Review article

The Supernova in Galileo's Starry Sky and Its Impact on Astronomy

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Abstract

In 1604, the last of the supernovae seen with the naked eye in the Milky Way had a great impact on the history of astronomy and cosmology. Scientists with different conceptions of the Universe - among them Galilei and Kepler but also Arab and Chinese astronomers - competed and collaborated to explain its nature, its origin and its astrological meaning. Even today, we still observe what remains of that supernova, and we learn about stellar astrophysics.

Keywords: Compact objects; Supernovae; High-energy astrophysics; History of astronomy.

Introduction

On the evening of October 9, 1604, a conjunction between Mars, Jupiter and Saturn was expected in front of the constellation Sagittarius. Many eyes pointed to the sky (the astronomical telescope would be invented five years later), partly because astrologers predicted that this rare conjunction would bring great events. A conjunction between Jupiter, Saturn, and Mars in a "fire sign" (Aries, Leo or Sagittarius) occurs approximately every eight hundred years. Previous conjunctions were related, according to Kepler [1], to the creation of the world (4000 B.C.), to the book of Enoch (3200 B.C.), to the universal flood (2400 B.C.), to the tablets of the Law (1600 B.C.), to the word of Isaiah (800 B.C.),

to the birth of Christ (at the turn of the year zero), and to the coronation of Charlemagne (800 A.D.).

The great event of 1604 was astronomical: a very bright star appeared out of nowhere between the conjoined planets. The first reports came from an anonymous doctor from Cosenza, who wrote about it to the *Collegio Romano* (the Jesuit University of Rome), and from Friar Ilario Altobelli, a mathematics teacher in Verona, who wrote in a letter dated November 3th Galileo Galilei, a professor in Padua and at the time along with Kepler the world's foremost authority on astronomy: “more beautiful than ever, born in the conjunction of Jupiter and of the hottest Mars, on October 9th, and not before, because on October 8th, while observing the conjunction of Jupiter and Mars [...] for a long time, concentrated with a companion on that part of the sky, no other star was seen, neither near nor far, apart from those.” It was called *stella nova* (new star) [2,3].

Today, it is known that the new star was a supernova (a term coined by astronomers Baade and Zwicky in 1934), the last of seven observed with the naked eye in the Milky Way for which records exist. Previous ones had been recorded in 185, 393, 1006, 1054, 1181, 1572. So not a new star, but a star that, running out of nuclear fuel at the end of its life, collapses gravitationally and explodes releasing a large amount of energy.

Galilei and observations in Padua

On the evening when the supernova appeared, the sky in Padua was cloudy, so the first detection was made a day later by medical students Baldassarre Capra (from Milan) and Camillo Sasso (from Calabria) and one of their lecturers, the German Simon Mayr. Due to poor weather conditions, it was not until the 15th and the following days that Capra and his friends saw the star again. Galileo Galilei was told the news about the *stella nova* (new star) by his neighbor Alvise Cornaro, who in turn was alerted by Capra. Galilei's first direct observation occurred only on October 28 [3].

In October 1604, Galilei was the professor of mathematics and astronomy at the University of Padua [3]. Padua had approximately forty thousand inhabitants. Its University was actually the University of the Republic of Venice, which the Venetians wanted to keep just far enough from the lagoon to protect themselves from the rebellions of the students, who are known to be difficult to tame - especially the brightest ones. Venetians knew that it is wise to guarantee freedom to scholars but also to keep them away from power. The University of Padua was one of the most famous in Europe

(possibly the most prestigious); it had approximately one hundred and fifty professors and fifteen hundred students, many of whom were foreigners, coming from twenty-three nations, which were more like communities than states [4]. The Venetian government granted full freedom to the scholars: as long as they did not meddle in politics or stir up religious issues, they could remain faithful to their customs and live as they pleased, unlike in Bologna, where foreigners were forced to Italianize and profess the Catholic faith. The *Capitanio*, the prefect who administered the city on behalf of the Republic of Venice, tolerated students brawling with each other, which happened often, as long as no permanent damage was caused. The proximity to Venice, which had one hundred and fifty thousand residents and offered an advanced postal system, made it easy to obtain books and documents from all over Europe in a short time. The chair of mathematics included teachings in geometry, astronomy, natural philosophy (a.k.a. physics), military engineering, and fortification. The chair of astrology had been abolished in Padua only a few years before, following pressure from the Pope, which had been endured with great discomfort. However, it was still expected that the mathematician-astronomer would also be somewhat knowledgeable in astrology.

