Do supernovas generate gamma-ray bursts?

Astronomers searching for the remnants of the explosions that spawn gamma-ray bursts have a problem. They don't know what they're looking for.

Last week, however, researchers reported progress in their quest to find the remains of bursts, the short-lived but most energetic events in the universe.

Q. Daniel Wang of Northwestern University in Evanston, Ill., made his discovery while examining two expanding shells of gas in the galaxy M101. Astronomers have assumed these to be the remnants of separate stellar explosions called supernovas. During a supernova, a massive star ejects its outer layers and a shock wave sweeps up the material along with surrounding gas and dust. Although powerful, supernovas have been thought to have too little energy to create a gamma-ray burst.

Analyzing the visible-light and X-ray emissions from the two remnants in M101, Wang found that each has 10 to 30 times more energy than a supernova remnant would typically carry. He suggests that both remnants represent material left over from the much more energetic outbursts called hypernovas.

According to theorists, a hypernova arises when a massive star collapses under its own weight to become a black hole. That catastrophic collapse could generate a gamma-ray burst (SN: 5/23/98, p. 326).

Wang says that his observations, presented at a meeting of the American Astronomical Society in Charleston, S.C., represent the first identification of a hypernova remnant.

However, "there is no clear signature that would tell you this is a gamma-ray burst remnant and not something else," comments Abraham Loeb of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass.

In a paper posted on the Internet, Loeb and his Harvard-Smithsonian colleagues suggest ways to search for the remnants of gamma-ray bursts (http://xxx.lanl.gov/abs/astro-ph/9904181). One clue could be oppositely directed jets of ionized gas—if the bursts are highly focused like a searchlight, as scientists have recently speculated.

Evidence of such jets has led Renyue Cen of Princeton University to argue that supernova 1987A, the nearest supernova to Earth since 1604, may have produced a gamma-ray burst. No one saw the burst because it pointed away from our line of sight, Cen suggests in a paper on the Internet (http://xxx.lanl.gov/abs/astro-ph/9904147).

He bases his proposal on a new analysis of images taken a month after astronomers witnessed the explosion 12 years ago. At that time, Peter Nisenson and Costas Papaliolios now of Harvard-Smithsonian and their colleagues found a mysterious bright spot next to the supernova.

Using a new computer algorithm, Nisenson and Papaliolios confirm the existence of this spot and also find signs of a second spot on the other side of the remnant (http://xxx.lanl.gov/abs/astro-ph/9904109). The two spots could indicate that 1987A spewed oppositely directed jets of material in addition to generating a bubble-shaped remnant, Cen says.

If these jets prove to be evidence of gamma-ray bursts, then supernovas may be capable of generating the most energetic phenomenon in the cosmos. Because supernovas are far more common residents of the celestial zoo than are hypernovas, this suggests gamma-ray bursts may erupt relatively frequently.

"It's far too early to tell whether this is correct or not," says theorist Bohdan Paczynski of Princeton University, "but it's very tantalizing." —*R. Cowen*

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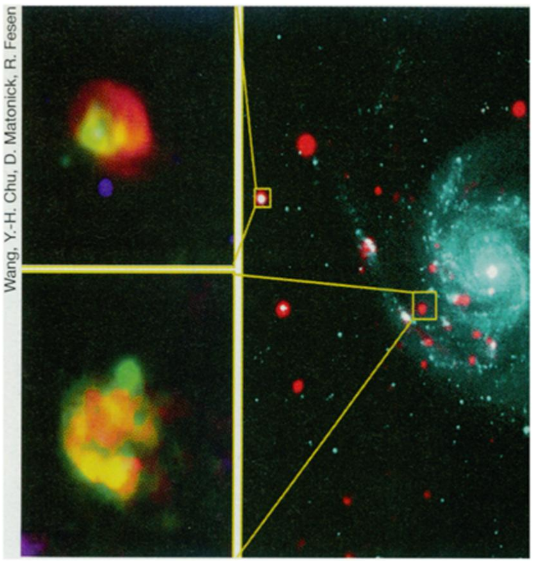

Two expanding blobs of gas (left top and bottom) in the galaxy M101 (right) may be remnants of energetic explosions capable of producing gamma-ray bursts. Red dots indicate sites of strong X-ray emissions.

Superplastic metals stretch to a new low

When heated to the right temperature, some metals can be drawn out like a string of taffy. Scientists have now found that this behavior, known as superplasticity, can occur at temperatures hundreds of degrees lower than expected.

This is good news for manufacturers, such as car makers, interested in making strong, lightweight parts from these stretchy metals. Superplastic metals can be molded almost like plastics themselves.

"You can make very complex shapes without machining," says Amiya K. Mukherjee of the University of California, Davis. He and his colleagues at Davis and the Ufa State Aviation Technical University in Russia report their findings in the April 22 NATURE.

The key to achieving superplasticity at low temperatures lies in a material's atomic structure. The researchers tested thumbnail-size samples of three metals: pure nickel, nickel aluminide, and a commercial aluminum alloy. They processed the metals by repeatedly twisting them under high pressure, breaking their internal structures into grains only a few nanometers in size.

The pure nickel ended up with a grain size of 20 nm, showing superplasticity between 280°C and 350°C, a little over one-third of its melting temperature. This result "contradicts the current opinion that a temperature of at least [half] of the absolute melting temperature is required for superplastic flow," says Terence G. Langdon of the University of Southern California in Los Angeles. The two alloys likewise became superplastic at lower than expected temperatures.

In a solid with a grain size of 20 nm, almost 30 percent of the atoms take on a noncrystalline structure, says Mukherjee. They lie along the edges of the grains, where "the chemical and physical properties are very different," he notes. "These atoms move and diffuse very fast" to fill in gaps opened by stretching. The process keeps the material from breaking, leading to superplasticity.

Only recently have materials scientists been able to make metals with such fine grains. Commercially available superplastic metals have grains at least 100 times as large.

Processing superplastic metals at lower temperatures means lower energy costs and less wear on tools. The time and expense of current commercial techniques for making superplastics have limited their use to special applications such as complex airplane parts and turbine engines.

"There is considerable interest in expanding the technology into a much wider industrial field—for example, the automotive industry," says Langdon. Automakers such as Lamborghini already make parts from superplastic metals, which is "OK for a $150,000 car, but not for a $20,000 one," he observes.

In addition to cost savings, such nanostructured metals provide exceptional strength at ambient temperature, says Mukherjee. These materials can be used to make strong but lightweight biomedical gear such as prosthetics or braces.

"This is opening a new, exciting window in the very active field of superplasticity research," says David C. Dunand of Northwestern University in Evanston, Ill. —*C. Wu*