Supernova makes heavy elements

Decades ago, as scientists considered how the universe might have generated the various chemical elements found in nature, they came up with plausible models for the formation of the lighter ones through processes of nuclear burning in stars. However, stellar processes cannot make the heaviest elements, so for these, theorists evolved the scenario called explosive nucleosynthesis: When stars explode as supernovas, they generate shock waves in which conditions are violent enough to form the heaviest elements. It seemed to be the only way.

The theory, which is 20 years old, now receives its first direct observational support by the first recordings of gamma rays from supernova 1987A. The Solar Maximum Mission satellite, which has been looking for gamma rays since the supernova first appeared on Feb. 23, 1987, found evidence for gamma rays of 843 kilo-electron-volts (keV) energy in data accumulated between Aug. 1 and Oct. 31.

Steve Matz of the National Research Council and the Naval Research Laboratory in Washington, D.C., and his colleagues reported the find at a recent meeting in Washington, D.C., and on International Astronomical Union Circular 4510. Two balloon-borne experiments, flown in October and November from Alice Springs, Australia, confirmed the finding.

The observers are suggesting that these gamma rays are from the decay of the isotope cobalt-56, a key element in the chain of nucleosynthesis postulated by the theory. The theoretical chain begins with silicon, which is present in the star before it explodes, and is turned to nickel-56 in the supernova shock. The nickel then decays to cobalt-56 and ultimately to stable iron-56. The cobalt gamma rays should have an energy of 847 keV. There is a 5-keV uncertainty in the Solar Max observation, so the observers feel the coincidence is close enough. Observers have been seeking cobalt gamma rays from supernovas since the theory was formulated, but other supernovas have been too distant for the observations to succeed.

One of the people who were involved in the formulation of the theory and in the first attempts to observe supernova gamma rays 19 years ago, Gerald J. Fishman of NASA's Marshall Space Flight Center in Huntsville, Ala., is a principal scientist for one of the balloon experiments. The research used a detector that observes both hard X-rays and gamma rays, which Fishman manages in collaboration with William G. Sandie of the Lockheed Palo Alto (Calif.) Research Center. The other balloon experiment is an imaging gamma-ray telescope from the California Institute of Technology in Pasadena, directed by Thomas A. Prince.

Solar Max was put up in 1980 to observe the sun as a joint effort of NASA, the U.S. Naval Research Laboratory and the Max Planck Institute for Extraterrestrial Physics in Garching, West Germany. Its principal investigator is Edward L. Chupp of the University of New Hampshire in Durham. When the supernova appeared, the satellite was able with some difficulty to turn its Gamma Ray Spectrometer (GRS) toward it.

When Japanese and German astronomers working with the Japanese Ginga satellite and the Soviet Mir space station first reported X-rays from supernova 1987A back in October (SN: 10/24/87, p.263), theorists had expected the discovery of gamma rays soon to follow. They theorized that the observed X-rays were actually generated from gamma rays by the process known as Compton scattering. At the time, theorists supposed that the matter in the supernova shock front was too thick for the gamma rays themselves to get out.

As the supernova's essentially spherical front expands into space, the matter in it gets thinner, and more and more wavelengths of radiation can get out. Observers had recorded visible light, ultraviolet, infrared and radio before the X-rays. Gamma rays were expected to be next.

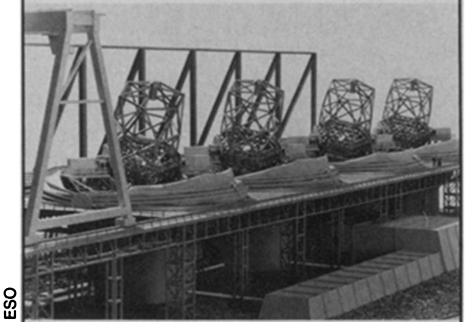
In fact, says the report of the Solar Max scientists, their satellite's first detection of the gamma-ray line roughly coincided with the first detections of X-rays by Ginga and Mir. In reference to the 847-keV gamma rays, the Solar Max scientists say, "This feature cannot be explained by any statistical or systematic fluctuations observed in the seven previous years of GRS data." In other words, they believe it's real. There is also evidence, they say, for another gamma-ray energy associated with cobalt decay, 1,238 keV.

According to theory, about 1 percent of the total mass of the star that exploded, Sanduleak -69°202, should have been turned into cobalt. From the fluxes of gamma rays that they measured, the observers conclude that they seem to be looking through a rift in the supernova front and seeing only 1.3 percent of the total amount of cobalt thought to be present in the supernova on Aug. 1.

The earlier X-ray observations had also suggested that radiation was coming through rifts or rare spots in the supernova front. This would indicate that the front's structure is not homogeneous, as previously thought, but patchy.

As time goes on, changes in the flux of gamma rays should indicate the rate at which the cobalt is decaying into iron and whether it conforms to theoretical expectations. Balloon flights will continue — several are planned for early 1988 — and Solar Max will continue to observe the supernova. *— D.E. Thomsen*

Very Large Telescope



ESO

Eight European nations, linked together in the European Southern Observatory (ESO), have agreed to construct the ESO Very Large Telescope. When completed, it will be the world's largest optical telescope, consisting of four 8-meter mirrors that will be able to combine their images to simulate a single mirror of 16-meter diameter. According to an ESO announcement, "This decision expresses Europe's confidence in the ambition of her astronomical community and the ingenuity of her high-tech industry; together they will ensure that Europe will be second to none in the exploration of the Universe for a long time to come." The eight nations involved are Belgium, Denmark, France, the Federal Republic of Germany, Italy, the Netherlands, Sweden and Switzerland.

The four mirrors will stand in a row, each housed in a separate dome. Designed in two pieces, the domes will fold back like awnings when the mirrors are operating. Mirrors of this size cannot depend on monolithic thickness of glass to maintain the shapes of their surfaces. Instead the mirrors will be thin, and an active support system composed of levers and thrusters controlled by a computer will hold the shapes. According to the announcement, ESO has tested the principle with a 1-meter mirror and it has been incorporated into ESO's 3.5-meter New Technology Telescope, which will start operating at ESO's present observatory at La Silla, Chile, in late 1988. ESO has not yet decided whether to build the Very Large Telescope at La Silla or somewhere else in the Atacama Desert of northern Chile. The La Silla site is an excellent one, the announcement says, but better sites may be found farther north. One such site that shows promise is Cerro Paranal, about 100 kilometers south of Antofagasta. The final choice of site is not expected for about three years.

European astronomers have been studying and planning the project since 1984. The telescope is expected to take 10 years to complete, although part of it could be in operation by 1994 or 1995. They estimate the total cost at $230 million. *— D.E. Thomsen*