As the days passed, the bright and pulsating *stella nova* generated wonder, terror and curiosity. Requests for horoscopes to interpret omens of the event multiplied. Galileo, who was teaching the mechanics of planets during that academical year, was the figure of reference to whom to direct questions that arose with the appearance of the new astronomical object. In November, the University of Padua asked Galilei to explain the situation by expounding his views in public lectures to answer the many questions posed by academics and ordinary people.

Galilei devoted three lectures to the *stella nova*, which were attended by more than a thousand students and citizens. The lectures were followed by debates, variously described by contemporaries as "pleasant discussions" or "bitter disputes." From the lectures remain [5] the incipit notes and some fragments. The closing of the incipit (here translated from Latin) gives an idea of Galileo's appeal as a professor. "This splendor has caused the dull eyes turned to earthly things of the people to be elevated to divine realities, as if it were a new miracle of heaven, what the conjunction of the most splendid and innumerable stars with which the fields of heaven are adorned fails to do. For human nature is such that everyday realities, even those worthy of admiration, escape us; in contrast, if something unusual and out of the norm happens, it attracts everyone. [...]

Heaven willing, may the paucity of my intelligence respond to the importance of the thing and to your expectation. I neither hope nor distrust: I believe that I am going to set out to establish only those things that are strictly within my competence, and report things demonstrated about the movement of substance, so that you will all learn about them." He then recounted the observational aspects of that light, which at first was faint and, in a few days, became so intense that it "surpassed all the stars, both fixed and movable, with the exception of Venus alone; a most splendid and entirely sparkling light, to the point that it seemed in the vibration of brightness almost to go out and immediately to come back on; light surpassing in splendor that of all the fixed stars, including Sirius itself; similar in color of light to the golden splendor of Jupiter and the reddish color of Mars." He recognized that it was tempting to suggest that such light was generated by the conjunction of Jupiter and Mars, but ruled it out, given the actual distance between the two planets despite the conjunction as seen from Earth. Some drawings in his notes, which he dared not publish, showed the conjunction from the heliocentric point of view, and thus made it clear that the phenomenon was purely relative to Earth. Galilei let it be understood that he had personally made some of the observations actually made by Capra, and this caused quarrels with the student, who felt misled [5].

Galilei affirmed that he had come to a "conclusion without contradiction, something more than mere speculation" about the position and motion of the *stella nova*. By means of parallax measurements made by himself and Spanish and Neapolitan astronomers, and with the group of astronomers who collaborated with Kepler, he demonstrated that the new star was beyond the Moon and the planets, thus between the fixed stars, and its motion appeared to be sympathetic to them. Parallax is the apparent displacement of an object due to a change in the observer's point of view. If you look at the tip of your nose with your right eye opened and left eye closed, then with your left eye opened and right eye closed, your nose will appear to move relative to a distant background, and you can calculate the distance of the tip of your nose from the line joining your eyes. One can measure the distance of an astronomical object by measuring its position relative to fixed stars from places as far away as Padua, Naples and Madrid. With the instruments of Galileo's time, stars appeared very distant, with no parallax: all observatories measured the same position, and this was the case with the *stella nova*.

Galilei knew he was risking censure. In fact, by claiming that the star was far beyond the Moon and the planets, he incurred the wrath of the followers of the Aristotelian school,

who were highly influential in the ecclesiastical field and in the Padua University. These professed a simple, perfect, ungenerable and incorruptible Heaven, devoid of change: nothing new could occur in the Heavens, that is, in space beyond the Moon. Therefore, they sought explanations that could make that newness compatible with their doctrine, which denied its very possibility. Many argued that since the *stella nova* was a new body, it must be within the lunar sphere, that is, between the Earth and the Moon. However, to support this hypothesis, they had to deny the validity of the parallax method. Some said that the star had always been there but before invisible, others that its creation was a divine decision and therefore there was no point in investigating it.

