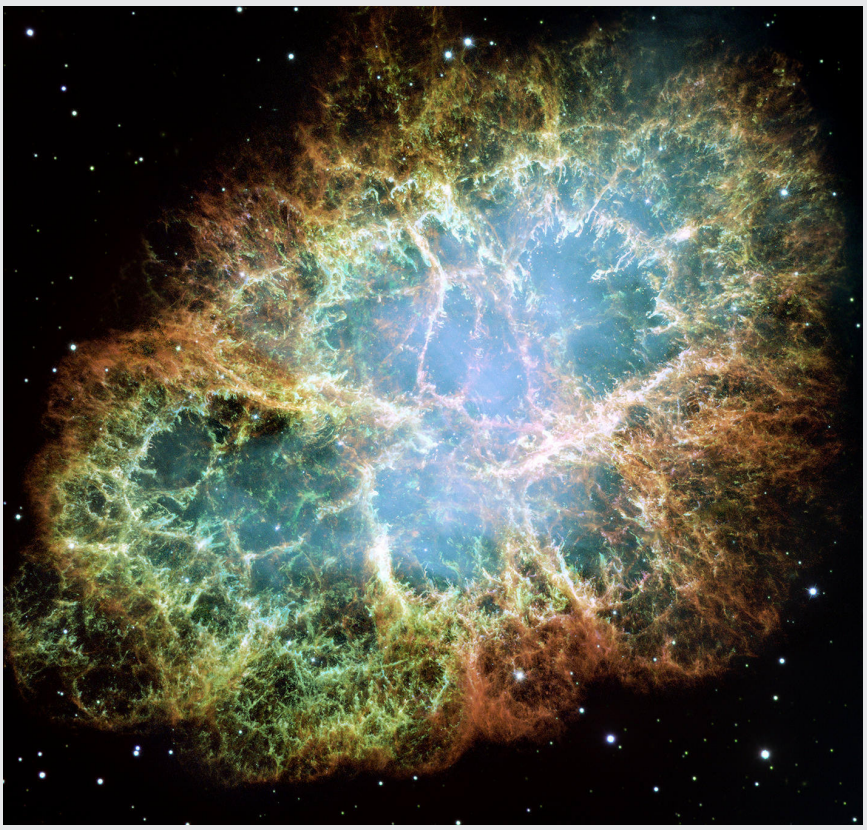
The grand finale of a giant star

Jonathan Freundlich

During the summer of the year 1054, Chinese and Japanese chroniclers recorded the apparition of a new object in the sky. It looked like a very bright star, so bright it was even visible during daytime for a couple of weeks. Its luminosity then slowly faded, although the new object remained visible to the naked eye during the night for about two years. Some American Indians carved the event in stone, while a doctor from Baghdad saw it as bad omen and related it to the plague epidemics that had burst in Constantinople and Cairo. In this epoch, people often tried to interpret astronomical events in the light of their own history.



BLAST FROM THE PAST *The Crab Nebula as seen by the Hubble Space Telescope (false colours).* CREDIT: NASA, ESA, J. HESTER AND A. LOLL (ARIZONA STATE UNIVERSITY)

A cosmic explosion

If we follow the indications left by the Chinese chroniclers and point our telescopes where this object appeared to them in the sky, there is an amazing thing to see: the Crab Nebula. It looks like a huge bomb blast with an intricate inner structure, and it is indeed a blast. This is what remains of the 1054 supernova.

A supernova is when a giant star explodes toward the end of its life. The explosion is so luminous it can be as bright as a whole galaxy! The violent blast ejects most of the star's material at incredible speed and diffuses the gas in the surrounding medium. Although you won't see the expansion of the nebula in a single observation session because of the distance, you could clearly perceive it when comparing pictures separated by a few years.

The blast of a supernova disperses the chemical elements formed in the star all around it, which makes them available when new stars and planets form. Elements like carbon or iron can be formed during the lifetime of the star through nuclear fusion reactions in its core, but the formation of heavier elements requires more extreme conditions like those of a supernova explosion. For example, the lead, the gold and the uranium found on Earth might all have been formed during supernovae.

A lighthouse beyond comparison

While most of its gas was pushed away during the 1054 supernova, the core of the giant star that lead to the Crab Nebula compressed dramatically. What remains now is almost entirely composed of neutrons, which makes it incredibly dense. Such a stellar remnant is called a neutron star. At the center of the Crab Nebula, the neutron star has approximately the same mass as our Sun, but just the size of a middle-sized city! The gravitational force at its surface is billions of times greater than on Earth and we would thus be totally crushed if we were to approach it too closely.

Besides, this neutron star rotates extremely rapidly, with about thirty revolutions per second, and its magnetic field is just colossal. Two narrow beams of radiation are emitted from its magnetic poles and rotate with the stellar remnant, like beams of a lighthouse sweeping the vastness of the Universe. One of these beams hit the Earth at each revolution, so the neutron star appears to pulse thirty times per second. Such an object is also called a pulsar.

Various supernovae have been recorded in the course of human history, either belonging to our Milky Way like the Crab Nebula, or belonging to other galaxies. But no supernova has ever been observed in our Milky Way since the invention of the telescope. Astrophysicists are eagerly waiting for such an astounding event to happen, and I hope that we will be able to witness one during our lifetime!

(Jonathan Freundlich is a PhD student at the Paris Observatory, in France, working on star formation and galaxy evolution. He can be reached at **jonathan.freundlich@obspm.fr**)

ASTROPHYSICAL SERIES

- No clear records of the 1054 supernova have been found in Indian and European medieval sources so far, although it must have been visible from all the northern hemisphere.
- Supernovae were initially referred as *stella nova*, or new stars in Latin.
- Typical neutron stars have radiuses of about 10 km.
- The cores of the most massive stars can become black holes instead of neutron stars when they explode as a supernovae.