Charles Messier

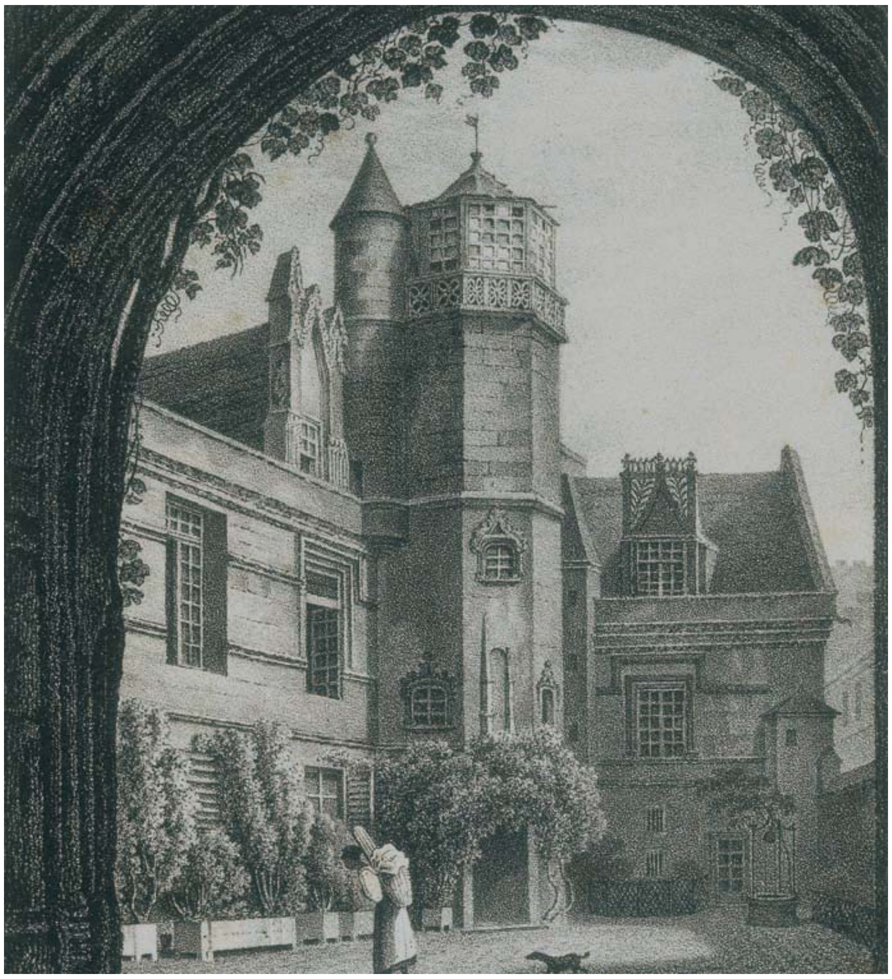
1730 to 1751: Childhood and adolescence

Charles Messier was born on the 26th of June 1730 in Badonviller, as the tenth child of the court bailiff Nicolas Messier (1682–1741) and his wife Françoise (maiden name Grandblaise, deceased 1765). His home village lies near the former German–French language border in the western part of the Vosges Mountains in Lorraine. In Messier's days, that region did not belong to France but to the independent dukedom of Salm. The Messier family was one of the richest in the little state, with high-ranking positions and excellent connections, which would later be very helpful to the young Charles.

He grew up in a house opposite the evangelic church of Badonviller, by a square which today bears his name. Six of his siblings died in their early childhood. An important role in Charles' life was played by his eldest brother Hyacinthe, who was older by 13 years. Hyacinthe started his professional career as an auctioneer and, eventually, became the highest financial officer of the dukedom. When their father died in 1741 – Charles was only 11 years old then – Hyacinthe was already able to take care of the Messier family. He gave Charles an apprenticeship in his office, mostly involving paper work. That helped develop the boy's good writing and drawing skills, and the accuracy required for finance and business. His first interest in astronomy was sparked by the large, six-tailed comet of 1744, discovered by the Swiss de Chéseaux, and the annular solar eclipse of 1748.

