Follow That Supernova

As SN 1987A develops, astronomers watch and wonder

By DIETRICK E. THOMSEN

Not in centuries have astronomers seen a supernova as close as SN 1987A, and never have they seen one so close with modern observing equipment. Its development keeps offering surprises, like the strange "companion" that suddenly appeared beside it about a month after its discovery last February. Astronomers are not sure whether these behaviors are common and just were not seen in more distant supernovas, or whether SN 1987A really is anomalous in some ways.

Scientists discussing the supernova at the joint gathering in June of the American Astronomical Society and the Canadian Astronomical Society in Vancouver, British Columbia, were puzzled over many of these developments. Even in its most general characteristic — its brightness, or, as astronomers say, its light curve — SN 1987A did not behave as expected. A quick rise to maximum brightness and a slow fading away in a prolonged "tail" are what's expected. Instead, SN 1987A has gone up and down and up again.

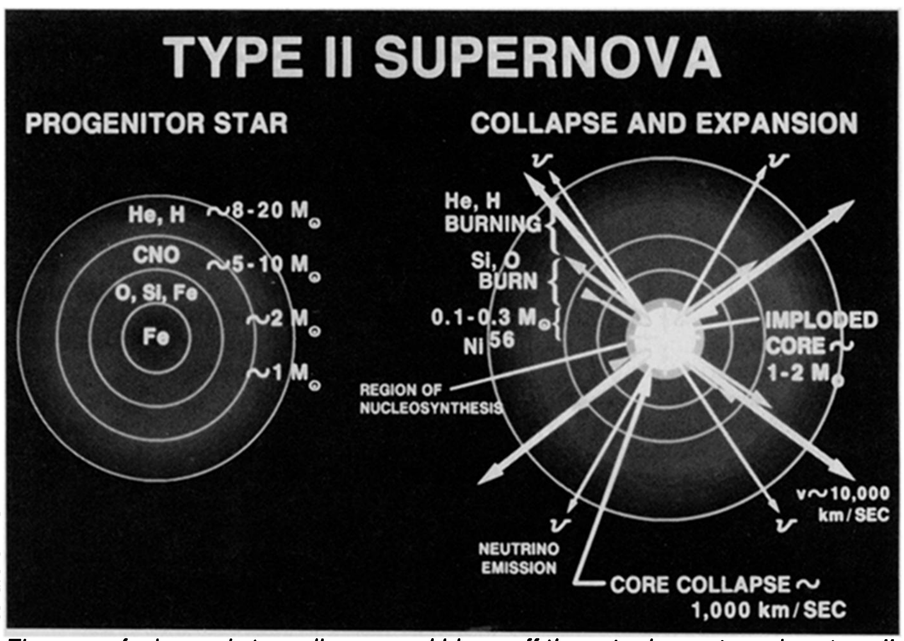
Mark M. Phillips of the Cerro Tololo Inter-American Observatory at La Serena, Chile, called it "a supernova in search of a tail." However, it may finally have peaked and the tail may be coming. Robert F. Garrison, director of the University of Toronto Southern Observatory at Las Campanas, Chile, where the supernova was discovered, reported at the meeting that it had peaked at magnitude 2.88 on May 22 and was decreasing by 3 percent a day thereafter.

The peak, just slightly brighter than third magnitude, is easily visible to the naked eye, but it doesn't dominate the southern sky as such a close supernova should. "Why so low luminosity?" Phillips asks. If there are more such underluminous supernovas, they would not be seen at large distances. Perhaps this one belongs to a new class, which Phillips calls "Magellanic irregulars."

The biggest recent surprise seems to be the companion object that suddenly appeared. Costas Papaliolios and Peter Nisenson of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass., discovered the object in observations made at Cerro Tololo on March 25 and April 2. At the Vancouver meeting Nisenson described the speckle interferometery that found it.