The controversy between Galilei and the Aristotelians

The response from the University of Padua was swift. A month after the lectures, in January 1605, the otherwise unknown Antonio Lorenzini published a booklet entitled *Discorso dell'ecc. sig. Antonio Lorenzini da Montepulciano intorno alla nuova stella* [6] at the Tozzi publisher in Padua. Lorenzini, without ever mentioning Galilei, attacked mathematicians and astronomers who placed the star outside the Earth-Moon sphere. In the face of the undeniable evidence of the lack of parallax, confirmed by measurements made in Europe, the guiding principle of his arguments lay in the fact that the parallax method could not be applied to celestial things: mathematics does not apply outside the Earth and the circumterrestrial medium. Behind Lorenzini's name, it is not difficult to see the inspiration of Cesare Cremonini, a professor of natural philosophy in Padua linked to Galileo by academic rivalry and personal association.

Galilei decided to be cautious and careful in examining possible hypotheses, and to wait before writing a scientific paper (which he finally never wanted to publish). He could not, however, hold back a response through one of his well-known, irreverent jokes, which made him as famous and popular in the student circles as he was suspect in academia. In February, the *Dialogo de Cecco di Ronchitti da Bruzene in perpuosito de la stella nuova* [7] was published (figure 1) by the same publisher Tozzi: a small booklet in Paduan dialect (a local form of Venetian) written, according to most critics, by Galilei, perhaps together with the Benedictine student monk Girolamo Spinelli, who knew better the Paduan. An appendix contained a poem in Florentine vernacular entitled *Stanze d'incerto contra Aristotele per la stella nuovamente apparsa*.

The *Dialogo* was an explicit mockery of what Lorenzini published. The use of dialect instead of Latin, in addition to being perfect for a light-hearted mockery, was a sign that the subject around which the pamphlet was built was not very worthy of consideration. Cecco di Ronchitti from Brugine (a small farming village near Padua, in whose birth books no Ronchitti is recorded), the unknown author who claimed to be a farmer and land surveyor, gave many indications in the book that he was in fact an astronomer. In the dialog, farmer Nale (Natale) tells his colleague Matthio (Matteo) about Lorenzini's book. The booklet analyzes point by point the contradictions and distortions expressed by Lorenzini, with accurate notes in the margins typical of academics.

Many of Galilei's characteristic findings can be recognized in the text (we will find them in the two great dialogs he wrote in his old age), and even at the time of publication, the treatise was attributed to him. Additionally, well supported by evidence is the collaboration of Spinelli, whom Galilei in a letter to Paolo Gualdo in 1614 [2] called "my pupil and companion of Cecco." Matteo, who expresses Galilei's concepts and his ideas around the new star, explains in simple terms taken from country life the validity of the concept of parallax, and proving himself as a Copernican also contemplates the seasonal displacement of the Earth related to its motion of revolution around the Sun. The exposition, far from being academic, has strong elements of even crude comedy, with floods of vulgarity.

In February 1605, Capra published a treatise [8] to claim the first observation of the supernova, in controversy with Galilei; apart from the diatribe, the study is of little interest. Galilei did not immediately respond (he would do so explosively in 1607 in a treatise [9] in support of a lawsuit brought against Capra for plagiarism of a scientific instrument, a case in which he succeeded in getting the former student convicted), but in his personal copy of the book (preserved in Florence), the Tuscan scientist wrote in his own hand numerous postscripts with vulgar insults.