The year 1751 brought important changes to the life of the Messiers. The dukedom of Salm lost its independence by becoming part of Lorraine, which later fell to France by annexation. Only the former residence of the dukes of Salm, the village Senones, a few kilometers from Badonviller, retained its independence and was to become the new home of the Messier family. Now at the age of 21, it was time for Charles to seek a life of his own. With the help of a good family friend, who had contacts in important circles in Paris, an assistantship at the new Naval Observatory in Paris became available to Charles Messier. It was not really his interest in astronomy which got him the offer, but his good skills as an office assistant. He left Badonviller on the 23rd of September 1751.

Charles Messier at the age of 40, painted by Ansiaume. Messier commented that his portrait was most appropriate but made him look younger than he really was.



Drawing of the Hôtel de Cluny, from the beginning of the nineteenth century. The octagonal sheltered platform of the tower is Messier's observatory.

Today, the Hôtel de Cluny is one of the most beautiful medieval buildings of central Paris. It hosts the National Medieval Museum, but there is no commemoration of the work of Charles Messier.

1751 to 1757: Assistant of the Naval Observatory

Joseph-Nicolas Delisle (1688–1768), who taught mathematics and astronomy at the Collège Royal in Paris (later to be the Collège de France), built a private observatory on the stair-tower of the Hôtel de Cluny in 1747, opposite to the Collège Royal. Originally, the Hôtel de Cluny was the Parisian residence of the Benedictine monks from the great abbey in Burgundy. Later, it became the property of the French Navy. In 1754, the aged Delisle made a deal: he signed over the observatory to the Navy and in return, he received the custom-tailored title "Astronomer of the Navy."

Delisle's humble observatory stood in the shadow of the established Royal Observatory of Paris, which was well known as a leading European institution for astronomers like Huygens, Cassini, and Maraldi. Delisle, by contrast, was not part of the French astronomy establishment. Hence, Messier entered a professional environment which allowed him to pursue his astronomical interests without any scientific obligations, but which also branded him from the outset as an outsider to professional astronomy.

The childless Delisle couple received and hosted Messier as though he were their own son, and he lived with them in their apartment in the Collège. Delisle's assistant Libour introduced Messier to the basics of astronomy, and the young Messier's first tasks were to make hand-drawn copies of maps and to write the observing logs.

Delisle had been in personal contact with the late, famous English scientists Newton and Halley. The latter had pointed out in his famous work of 1705 that the comet apparitions of 1456, 1531, 1607, and 1682 were due to the same physical comet, which would reappear in 1758. Delisle made an independent calculation of the comet's orbit and derived April 1759 for the perihelion passage. Based on his master's work, Messier drew a map of the comet's path among the stars and had orders to watch for it from the summer of 1758 onward. That comet hunt was the first real astronomical task given to the 28-year-old, who so far had carried out only basic observations. Messier understood that this was the chance of a lifetime; he wanted to be the first to prove Halley's milestone work.

But life took a different course. While Messier did rediscover the comet on the 21st of January 1759, he soon had to learn that a farmer in Saxony had beaten him by about a month: the previously unknown amateur astronomer Johann Georg Palitzsch (1723–1788) from Prohlis near Dresden had already spotted Halley's Comet on Christmas night 1758. Messier had confined his search to Delisle's orbital path for too long. And to his great dismay, Messier could not even get his master's permission to publish his independent discovery, since Delisle did not believe that he'd made a mistake in his calculations. He thought the comet was an unrelated object. Messier bowed to the wishes of his master and host and withheld his obser-

M 1

The Crab Nebula

Degree of difficulty	3 (of 5)
Minimum aperture	50mm
Designation	NGC 1952
Type	Galactic nebula
Class	Supernova remnant
Distance	6200 ly (1999) 5250 ly (proper motion, 1993)
Size	10 ly
Constellation	Taurus
R.A.	5^h 34.5^{min}
Decl.	+22° 1'
Magnitude	8.4
Surface brightness	20mag/arcsec^2
Apparent diameter	6'×4'
Discoverer	Bevis, 1731

History

On the 4th of July 1054 or maybe even earlier, in April or May that year, a new bright star near the Sun was observed in the constellation of Taurus by witnesses in Italy, Armenia, Iraq, China, Japan, and North America. The unusual object appeared with a magnitude between –4 and –7.5 and was visible to the naked eye, even in the daytime sky. Apparently, maximum brightness coincided with the solar conjunction. Chinese astronomers observed the star in daylight until the 27th of July 1054, and they were able to see it in the night sky until the 17th of April 1056, before it faded from naked-eye visibility. In Europe, sightings of the supernova were probably censored, since the catholic church saw this celestial event as a bad omen in connection with the split from the orthodox church in the same year.

