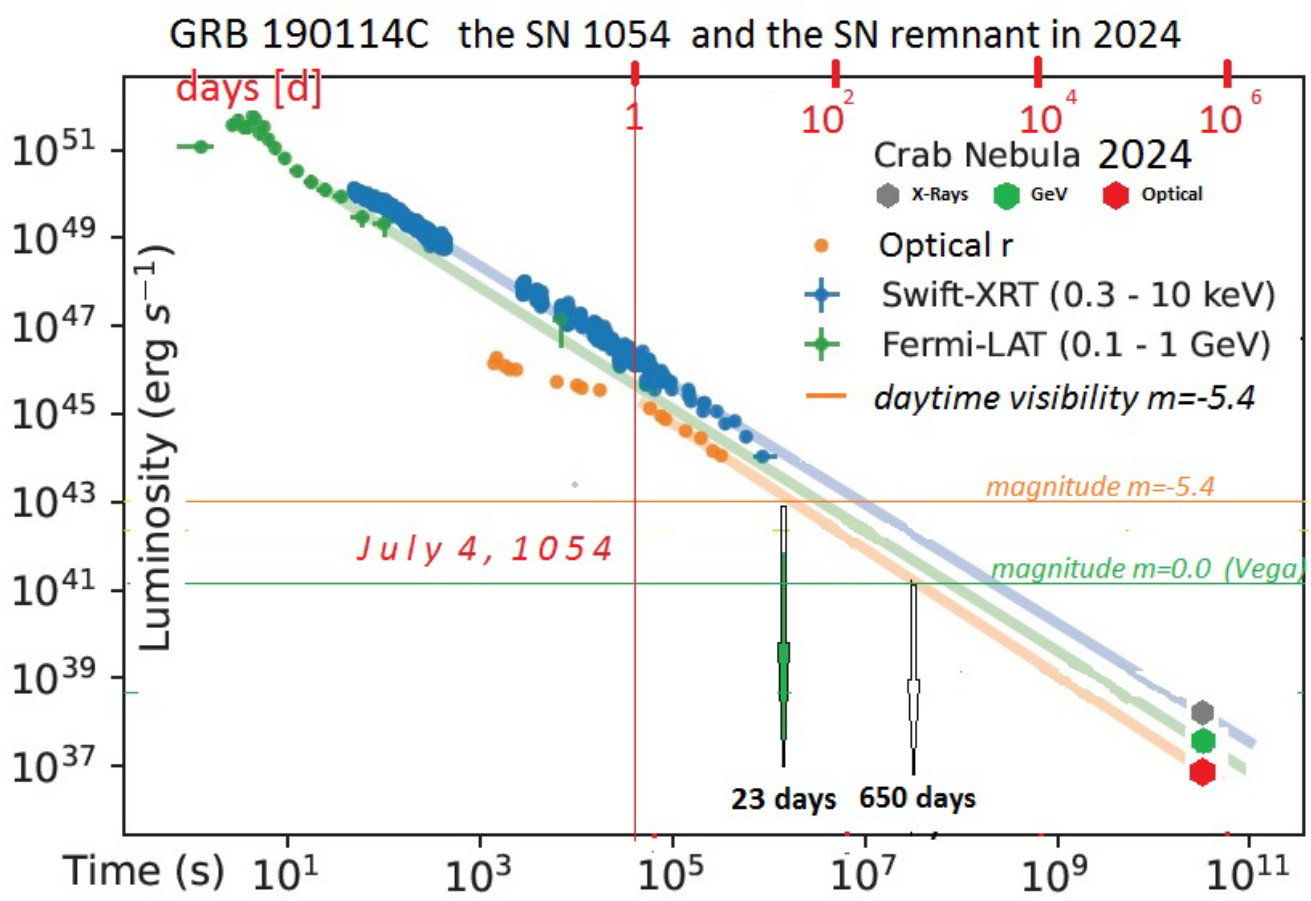


Fig. 4 The llight-curve of the GRB 190114C and its extrapolation toward the present value (red star) of the Crab Nebula. The apparent magnitudes are calculated if the GRB would have exploded at the distance of the Crab. Daytime visibility is better established by a magnitude -5.4, brighter than Venus, than -4, and it lasts 20 days, as the Chinese source reports (23 days in *Sung-hui-yao*)[29] . Nighttime visibility is considered down to magnitude +5.5 and it would requires 25 years to disappear, instead of 650 days (21 months).

