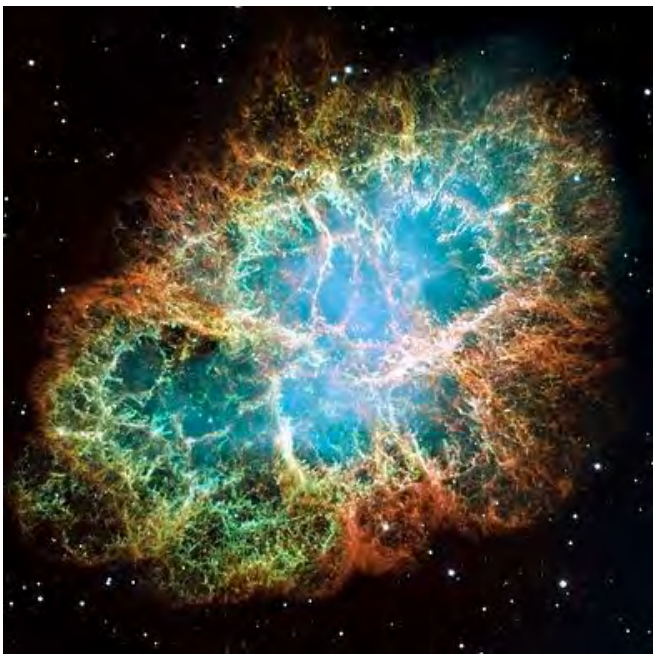
The Crab Nebula (Messier Object Number 1 (M1)



It is a supernova remnant and pulsar wind nebula in the constellation of Taurus with the Catalogue designations M1 or NGC 1952. The now-current name Crab Nebula is due to **William Parsons, 3rd Earl of Rosse,** who observed the object in 1840 using a 36-inch telescope and produced a drawing that looked somewhat like a crab.

At an apparent magnitude of 8.4, comparable to that of Saturn's moon Titan, it is not visible to the naked eye but can be made out using binoculars under favourable conditions. The nebula lies in the Perseus Arm of the Milky Way galaxy, at a distance of about 6,500 ly from Earth. It has a diameter of 11 ly, and is expanding at a rate of about 1,500 kilometres per second, or 0.5% of the speed of light.

The nebula was the first astronomical object identified with a historical supernova explosion.

At the centre of the nebula lies the Crab Pulsar, a neutron star 28–30 kilometres across with a spin rate of 30.2 times per second, which emits pulses of radiation from gamma rays to radio waves. At X-ray and gamma ray energies above 30 keV, the Crab Nebula is generally the strongest persistent source in the sky, with measured flux extending to above 10 TeV. The nebula's radiation allows for the detailed studying of celestial bodies that occult it. In the 1950s and 1960s, the Sun's corona was mapped from observations of the Crab Nebula's radio waves passing through it, and in 2003, the thickness of the atmosphere of Saturn's moon Titan was measured as it blocked out X-rays from the nebula.

Modern understanding that the Crab Nebula was created by a supernova dates to 1921, when **Carl Otto Lampland** announced he had seen changes in its structure. This eventually led to the conclusion that the creation of the Crab Nebula corresponds to the bright SN 1054 supernova recorded by Chinese astronomers in AD 1054. Although the event was long considered unrecorded in Islamic astronomy, in 1978 a reference was found in a 13th-century copy made by **Ibn Abi Usaibia** of a work by **Ibn Butlan**, a Nestorian Christian physician active in Baghdad at the time of the supernova.

Although first identified in 1731 by **John Bevis**, the nebula was independently rediscovered in 1758 by **Charles Messier** as he was trying to locate the predicted return of Halley's Comet in an area within the constellation of Taurus . It is in searching for the comet that Charles Messier found the Crab nebula, which he at first thought to be Halley's comet. After some observation, noticing that the object that he was observing was not moving across the sky, Messier concluded that the object was not a comet. **Messier then realised the usefulness of compiling a catalogue of fixed celestial objects of a cloudy nature, to avoid incorrectly cataloguing them as comets. His list eventually covered over 100 items**. **William Herschel** observed the Crab Nebula numerous times between 1783 and 1809. After several observations, he concluded that it was composed of a group of stars. The 3rd Earl of Rosse observed the nebula at Birr Castle in 1844 using a 36-inch (0.9 m) telescope, and referred to the object as the "Crab Nebula" because a drawing he made of it looked like a crab. He observed it again later, in 1848, using a 72-inch (1.8 m) telescope and could not confirm the supposed resemblance, but the name stuck nevertheless.