In 1731, the English physician and self-taught astronomer John Bevis, without any knowledge of the related historic observations, discovered a nebula at the position of the supernova. Independently, Charles Messier found the nebula on the 28th of August 1758, while following a comet for the first time. In fact, at first he took M 1 for the comet. Messier wrote: "Nebula, contains no star; it is a whitish light, elongated in the shape of a candle's light." Only later did Messier learn of Bevis' observation and recognized the Englishman's priority on the discovery.

William Herschel described the object as "very bright, of irregular figure, full 5' in longest direction," and he speculated that "it consists of stars." His son John described M 1 as a "fine object, very large, extended, very gradually brightening a little toward the middle, mottled, 4' long, 3' broad." Admiral Smith spoke of a "pearly-white nebula" and added: "It is of oval form, with a major axis from northwest to southeast, and the brightest portion toward the south."

In 1844, Lord Rosse devoted an extended study to the "Crab Nebula," so called after an earlier observing report by him. Because of its fine-structure, he mistook it for a star cluster: "We see resolvable filaments singularly disposed, springing principally from its southern extremity, and not, as is usual in clusters, irregularly in all directions. Probably greater power would bring out other filaments, and it would then assume the ordinary form of a cluster. It is studded with stars, mixed however with a nebulosity probably consisting of stars too minute to be recognized."

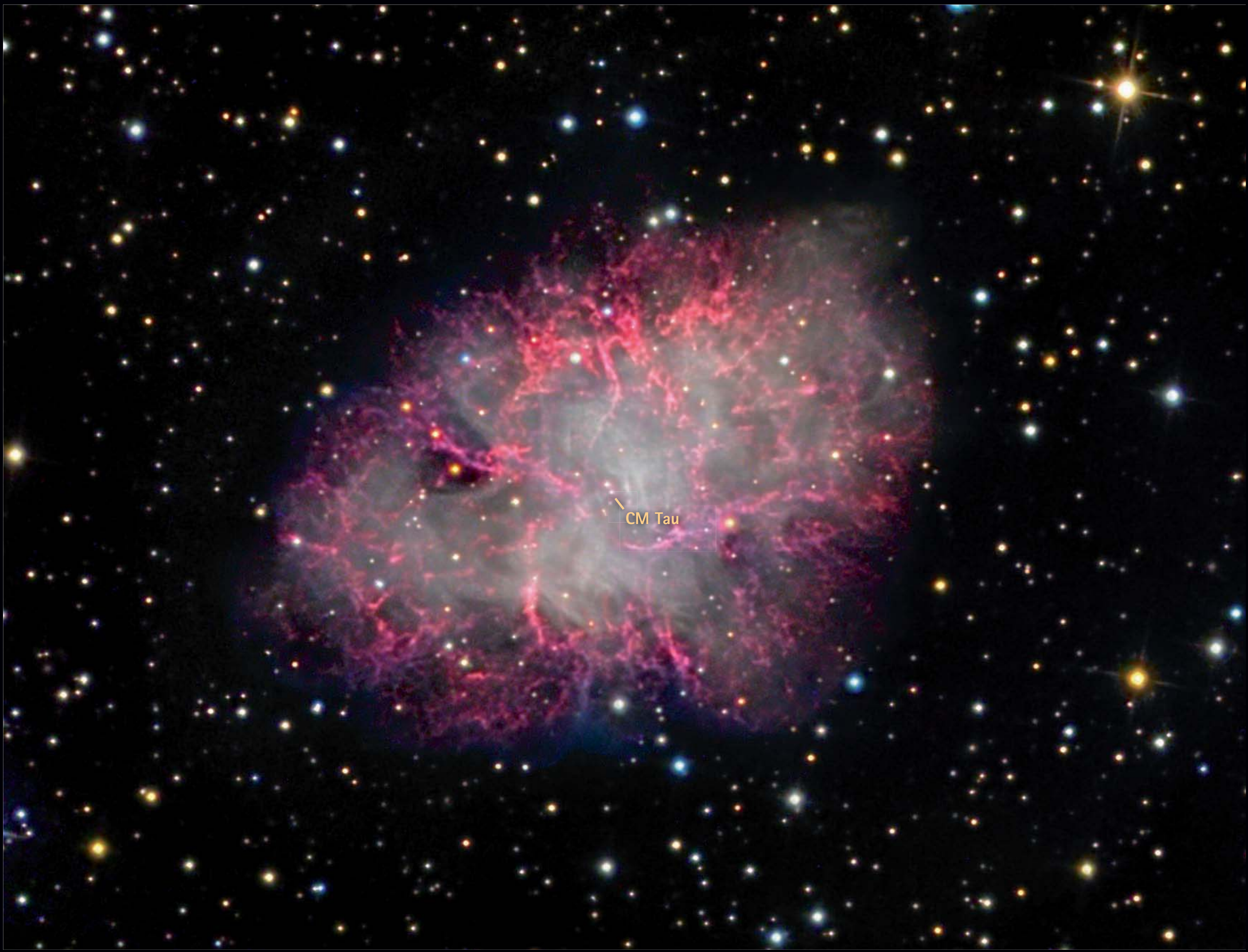
A few years later, William Lassall, too, mentioned the filaments, after his observations from Malta: "Long filaments run out from all sides, there appears to be a number of very minute and faint stars scattered over it. The brightest parts are 2' long, while its extensions reach 6'."