Energetics of a GRB

The energy released by this GRB is $3{\cdot}10^{53}$ erg. The peak luminosity of the correlated SN 2019jrj was $6{\cdot}10^{42}$ erg/s.[30] The luminosity of the GRB started at about $4{\cdot}10^{51}$ erg/s.

What would have been the luminosity if this GRB was at 2 Kpc, at the distance of the Crab?

The Sun has a luminosity of $4{\cdot}10^{33}$ erg/s and its apparent magnitude is -26.4, its distance is 1AU. Its absolute magnitude is 4.8 at 10 pc. At a distance 200 times larger its magnitude would be dimmed by 2.5 $\log(200^2)$=11.5 mag, becoming a 16.3 mag star. The GRB with a luminosity of $4{\cdot}10^{51}$ erg/s is 10^{18} times the Sun, and it would shine at -28.3 mag. Each 10^2 factor in intensity is 5 magnitudes, then $4{\cdot}10^{41}$ erg/s is $10^{10}=(10^2)^5$ then 25 magnitudes less, then -3.3.

[29] https://jila.colorado.edu/~ajsh/courses/astr2030_12/sn/sung.html

[30] Lordana-Mitjans et al. ApJ **892**, 97 (2020)

10^{41} erg/s at 2 Kpc is -1.8 mag, slightly brighter than Sirius, this is the luminosity that the optical Supernova associated to the GRB 190114C would have after 650 days, or $5.6 \cdot 10^{7}$ s after the explosion, while 23 days after, or $2 \cdot 10^{6}$ s after, the luminosity would be 5 magnitudes brighter, then -6.8 as it was very reliably when Chinese astronomers observed it on July 4th 1054.

The luminosity after 650 days is too bright (like Sirius) with respect to the invisibility at dusk (mag. 5).

2 Kpc=2000*206265 AU=$4 \cdot 10^{8}$ AU. The intensity is inverse to the square of the distance, and the magnitude is 2.5 its logarithm, so $2.5 \cdot \log(10^{-16}/16)$=43 magnitudes dimmer than -26.4. But the absolute luminosity of $4 \cdot 10^{43}$ erg/s would be 10^{10} times the one of the Sun, then 25 magnitudes brighter, result: mag. -8.4, compatible with the first Chinese observations.

If we fit the Crab observations with that GRB, we have an optical flare at 10^{46}erg/s after 1000 s from the prompt GRB, which corresponds to a magnitude -13, the same of the full Moon, concentrated in a pointlike object, visible in daytime. The initial optical transient, not available for that GRB, has been even brighter, and it could have been appear as an orb, circle surrounded by sparkling rays, ***innumerable brilliant lamps***, probably due to the air shower occurred when high energy gamma rays hit the atmosphere. It lasted 1000 s, or 17 minutes, compatible with the half hour described in the European accounts defined "visions" by the authors criticizing them.

In any case the fit with the GRB 190114C for a two years visibility in the night would imply a final magnitude of zero, as bright as Vega, the most luminous star of the Northern hemisphere, or even Sirius, the brightest star, then this comparison does not apply in this case. The second possibility is to calculate when the optical power law reaches the apparent magnitude 5.5, and it is 25 years later, with evident disagreement with the Chinese sources.

Absolute luminosity of a GRB similar to the Crab SN event, and distance effect

The GRB 190114C had a supernova associated, with an energy of $(3.5 \pm 0.2) \cdot 10^{52}$erg. The luminosity of the GRB in optical wavelengths has been detected as large as 10^{46} erg/s after the trigger in Gamma-rays observed by the Fermi LAT Large Area Space Telescope in nearly real time.

The Crab Nebula is at 2 Kpc of distance and these values imply apparent luminosities as big as the full Moon, concentrated in a pointlike object. This tremendous luminosity would also be enforced by air shower's effect, given by the Gamma-rays impacting the atmosphere, with innumerable brilliant lamps.

The association of this phenomenon with the assumption of the soul of the pope is probably wrong in time, but not with respect to the observed phenomenon, of which the chroniqueurs or the final redactors gave their supernatural explanation.

When this phenomenon had to occur? July 4th 0 UT was like Venus and remained 23 days visible in daylight, then the explosion could have happened on July 3rdaround 11 UT on the European skies.

The association with the pope's soul was made after, even many years after.

Nowadays the optical luminosity would be still 10^{37}erg/s, or 10 magnitudes dimmer than (-1.8) Sirius, or mag. +8.2, approximately the integrated magnitude of the Crab Nebula (mag. 8.4).

This coincidence is remarkable, and may be a strong indication that a GRB originated the Crab Nebula and its pulsar, and a rogue black hole, which was the responsible of the GeV emission .