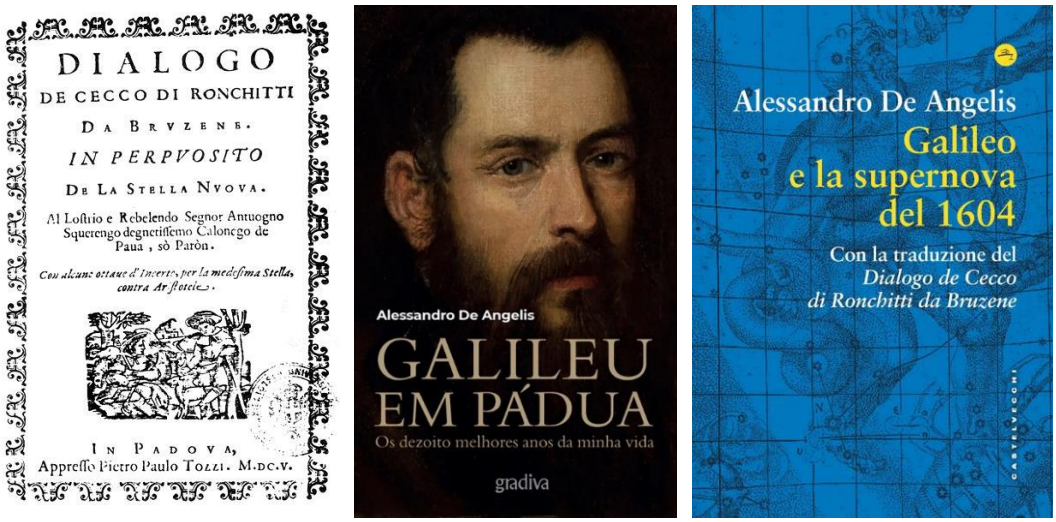

Figure 1. Covers of three books talking about the supernova; the first one on the left is the original Galilei's book.

Kepler's observations

While studies in Italy were beginning to stagnate, important observations were being made in Central Europe; the focal point of these observations was the German Johannes Kepler. Kepler, seven years younger than Galileo and his correspondent, had become in 1601, at the age of 30, the imperial astronomer of Holy Roman Emperor Rudolf II, taking the place of his master Tycho Brahe. Communication between Italian and German cultural groups about the new star became relevant since early 1605.

Kepler studied the *stella nova* for more than two years, at the end of which he published *De Stella Nova in Pede Serpentarii* (The New Star in the Foot of Ophiuchus) in 1606 [1]. This book is the most comprehensive repository of information on the new star, and contains an enormous amount of highly accurate observational data, acquired during the 18 months that the celestial object remained visible, provided by astronomers from all over Europe (particularly Germans and Italians). In view of this monumental study, the supernova of 1604 is now known as Kepler's supernova. In addition to describing and analyzing, Kepler examines the possible astrological meanings of the event, a popular topic at the time. In particular, he prophesies the spread of Christianity and the power of the Holy Roman Emperor, and expresses the hope that some signs will lead to a decrease in the price of wine. At the end of his treatise, in which he does not fail to mock Lorenzini, Kepler goes thus far as to make an astrological prediction about the historical events associated with the next great conjunction in a fiery sign, scheduled for the year

2400. What will happen to Germany then? "Who will be our successors? Will they remember us? All this, at any rate, if the world still exists."

In early 1606, the *stella nova* disappeared. After Kepler's study, there were no major scientific breakthroughs for three centuries (although there was contact between the Western world and the Arab, Chinese and Korean scientific communities that had made observations compatible with European ones), but the controversy lasted for a long time. In 1606, a treatise by the Florentine philosopher Lodovico Delle Colombe was published that defended an Aristotelian view of cosmology by assuming that the star had always existed, but was small, and because of its enormous distance became visible only when a part of the crystalline sky, which was denser than the remainder, passed in front of it, enlarging it like a convex spectacle. Various treatises that added little to Kepler's were published in the following decades, but by then, largely because of Kepler's very profound study, the scientific community had taken it for granted that the heavens could be mutable.

Today and tomorrow

In 1941, astronomers at California's Mount Wilson Observatory discovered a very dim, reddish-colored nebula that they recognized as the wreckage of the 1604 supernova. Today, the object, with an apparent size one-tenth that of the Moon, is a strong source of radio waves, X-rays and gamma rays, billions of times more energetic than visible light [5,10]. It is a "bubble" of cosmic material that after four hundred years is still expanding at the astounding speed of 10,000 kilometers per second (one-thirtieth the speed of light, figure 2).