On the eve of the 19th century, Leo Brenner wrote about the popular name of the nebula: "So called, because Rosse pictured it in his fantastic drawing like a crab, with which it shows no resemblance, however. It rather likens a sponge. A broad, deep bulge, not containing any nebular masses, is located on its north-eastern side; a smaller bay is partially filled with nebulosity."

A first photo of M 1 was obtained in 1892, and Slipher's spectroscopic work of 1913–1915 showed split spectral lines in the vicinity of the outer filaments. Later, this was explained by means of the Doppler effect in combination with a fast expansion of the nebula.

Not without some doubt, Curtis characterized the Crab Nebula in 1918 as a planetary nebula – a contemporary assumption, but a mistake, which reappeared in some catalogs until the 1960s. On this occasion, however, the central star got mentioned for the first time: "Two stars of mag 16 are close together near the center but it is not certain that either of them is a central star. This very complex and interesting object is nearly 6'×4' in P.A. about 125°. It is not a typical planetary in form and it is doubtful whether it is properly to be included as a member of the class."

Lampland, in 1921, found displacements of filamentary detail when comparing photos of different age. The same year, Duncan found an expansion rate of 0.2'' per year from such a comparison, and dated the possible creation of the nebula to 900 years back. Lundmark, also in 1921, then suggested the historic supernova of 1054 as the cause of the nebula, which nowadays is a commonly ac-



M 1. The only supernova remnant in the Messier catalog is also the youngest Messier object, with an age of only 950 years. Bernd Flach-Wilken, Volker Wendel.

cepted fact. In 1968, the central pulsar was discovered by the radio telescope in Arecibo.

Astrophysics

The Crab Nebula is the only supernova remnant in the Messier catalog. Because of its proximity, its young age, and the interesting astrophysics related to it, M 1 is regarded as the most-studied deep-sky object in the Galaxy.

