Unfortunately, that's where the *JOIDES Resolution* is now, on Leg 114, which is supposed to address some of the same questions of Leg 113 but in a slightly warmer climate. According to O'Connell, the *Resolution* is battling 50- to 80-knot winds and rolling 25°. "It's just horrendous," she says. "They probably have a whole ship full of sick people."

— *S. Weisburd*

Supernova: High on understanding

Supernova 1987A in the Large Magellanic Cloud is inspiring a growth industry in scientific papers. Particularly satisfying to a scientist is to have predicted something before or immediately after the appearance of 1987A that now comes true in the ongoing development of the phenomenon. At last week's meeting of the American Physical Society (APS) in Crystal City, Va., this attitude was parodied by Michael Turner of the University of Chicago, who made the facetious claim that on Feb. 22, the day before the supernova, he had written a paper stating that superstring theory predicted a supernova in the Large Magellanic Cloud: "Six of my friends signed the cover to witness that I did it on the 22nd." Turner got a good laugh — because, although superstring theory apparently has nothing to do with supernovas, many serious predictions *are* coming true.

As a result, astrophysicists are beginning to understand a good deal: "We understand what makes a type II supernova," says Stirling A. Colgate of Los Alamos (N.M.) National Laboratory.

This claim of understanding fits in well with other descriptions of supernova euphoria: "more exciting than Woodstock" (John N. Bahcall of the Institute for Advanced Study in Princeton, N.J.); "first time we've actually caught a core collapse of a star" (Adam Burrows of the University of Arizona in Tucson); "uniting a wide group of people who ordinarily pass each other in halls with polite grunts" (Robert P. Kirshner of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass.).

The current situation is something of a turnaround from the days of early March, when confusion over what star had exploded was giving astrophysicists a boxed-in feeling (SN: 3/14/87, p.65). Now observers seem to agree that it was a rather unusual blue giant star that exploded — Sanduleak -69° 202. As astrophysicists take into account the characteristsics of this star, things begin to fall into place.

In the first few days after the Feb. 23 discovery of the supernova, observers thought it was Sanduleak -69° 202 that had exploded. Then data from the International Ultraviolet Explorer satellite, supervised by Kirshner, seemed to show the blue giant star still there. Now a reexamination of those data show that of the three stars known to be in the immediate area before the supernova, the two on either side of Sanduleak -69° 202 remain, but it has vanished.

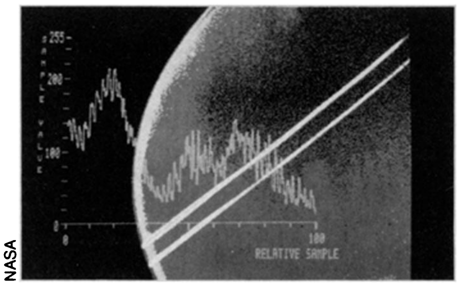
Neutrinos from the supernova have gained a great deal of attention in recent weeks (SN: 3/21/87, p.180; 4/11/87, p.231; 4/18/87, p.246). Well they might, as they involve a fantastic amount of energy. Burrows estimates it at 10^{53} ergs. Trying to put this into a human perspective, Alfred K. Mann of the University of Pennsylvania in Philadelphia translates it to a power of 10^{45} watts and calculates that a million power plants producing 1,000 megawatts of electricity each would still be 10^{30} times short of the amount. So, he says, the explosion is "10^{30} times larger than anything human beings would ever dream of."

All this means, as Burrows puts it, that "[the visible flash of] the supernova is a sideshow compared with the main event, which is the formation of a neutron star." The neutron star forms as the core of the exploding star collapses. Neutrinos are produced, as Colgate points out, by the "deleptonization of this core" — that is, particles of the lepton class, primarily electrons, disappear as everything turns to neutrons.

Burrows estimates that about 10^{58} neutrinos are produced and, after being trapped in the core for a short while, eventually diffuse out and fly off into the universe. He estimates that about 1 kilogram (in mass-energy equivalent) of neutrinos passed through the earth, and says neutrinos probably passed (harmlessly) through the bodies of some 8 million people. On this basis Colgate suggests that many supernovas are not seen — they expend nearly all their energy in neutrinos and other unseen radiation. He estimates there is one supernova a second in the whole universe.

Gravity waves are another form of radiation expected from supernovas. The case for neutrinos is relatively certain, being based on simultaneous observations by detectors in Japan and Ohio. The case for gravity waves is almost nonexistent, but nevertheless there are some tantalizing data.

Gravity waves are gravity's analog to radio waves. Cyclic disturbances of gravitational forces that propagate themselves through space, they carry energy and therefore information. For astronomers they could be a completely new way of getting data about the universe. Gravity waves should produce microscopic vibrations in large massive objects. Several detectors around the world occasionally see rumbles that could be gravity waves, but a positive claim to their discovery will require two or more detectors seeing the same vibration at the same time.



NASA

Ultraviolet spectrum of the supernova. Two slanted bands show how the spectrograph spreads out the ultraviolet light. The wiggly line is a graph of ultraviolet brightness vs. wavelength.

A detector at the CERN laboratory in Geneva, Switzerland, operated by physicists from the University of Rome, reported events at the time of the supernova. And at the APS meeting, Joseph Weber of the University of Maryland in College Park showed a spike — a vibration stronger than background — in one of his detectors, but he commented: "I am reporting an observation. I am not claiming to have discovered anything."

Radio waves also come from supernovas, and those from supernova 1987A prompted an attempt to measure the size of the exploding volume by the technique of very long baseline interferometery, which uses simultaneous observations by widely separated telescopes. Norbert Bartel of the Harvard-Smithsonian Center for Astrophysics told the meeting that if optical astronomers thought they had a hard time getting telescope time in a hurry, they should have been in on the 58 hours of telephoning it took to arrange simultaneous observations by the two radiotelescopes in the Southern Hemisphere capable of this work, which are located at Hartebeesthoek, South Africa, and Tidbinbilla, near Canberra, Australia.

The effort did not succeed in measuring the actual supernova — though the observers still hope for a more positive result as they continue to refine their data analysis — but it did determine that the supernova was no bigger than two-thousandths of an arcsecond across. To put that in perspective, says Bartel, if someone held up a penny in Boston, to an observer in Washington, Lincoln's head would be about two-thousandths of an arcsecond wide.

A successful measurement of the supernova's width would give astronomers, who already know the distance of this one, a size/distance ratio for a supernova. They could then hope to use this on supernovas in more distant galaxies, as an independent way of measuring the distances of such galaxies and so checking on the expansion of the universe and other cosmological parameters.

— *D.E. Thomsen*