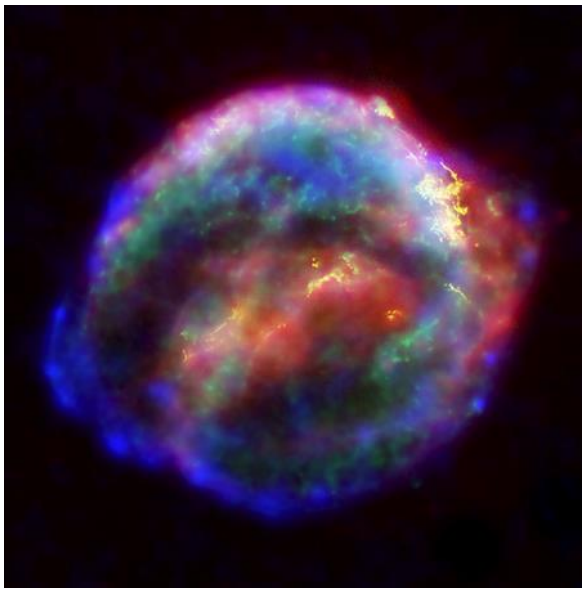

Figure 2. What remains of the 1604 supernova, in a collage of images at different wavelengths from NASA's large telescopes (particularly Hubble and Chandra).

No one can say for sure when and where the next great galactic supernova will appear; perhaps it will be Betelgeuse, the brightest star in the constellation Orion, which will become a thousand times brighter than Venus. Perhaps it will be Aludra, the fifth brightest star in the constellation of Canis Major (that of Sirius), as Primo Levi predicted in 1978 [11] in his short story *A Quiet Star*. Wherever it is, we physicists would like it to explode tonight.

Acknowledgments

I am grateful to Nuno Castro who invited me to know the School of Sciences of the University of Minho, to the colleagues of the University who were so kind to listen to me – in particular the President of ECUM, José Manuel González-Méijome, to the Rector, and finally to Carla Fernandes: I like a lot the idea of having scientific journals based at Universities and handled by students. Digital editing makes it possible, and young people must be smart enough to profit – and they are, it seems.

Note on the Author

A physicist, professor in Padua and Lisbon and a member of the Italian national institutes of nuclear physics and astrophysics, Alessandro De Angelis is the scientific advisor at Italy's delegation to international organizations in Paris. He has worked at CERN in Geneva and the Max Planck Institute in Munich, carried out some of the most important experiments for the study of cosmic rays and is the author of numerous publications in the *Science* and *Nature* magazines.

He is an acknowledged expert on the Galileo period, to which he has dedicated the books *Discorsi e dimostrazioni matematiche di Galileo Galilei per il lettore moderno* (Codice 2021), published in English by Springer Nature and in French by EDP Sciences, and a biography of the Paduan years of Galilei translated in Portuguese as *Galileu em Pádua* (Gradiva 2023), as well as the book *Galileo e la supernova del 1604* (Castelvecchi 2022).

Conflict of Interest

The author has not declared any conflict of interest.

References

[1] J. Kepler, “De Stella Nova in Pede Serpentarii”, et Qui Sub Eius Exortum de Novo Iniit, Trigono Igneo, Ex Officina Pauli Sessii, Prague, Czech Republic, 1606. [Google Scholar]

[2] A. Favaro, (Ed.) “Le Opere di Galileo Galilei”, Barbera, Firenze, Italy, 1890–1909. [Google Scholar]

[3] A. De Angelis, “Galileu em Pádua”, Gradiva, Lisboa, Portugal, january 2023, ISBN: 9789897851926.

[4] A. Favaro, “Galileo e lo studio di Padova”, Antenore, Padua, Italy, 1966.

[5] A. De Angelis, “Galileo e la supernova del 1604”, Castelvecchi, Rome, Italy, 2022.

[6] A. Lorenzini, “Discorso Intomo Alla Nuova Stella”, Tozzi, Padua, Italy, 1605. [Google Scholar]

[7] G. Galilei, “Dialogue of Cecco di Ronchitti da Bruzene”, Tozzi, Padua, Italy, 1605. [Google Scholar]

[8] B. Capra, “Consideratione Astronomica Circa la Nova, e Portentosa Stella che Nel’anno 1604 al dì 10 Ottobre Apparse, con un Breve Giudicio Delli Suoi Significati”, Pasquati, Padua, Italy, 1605. [Google Scholar]

[9] G. Galilei, “Difesa Contro Alle Calunnie et Imposture di Baldessar Capra”, Baglioni, Venezia, Italy, 1607. [Google Scholar]

[10] A. De Angelis, and S. Broccio, “First Observations of SN 1604 (Kepler’s Supernova)”, Universe, 7 (11), 430, 2021, https://doi.org/10.3390/universe7110430

[11] P. Levi, “Una stella tranquilla”, La Stampa, Torino, Italy, 1978.