M 1 measures about 10 light-years in diameter. The nebula consists of about five solar masses, and its absolute magnitude is –3, corresponding to about a thousand solar luminosities. In visual light, two components of nebular emission can be distinguished by spectroscopy. One shines in the green and red light of the [OIII] and Hα emission lines of the filaments. It represents the former outer layers of the progenitor star, which have been expelled at high speed in the supernova event of 1054 and are now colliding with the surrounding interstellar medium. The gas is heated in shock fronts and forms today's filamentary emission nebula. The other, blue component shows a continuous spectrum and is highly polarized. Here we have synchrotron radiation, found on Earth only when generated by large particle accelerators. It is caused by accelerated electrons in a strong magnetic field. Hence, M 1 can be regarded as the best extraterrestrial laboratory for the observation of this type of emission, which is detectable from the radio to the X-ray range of the electromagnetic spectrum. This was first recognized by Shklovsky in 1953.

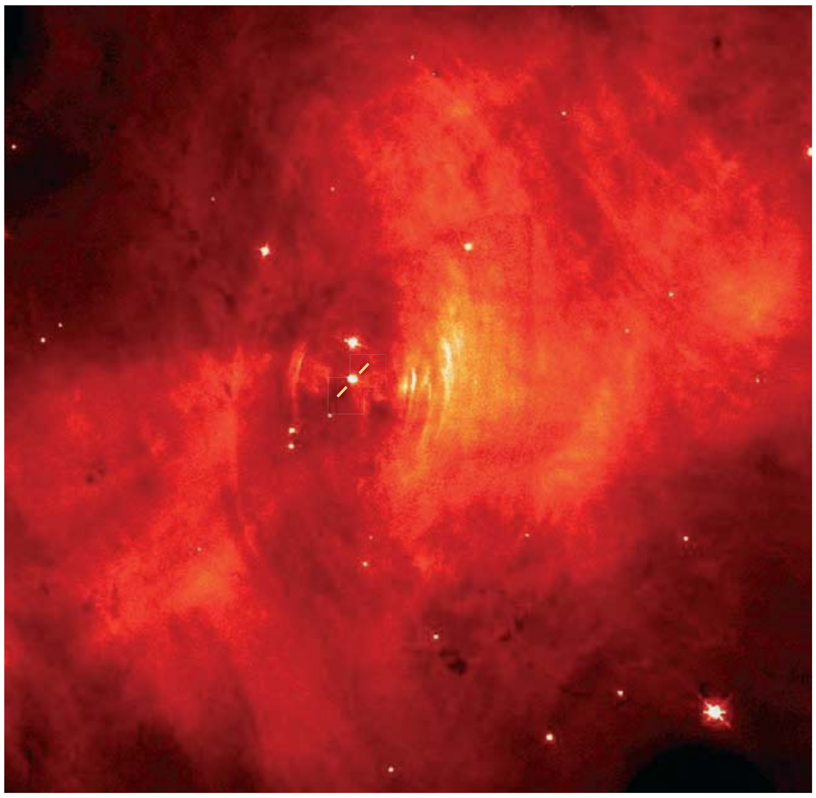
M 1. The red and green, filamentary structure is the debris of the supernova progenitor star. Bluish, by contrast, is the haze of synchrotron emitting nebulosity. Philipp Keller.

M 1 can be studied throughout the electromagnetic spectrum: in 1948, strong radio emission was found, and X-rays were detected in 1964. Hence, the Crab Nebula has additional designations as the Taurus A or 3C 144 radio source and as Tau X-1. Its radiated X-ray flux exceeds its optical flux by more than a hundredfold, and the total energy output has been quoted as 5×10^{11} joules per second.