Reproduction of the first depiction of the nebula by Lord Rosse (1844)

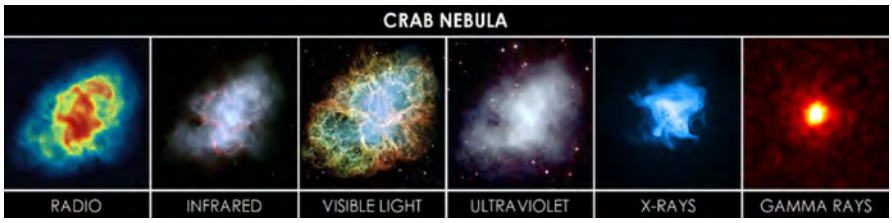
In 1913, when **Vesto Slipher** began his spectroscopy study of the sky, the Crab Nebula was again one of the first objects to be studied. In the early twentieth century, the analysis of early photographs of the nebula taken several years apart revealed that it was expanding. Tracing the expansion back revealed that the nebula must have been visible as a star on Earth about 900 years ago. Historical records revealed that a new star bright enough to be seen in the daytime had been recorded in the same part of the sky by Chinese astronomers in 1054.

In 1928, **Edwin Hubble** proposed associating the cloud to the star of 1054, an idea which remained

controversial until the nature of supernovae was understood, and it was **Nicholas Mayall** who indicated that the star of 1054 was undoubtedly the supernova whose explosion produced the Crab Nebula. **The search for historical supernovae started at that moment: seven other historical sightings have been found by comparing modern observations of supernova remnants with astronomical documents of past centuries**. Given its great distance, the daytime "guest star" observed by the Chinese could only have been a supernova—a massive, exploding star, having exhausted its supply of energy from nuclear fusion and collapsed in on itself.
Recent analysis of historical records have found that the supernova that created the Crab Nebula probably appeared in April or early May, rising to its maximum brightness of between apparent magnitude -7 and -4.5 (brighter than everything in the night sky except the Moon) by July. The supernova was visible to the naked eye for about two years after its first observation. Thanks to the recorded observations of Far Eastern and Middle Eastern astronomers of 1054, Crab Nebula became the first astronomical object recognized as being connected to a supernova explosion.
In the 1960s, because of the discovery of pulsars, the Crab Nebula again became a major centre of interest. It was then that Franco Pacini predicted the existence of a Crab Pulsar to explain the brightness of the cloud. The star was eventually found in 1968 with pulses of radiation every 33 milliseconds. The discovery of the Crab pulsar, and the knowledge of its exact age (almost to the day) allows for the verification of basic physical properties of these objects, such as characteristic age and spin-down luminosity, the orders of magnitude of its magnetic field strength and various aspects related to the dynamics of the remnant. The role of this supernova to the scientific understanding of supernova remnants was crucial, as no other historical supernova created a pulsar whose precise age we can know for certain.

Image combining optical data from Hubble (in red) and X-ray images from Chandra X-ray Observatory (in blue).

In visible light, the Crab Nebula consists of a broadly oval-shaped mass of filaments, about 6 arcminutes long and 4 arcminutes wide (by comparison, the full moon is 30 arcminutes across) surrounding a diffuse blue central region. In three dimensions, the nebula is thought to be shaped like a prolate (oval) spheroid. The filaments are the remnants of the progenitor star's atmosphere, and consist largely of ionised helium and hydrogen, along with carbon, oxygen, nitrogen, iron, neon and sulfur. The filaments' temperatures are typically between 11,000 and 18,000 K, and their densities are about 1,300 particles per cm^3.
In 1953 **Iosif Shklovsky** proposed that the diffuse blue region is predominantly produced by synchrotron radiation, which is radiation given off by the curving motion of electrons in a magnetic field. The radiation corresponded to electrons moving at speeds up to half the speed of light. Three years later the theory was confirmed by observations. In the 1960s it was found that the source of the curved paths of the electrons was the strong magnetic field produced by a neutron star at the centre of the nebula. Estimates of the total mass of the nebula are important for estimating the mass of the supernova's progenitor star. **The amount of matter contained in the Crab Nebula's filaments is now estimated to be about 5 Solar masses**



The Crab Nebula lies roughly 1.5 degrees away from the ecliptic—the plane of Earth's orbit around the Sun. This means that the Moon—and occasionally, planets—can transit or occult the nebula. Although the Sun itself does not transit the nebula, its corona passes in front of it. These transits and occultations can be used to analyse both the nebula and the object passing in front of it, by observing how radiation from the nebula is altered by the transiting body.
The Crab Nebula features in a number of science fiction stories, such as First Contact, Uxarieus "Colony in Space" in Dr Who, Colossus and the Crab, Battle of the Planets, Free Space, the Mass Effect game, and even the Teenage Mutant Ninja Turtles cartoon has used "Made in Crab Nebula" to steal famous renaissance artworks.

AK, with Wikipedia Notes