Supernova's Light Curve Tells Its Tail

Since reaching its maximum brightness 85 days after its core explosively collapsed almost 22 months ago, supernova 1987A has gotten steadily fainter. But that may be changing. Recent observations of the total light coming from the supernova indicate a possible slowing in the rate at which the light is dimming. If that trend continues, the leveling off in the supernova's "light curve" would be the first hint of a hidden source of energy — perhaps a pulsar — buried at the supernova's center.

Initially, astronomers at the Cerro Tololo Inter-American Observatory in Chile reported that, starting near the end of October, the supernova's brightness began to decline less sharply than it had during the previous 300 days. Data from the International Ultraviolet Explorer satellite and observations made at a South African observatory confirmed this "inflection" in the light curve. But the most recent South African observations show the brightness decline is again close to its previous faster rate.

"Everyone agrees that something is going on, but it's too soon to say that [the light curve] is leveling off," says Stanford E. Woosley of the University of California, Santa Cruz. "If anything, it looks like the light curve is wiggling more than leveling out."

Astronomers have seen wiggles in the tails of light curves from other supernovas. Such wiggles may occur if the gas cloud around a supernova becomes lumpy, and the amount of matter between an observer and the supernova's center changes, causing the brightness to vary.

On the other hand, the light-curve shift might be the first sign of an energy source at the supernova's center. Until now, the supernova's major light-producing energy source has been the radioactive decay of the isotope cobalt-56.

The new energy source could be radiation emitted by a neutron star when ejected matter settles back onto its hot surface. A more tantalizing possibility is that the neutron star is rotating fast enough and has a sufficiently large magnetic field to be a pulsar. In that case, the pulsar's energy would be captured by surrounding gas and reradiated as visible light. Because the pulsar itself would be hidden in the cloud of gas, the chances of seeing optical pulses at this stage would be small.

"It is true that there is a little more light coming from the supernova than you'd expect just from radioactive decay," says Robert P. Kirshner of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass. "What we see is consistent with the formation of a neutron star that's a pulsar, but it doesn't prove it."

Nevertheless, according to predictions made by numerous astronomers, the timing of the light-curve shift is close to what would be expected if the pulsar at the supernova's center were somewhat less luminous than the pulsar in the Crab Nebula and similar in energy to a pulsar found in a supernova remnant in the same region of the Large Magellanic Cloud as supernova 1987A. The timing is also consistent with estimates of how much energy would be produced by matter falling onto a neutron star. At the same time, nothing in recent observations totally rules out the unlikely possibility that a black hole sits in the middle of supernova 1987A.

"At the present time, we can't be absolutely sure just what is giving rise to the change in the light curve," says Roger A. Chevalier of the University of Virginia in Charlottesville. The trouble is, says Woosley, "you're just starting to see the last few hairs on the tail of the elephant, and you're trying to talk about its trunk."

With no clear view directly into the center of the supernova, astronomers will keep a close eye on the supernova's overall brightness to see if the light curve really does flatten out. The trend should become clearer during the next few weeks, Woosley says. "I think next year will be the year of the pulsar. One way or another, we should see some evidence for it." — *I. Peterson*

Grave findings at ancient Mexican site

Large burial pits unearthed around and inside a prehistoric Mexican pyramid provide important clues to the nature of a civilization contemporary with the Mayas and preceding the Aztecs by 1,000 years, according to anthropologist George Cowgill of Brandeis University in Waltham, Mass.

The 83 human skeletons found in the pits appear to be victims of a ritual sacrifice, says Cowgill, who directed excavations last summer with Ruben Cabrera of Mexico's National Institute of Anthropology and History. The remains are located at Teotihuacan, an 8-square-mile site near Mexico City. The massive urban center had its beginnings around 100 B.C. and thrived until A.D. 750. At its peak, Teotihuacan contained as many as 200,000 people and its cultural influence spread throughout the region.

"We knew the Teotihuacanos occasionally made sacrifices, but this is the first time we've found large-scale sacrificial burials," Cowgill says.

In and around the pyramid, the researchers excavated four mass graves containing more than 40 skeletons. The first burial pit unearthed near the pyramid, known as the Feathered Serpent Pyramid, was discovered in 1983 by a graduate student now at Brandeis. In 1986, Mexican archaeologists uncovered another pit containing several dozen skeletons. Radiocarbon testing dates the remains to between A.D. 150 and 200.

Cowgill cites two major reasons for considering the remains sacrificed humans. First, the skeletons' hands are behind their backs with their wrists crossed, indicating they were forcibly bound. Also, many skeletons are clad in military attire, but there is no indication they suffered serious battle wounds.

Cowgill

Teotihuacan skeleton wears shell collar of cut rectangles, with imitation human jaws hanging from the collar. Its arms are crossed behind the back.

Military garb includes marine-shell collars with imitation human jaws carved from shells and slate disks placed around the waist. The graves also hold obsidian spear points.

The victims were most likely sacrificed to honor a dead ruler buried within the pyramid, Cowgill says.

The burials support the theory that Teotihuacan culture can be divided into two periods, he notes. The first lasted until about A.D. 300 and is characterized by single, powerful rulers. After that, murals at the site mainly display communal activities and do not depict preeminent rulers.

Cowgill says he expects to find many more burials, and possibly the remains of the ruler for whom the pyramid was built, when work continues next summer. — *B. Bower*

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