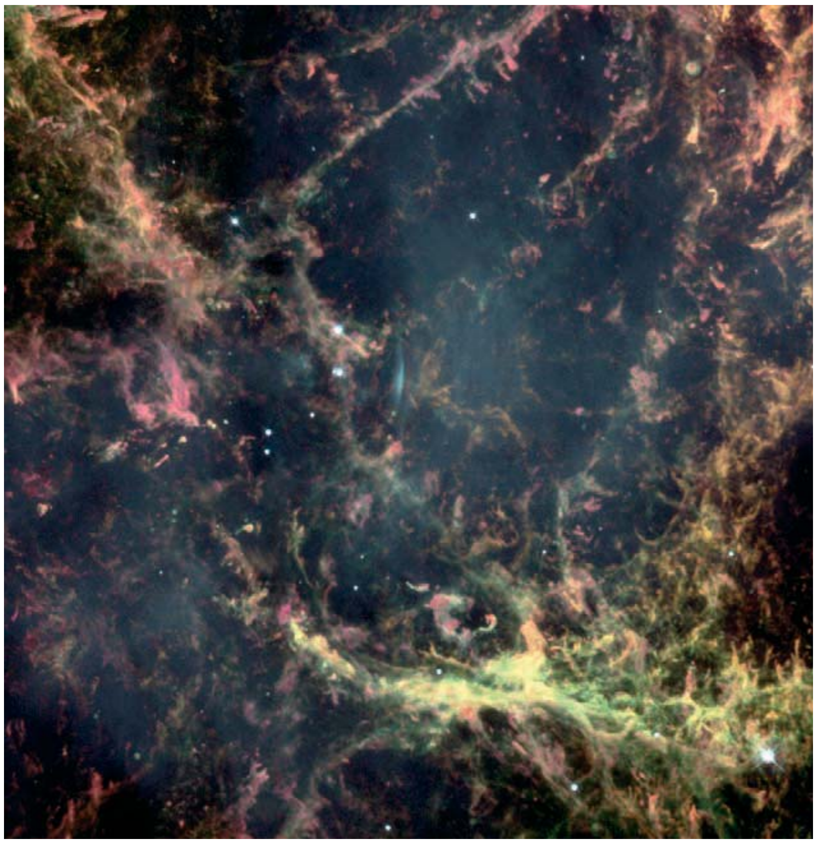
The collapsed core of the star that caused the supernova is still present in the center of the nebula. In its intense magnetic field, charged particles get accelerated near the field poles and emit collimated radiation along the magnetic field axis, which is tilted with respect to the rotation axis of the rapidly spinning neutron star. As Earth happens to be in the right direction to be hit by one of these sweeping radiation beams, a sharp pulse is observed every revolution, and hence this type of neutron star is called a “pulsar.”

The M 1 pulsar measures only 10 km in diameter but has an absolute magnitude of +4.5, slightly brighter than the Sun. A cubic centimeter of its matter would weigh a thousand million tons – so much has it been compressed in the gravitational collapse of the supernova!

The pulsar in M 1 was the first of its kind for which an optical counterpart was found. This 16th-magnitude star, registered as CM Tauri, sends pulses of light with the same period as the radio pulses, 33.085 milliseconds. This makes it a valuable object for scientific study, as very few other optical pulsars are yet known.



M 1. This false color image shows the pulsar and ring-shaped structure at a 550 nm wavelength. Hubble Space Telescope.



M 1. Close-up of the inner region of the nebula. Hydrogen is pictured orange, nitrogen red, sulphur pink, and oxygen green. Hubble Space Telescope.

Modern X-ray observations and high-resolution images from the Hubble Space Telescope show rings of highly energetic particles around the pulsar of M 1, at distances of 0.1 to 1 light-year, and jets emerging perpendicular to the ring plane. Fine structure resolved by Hubble in 1995 includes a knot of emission only 1500 AU from the pulsar, which has been interpreted as a shock in the jet – a region where material piles up as the jet meets the surrounding nebula. Image sequences revealed its outward velocity as half the speed of light! The jets stop at a halo of blue light with 80'' radius, which shows delayed brightness fluctuations, reflecting the arrival of bright knots.

The supernova's progenitor star has been estimated to have had 8–13 solar masses. The supernova event released 400 thousand million solar luminosities, leaving the debris of the star expanding with velocities of up to 2500 km/s, while the blue halo expands with 1160 km/s. This expansion and the energy losses of the pulsar lead to a decrease of the synchrotron radiation by 0.5% per year, as shown by Smith (2003). At the same time, the expansion velocity seems to increase: present expansion rates would suggest an explosion time of 1130, more recent by 76 years. This effect is caused by the hot stellar wind that pumps additional kinetic energy into the expanding nebula.

