Astronomy

Echoing supernova

Infrared observations of supernova 1987A show a bright ring around the supernova that is apparently an infrared echo of it. The recently completed analysis of those observations, which were made Aug. 6 at the European Southern Observatory in La Silla, Chile, were reported in "International Astronomical Union Circular 4481" by A. Chalabaev of the Observatoire de Haute Provence at St.-Michel-l'Observatoire, France, and C. Perrier and J.M. Mariotti of the Observatoire de Lyon (France).

At the same time, in the Dec. 1 ASTROPHYSICAL JOURNAL LETTERS, Bradley E. Schaefer of the NASA/Goddard Space Flight Center in Greenbelt, Md., predicts the appearance of an echo in visible light. This visible echo should in fact already be there, he says, although it is indistinguishable because of the brightness of the supernova itself. Later, as the supernova dims, the echo should become more dominant. By a year after the supernova explosion — around March 1988 — the echo should be a ring of about 10th magnitude, visible in small telescopes and maybe binoculars. It should persist for decades. "After the supernova itself has faded, the light-echo nebula will remain visible like the Cheshire Cat's smile," Schaefer writes.

On earth, the first indication of a supernova is light coming directly from the exploding star. However, the exploding star is surrounded by diffuse interstellar matter and may also have a somewhat denser circumstellar shell of material that sometime in the past came off the star itself. Light going out in all directions from such an explosion will be reflected off this matter, and some of the reflected light will eventually come to earth. This reflection, the "echo," will first appear sometime after the supernova itself, as the light takes time to go out and get reflected. The geometry of the situation is such that at any particular time, a ring of matter at a particular distance and angle from the supernova will reflect the light seen on earth as the echo, accounting for the ring shape.

The echo is interesting not only as an optical phenomenon but also as a probe of the nature of the matter surrounding the supernova. Terrestrial telescopes cannot resolve the light echoes of distant supernovas, says Schaefer, but two fairly close novas have exhibited the effect, Nova Persei 1901 and Nova Sagittarii 1936.

A supernova remnant around a pulsar

One of the things a supernova is supposed to produce is a pulsar. The core of the exploding star collapses, forming a neutron star, which, as it spins, produces the characteristic pulsed radiation. However, of the more than 300 known pulsars only two or three are known to be inside supernova remnants, the glowing nebulas of energized interstellar matter that remain after the supernova itself has died away. Astrophysicists suppose that the remnants may be too faint to be seen or that pulsars have a way of escaping from the remnants, but to strengthen the credibility of the theory they would still like to find more pulsars in supernova remnants.

Now they seem to have at least one more. France A. Cordova and John Middleditch of Los Alamos (N.M.) National Laboratory, Robert M. Hjellming of the National Radio Astronomy Observatory in Socorro, N.M., and K.O. Mason of the Mullard Space Science Laboratories in Manchester, England, report that PSR 0656+14 emits X-rays with a very "soft" spectrum, possibly pulsed ones. The softness (low frequency) of the X-rays argues for the nearness of the pulsar, and a recent measurement of the rate of change of its pulse period argues for relative youth (about 100,000 years old). Together these data suggest that a diffuse X-ray flux in the neighborhood, known as the "Gemini-Monoceros soft X-ray enhancement," could be a supernova remnant of the explosion of PSR 0656+14. The data are on International Astronomical Circular 4490.

Technology

Looking into metal specimens

In magnetic resonance imaging, certain atomic nuclei in samples held within a magnetic field absorb, then emit, radio waves at characteristic frequencies. Such data can be used to construct images showing the location of particular atoms in the sample. These images have important medical applications because researchers can use the technique to examine animal and human tissue without having to remove a specimen.

Now, Stephen J. Norton of the National Bureau of Standards (NBS) in Gaithersburg, Md., has proposed a new imaging technique based on a somewhat different nuclear effect. Unlike magnetic resonance imaging, this technique can be used for studying the internal structure of metal alloys, composites and other materials.

Norton's technique is based on a nuclear phenomenon known as the Mössbauer effect. Nuclei of atoms such as iron, when embedded in a solid lattice, can emit and absorb gamma rays without suffering any recoil. As a result, the absorption or emission frequency of a typical gamma-ray signal is confined to a narrow range, allowing precise measurements of nuclear phenomena or a remarkably sensitive means of marking the presence of certain elements in a sample.

In a conventional Mössbauer experiment, a moving radioactive source emits gamma rays, which are then absorbed by the sample. A detector counts the number of gamma rays that manage to pass through the sample. Such measurements, however, provide only bulk averages. Any variations in the distribution of an element within a sample go undetected in the averaging process. Norton's idea is to rotate the sample while moving the source. This provides enough information for a computer to construct an image showing how absorption varies with position within a sample. From this, researchers can deduce the distribution of certain elements.

"Applications of Mössbauer imaging to the interior of objects appear to be limited to lighter materials, or small objects, that permit sufficient [gamma]-ray penetration," Norton reports in the Nov. 12 NATURE. "One possibility is the imaging of composite materials, in which one wishes to image the distribution of a Mössbauer element embedded in a lighter matrix."

In a recent test of Mössbauer imaging, also reported in the Nov. 12 NATURE, a group of NBS researchers successfully generated a one-dimensional image that accurately represented the distribution of stainless steel across a sample. They suggest that even a primitive version of Mössbauer imaging may be useful for materials science applications, such as examining variations in composition across rapidly cooled ribbons of iron-containing alloys.

"The experiment was very simple and designed to show the idea works," says Norton. NBS researchers are now considering the possibility of trying a two-dimensional experiment — determining the distributions of specific elements across a thin metal foil.

Shock full of nuts

A supercritical fluid is a substance that has been heated and compressed so that it exists neither as a liquid nor as a vapor but as a combination of the two states with its own distinctive properties. Such fluids are often excellent solvents and are used commercially for processes such as extracting caffeine from coffee beans. However, conventional techniques for bringing a fluid to its critical point are slow and expensive, taking as long as 36 hours. As an alternative, Philip A. Thompson of the Rensselaer Polytechnic Institute in Troy, N.Y., suggests the use of shock waves, which can bring a fluid to its critical point in less than a millisecond. Thompson has been using the shock-wave technique in his laboratory to study the behavior of supercritical fluids.

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