Speckle interferometry is a means of getting around the twinkling caused by turbulence in the earth's atmosphere. Turbulence continually changes the refractive properties of the air over the telescope, and in so doing blurs together the images of objects that lie very close together. Speckle interferometry takes a large number of short exposures, trying basically to keep up with the changes, and also uses specially designed apertures in the camera to sharpen the resolution. In this case, Nisenson says, they used a mask with seven pinholes in it. The result is a pattern of a great many speckles, imprinted as the changes in the atmosphere make the image jump around. Computer analysis of the speckles can find correlations that show whether more than one body is present and can draw a picture of their relative locations.

Nisenson says his group's analysis of 50,000 frames revealed something characteristic of a double star — that is, two bright objects very close together. "We found this thing," he says, "and we didn't quite know what to make of it." It was brighter by five or six magnitudes than the star that was there before the supernova exploded. It was about three magnitudes fainter than the supernova itself and about 2 light-weeks away from it. They see it in various colors — Lyman alpha (ultraviolet), 5,330 angstroms (green) and 4,500 angstroms (blue) — but with slightly different ratios of brightness to the supernova at different wavelengths. A group from Imperial College, London, working with the Anglo-Australian Telescope in Australia, confirmed the finding on April 22. Nisenson



Illustrations: NASA

The core of a layered star collapses and blows off the outer layers to make a type II supernova. Numbers are multiples of the sun's mass.

summed up with the remark: "Nobody's seen this detail before."

As theorists grope for an explanation, certain obvious suggestions can be ruled out from the start. For one, as Stanford E. Woosley of the University of California at Santa Cruz pointed out at the meeting, the thing wasn't there before, so it couldn't be an ordinary star. By its appearance it is not a second supernova. Nor is it something ejected from the supernova; 2 light-weeks is too far for anything to have flown in the time since the explosion at the speeds measured for matter involved in the explosion. An obvious solution is that the spot represents a bit of interstellar gas that was already there and is reflecting or reprocessing light or some similar radiation received from the supernova.

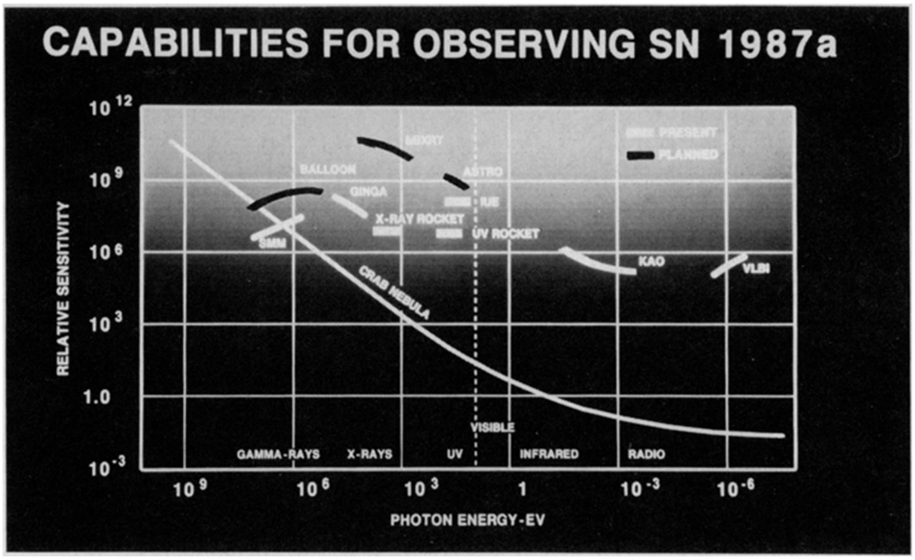
Adopting such a solution raises other problems, however. The companion spot represents a small part of a spherical surface around the supernova at its distance. If one assumes that the radiation that lights the spot comes out in all directions with equal intensity, the total amount is fantastic, according to several commentators. Richard N. Manchester of the Commonwealth Scientific and Industrial Research Organization in Epping, New South Wales, Australia, suggests that a beam of neutrons sent out by the supernova explosion might be hitting just the one spot and causing it to radiate light.