Observation

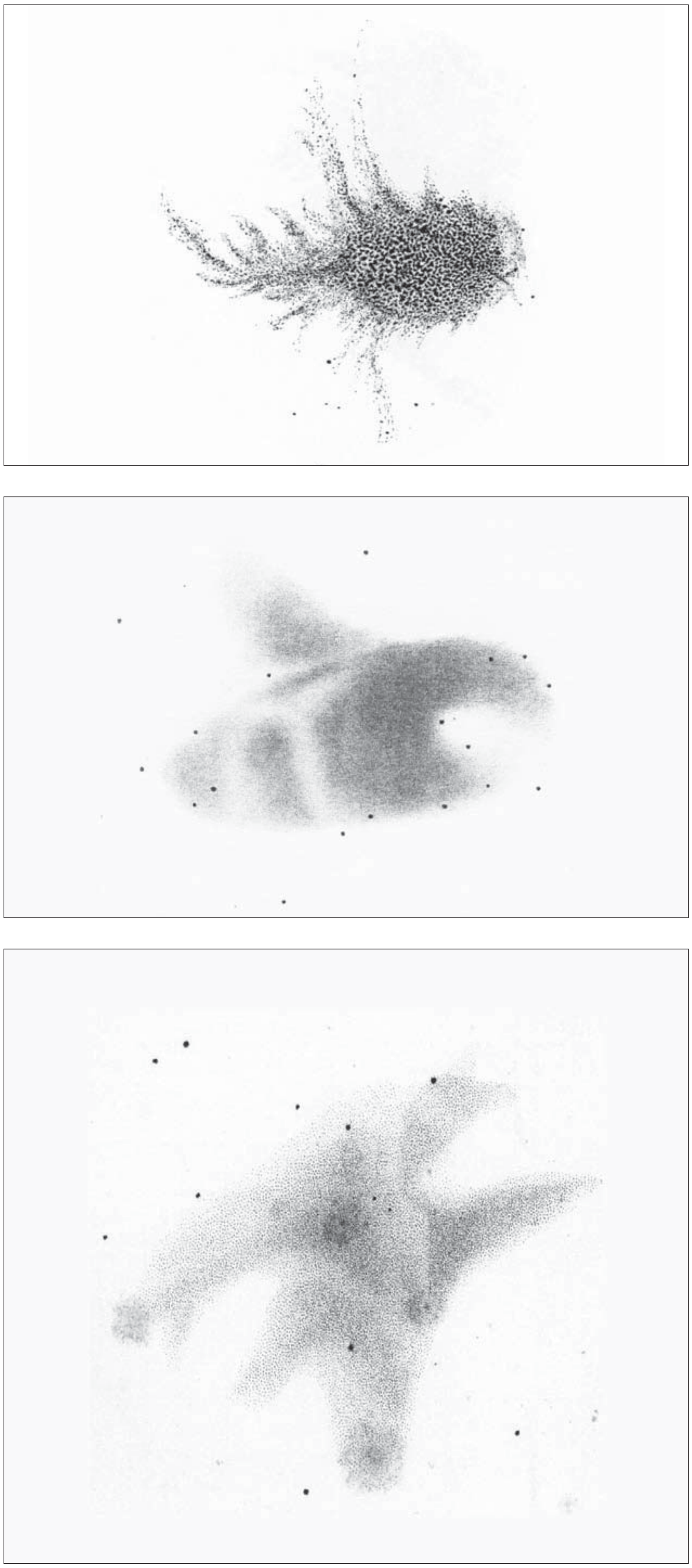
M 1 is relatively faint and by far the most difficult object to observe among the 45 entries of the first version of the Messier catalog. 10×50 binoculars show just a little smudge. With a telescope of 2" aperture, hardly any shape is recognized, but M 1 already appears as noncircular.

A 4.7-inch refractor shows an irregular nebula of about 5'×4' size, with an S-shaped main body in a northwest to southeast orientation. The southeastern side is fainter and ends in an extension, which is separated from the nebula in the north by a vague dark zone.

