Take it to the max: Supernova in overdrive

Of all the things that go bang in the sky, astronomers have ranked supernovas as the most powerful. In these explosions, a star hurls its outer layers into space at 10 percent of the speed of light and crushes its mammoth core down to a cinder a few kilometers in diameter.

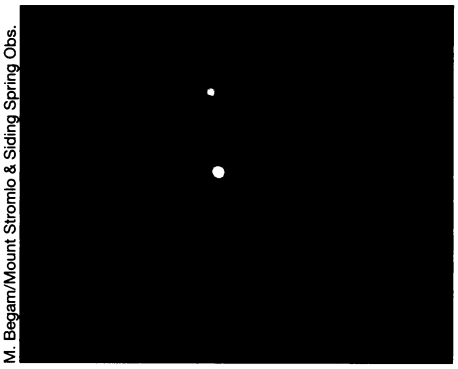
Now, researchers have the first evidence of a souped-up supernova—an eruption of similar origin that generates 100 times more energy. Traditional supernovas often leave behind a compact kernel known as a neutron star, but this explosion may have given birth to a much denser remnant, a black hole.

On May 5, researchers at the Australia Telescope Compact Array in Narrabri detected the most intense radio emission ever recorded from a stellar explosion. The most likely explanation is that a massive star underwent an explosion so cataclysmic that material raced into space at nearly the speed of light, asserts Shrinivas R. Kulkarni of the California Institute of Technology in Pasadena. He and his colleagues describe the findings in a May 13 circular of the International Astronomical Union.

Theorists recently invoked such an explosion, dubbed a hypernova, to explain the enormous energy unleashed by a gamma-ray burst recorded in December 1997 (SN: 5/9/98, p. 292).

Intriguingly, just 10 days before the May 5 radio outburst, the Dutch-Italian satellite BeppoSAX recorded a burst of gamma rays from the same patch of sky. However, X-ray emissions recorded by BeppoSAX shortly after the gamma-ray burst do not coincide with the radio emissions. Thus, it remains uncertain whether the radio emission is associated with this gamma-ray burst, notes Bohdan Paczynski of Princeton University.

The recent stellar explosion is fascinating in its own right, says Kulkarni. The



M. Begam/Mount Stromlo & Siding Spring Obs.

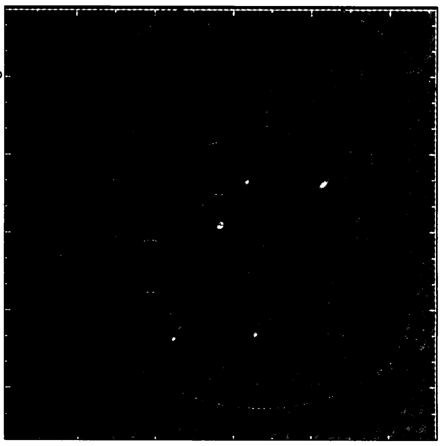
The bright spot at the center of this visible-light image gives evidence of the supernovalike explosion.

visible light radiated by the exploding object, which astronomers first observed on May 2, is characteristic of a newborn supernova, he notes. Spectra revealed that the explosion originated in a relatively nearby galaxy about 130 million light-years from Earth.

When Kulkarni's Australian collaborators recorded radio waves from the exploded object shortly afterward, it marked the first time that astronomers had detected a strong source of radio waves from a newborn supernova, he says.

Kulkarni and his collaborators calculated the intensity of the radio wave emission, measured in terms of temperature, as about 300 trillion kelvins—100 times greater than an ordinary supernova could produce. The most reasonable explanation, he says, is that this supernova expelled a portion of its material at 99 percent of the speed of light.

If the discovery holds up, "it will provide the missing link between supernovas and gamma-ray bursts and a Rosetta stone for understanding both," says Stanford E. Woosley of the University of California, Santa Cruz. He argues that if supernovas mark the birth of neutron stars, then hypernovas and gamma-ray bursts may mark the birth of black holes. —*R. Cowen*



M. Wieringa/CSIRO

The central bright point (arrow) indicates a radio emission from the stellar explosion. The outer circle indicates the region in which a gamma-ray burst was detected on April 25. Two inner circles indicate the X-ray emissions that may be linked with that burst.

Seizure prelude found by chaos calculation

Concertgoers take delight in hearing the cacophony of tuning transform into the harmony of a symphony. In the brain, however, the subtle shift from a disorderly chatter of neurons into a more synchronized pattern can be a step toward the uncontrolled electrical storm of a seizure.

Epilepsy researchers have long suspected that too much synchrony among too many neurons may be dangerous. Now, a German research team has demonstrated that a "loss of complexity" due to coordinated nerve firing is detectable in brain waves an average of 11 minutes before the onset of a seizure.

In reaching this finding, University of Bonn researchers Klaus Lehnertz and Christian E. Elger made innovative use of a mathematical property from chaos theory, known as dimension, that many scientists had deemed useless for highly complicated biological systems such as the brain.

The finding opens a possible way to preempt seizures, the researchers state in a report slated to appear in the June 1 Physical Review Letters.

They are already testing whether patients whose seizures originate in the hippocampus, a region associated with memory and learning, can avoid the paroxysm by means of mere remembrances or learning tasks, Lehnertz says. The team also expects to develop in the next 3 to 4 years an implantable monitor capable of providing a warning or automatically delivering drugs or electrical stimulation.

"It's a good, solid piece of work," says Steven Schiff, a neurosurgeon and epilepsy researcher at Children's Research Institute in Washington, D.C. "In the future, if we're going to develop technologies to have electrical control of seizures, we'll need techniques like this."

On the other hand, he says, many hurdles lie in the path of stopping seizures electrically, not the least of which is safely putting electrodes on or in the region where seizures originate, called the focus.

Lehnertz and Elger analyzed electroencephalograms, or EEGs, from 16 awake patients whose epilepsy could not be controlled with drugs. One set of measurements covered periods just before seizures, and the other looked at periods at least 24 hours before or after seizures.

Using an array of 30 parallel-linked personal computers to calculate dimension throughout each of their 68 observation periods, Lehnertz and Elger found that its numerical value tended to take markedly deep, long dips just before a seizure. Also, this pattern was more pronounced in tissues near the focus.

By using dimension to assess EEGs, the researchers have revived a practice—using chaos theory to study the brain—that had lost credence with many researchers.

"My eyes glazed over," says Daniel T. Kaplan, a specialist in nonlinear analysis at Macalester College in Saint Paul, Minn., when he first heard of the EEG analysis. In this case, though, "it really seems to work."

The epilepsy researchers took pains to avoid the pitfalls of earlier research by making no claim that their dimension data represent some functional characteristic of the brain's wiring.

"We don't say the brain is linear or nonlinear or chaotic or whatever. We just compare different states and nothing else," Lehnertz says. —*P. Weiss*