Kenneth Brecher of Boston University suggests beamed radiation from a pulsar inside the supernova. Astrophysicists expect supernovas to produce pulsars. The explosion crushes the core of the exploding star, turning it into a neutron star — a tiny, extremely dense body composed almost entirely of neutrons. All neutron stars may not be pulsars, but astrophysicists generally believe that all radio pulsars are neutron stars.

If there is such a pulsar in the supernova, Brecher says, it may be beaming some kind of electromagnetic radiation or some highly energetic particles in such a way that they strike just the spot represented by the mystery companion. Subatomic particles moving at at least half the speed of light could have covered the distance by now, he calculates. However, the energy supplied by such a beam has to be converted to light by the gas or other matter in the companion object, and on this point Brecher passes: "How you reprocess it, I don't know."

Manchester objects that this "would be an extraordinary pulsar," 10 times as bright as the one in the Crab nebula, which is considered a standard.

Referring to the companion, Richard A. McCray of the Joint Institute for Laboratory Astrophysics at the University of Colorado in Boulder says, "Nature is more imaginative than astronomers." He points out that if the companion is a real object lit up by the supernova, then in 10 to 20 months, material flying out from the supernova will begin to shove into it. "That's going to be exciting," he says.



Capabilities of various satellites, rockets and balloons observing SN 1987A are graphed according to the wavelengths each receives and its relative sensitivity (sensitivity is greatest at top). The output of the Crab nebula, the remnant of a supernova of 1,000 years ago, appears for comparison.

Whether or not the pulsar is beaming something at the companion, it should eventually manifest its presence with its own direct radiation, a pulsed radio signal and maybe a pulsed light signal. Right now the thickness of the material flying out from the explosion hides the pulsar, but as that material spreads out in space it will thin, and eventually the pulsar in the middle should shine through. Actually discovering it will be a direct proof of the hypothesis that pulsars are made in supernovas. For the first time, scientists will have observed the birth of a pulsar.

Astronomers are keeping watch in the hope of making the discovery. Brecher notes that Jerome Kristian of the Mount Wilson and Las Campanas Observatories in Pasadena, Calif., has a millisecond pulsar detector watching in case the pulsar turns out to have a pulse period in the millisecond range. Manchester reports that telescopes in Australia are watching for both visible and radio pulses. The Anglo-Australian Telescope looks for optical pulses once a week, while radio telescopes at Parkes and Molonglo in New South Wales are looking for radio pulses.

So far astronomers observe the supernova in light, ultraviolet and radio. They are also keeping watch for other forms of radiation expected from the supernova. One of these is infrared.

According to Robert D. Gehrz of the University of Minnesota in Minneapolis, who specializes in infrared observations, dust may form in a supernova. He points out that dust forms in the ejecta of a nova, a less catastrophic form of stellar explosion. Reasoning from this and from inclusions of dust in meteorites, he concludes that "we have every reason to believe dust should form in a supernova." Heated dust would radiate infrared, and infrared would enable astronomers to follow the supernova in daylight, something visible-light observations can't do.

The onset of such dust formation may be as early as August or September, or it could be as much as six months later, Gehrz suggests. However, when and if it comes, it will seriously obscure the visible and ultraviolet radiation from the supernova. This part of the prediction caused Robert P. Kirshner of the Harvard-Smithsonian Center for Astrophysics, who supervises observations by the International Ultraviolet Explorer satellite, to remark, "I hope not."

Dust and infrared may be controversial, but gamma rays are not. Experts generally expect them from a supernova. Theorists of nuclear physics consider supernova explosions to be the only likely places for the formation of some of the heaviest chemical elements. The nuclear fusion processes that synthesize these elements produce gamma rays that will be recognized by their characteristic energies. The pulsar in the supernova may also emit gamma rays.

Under the direction of Edward L. Chupp of the University of New Hampshire at Durham, the Solar Maximum Mission satellite is looking for both kinds of gamma rays. Finding those from nuclear synthesis would be a direct confirmation of a theory that is of capital importance to cosmology, chemistry and ultimately biology. As Chupp puts it, we would "find out where the elements come from that we're all made of." □