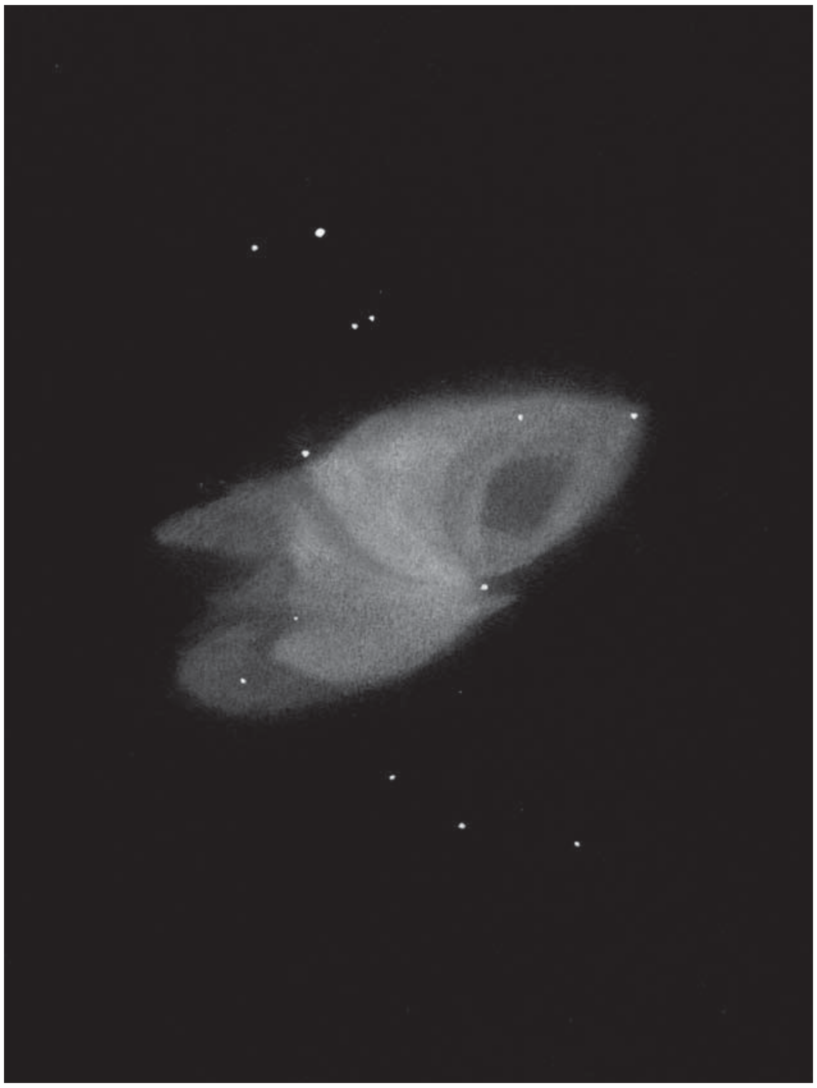
Even with large apertures, it is difficult to make out detail in M 1. 14 inches show an irregular, longish nebula. The northeastern border is straight, three 12th-magnitude stars line up along it. The northwestern tip is fainter but clearly visible, while the southwestern border is irregular. A dark bay reaches into the southeast and divides it into a brighter southern and a fainter northern branch. These were interpreted by Rosse as the claws of his "crab." In the middle of the nebula, a darker area can be made out. In it, two 16th-magnitude stars are visible under best observing conditions. The somewhat fainter, southern star is the pulsar. Four other stars are found elsewhere in the nebula.

With an [OIII] filter, the visual appearance of M 1 changes significantly: the shape is rather round, and both the northwestern tip and southeastern bay have disappeared. Instead, a bright, curved filament dominates the view. Originating in the west near an 11th-magnitude star, it stretches all across the nebula to the east. Beginning in the west, other, fainter filaments become visible, reaching into the rest of the nebula. Since their synchrotron radiation is strongly polarized, interesting changes of shape and structure appear when a variable polarizing filter is used in different PAs.

The bright double star Σ 742 is found 26' east of M 1. It consists of components of magnitudes 7.2 and 7.8, separated by 3.9" in PA 14°.



M 1, historical drawings. Lord Rosse (1844, 1853), William Lassell (1864).



M 1, drawing. 14-inch Newtonian. Ronald Stoyan.