ASTRONOMY

Supernova and Gamma Burst Might Have Common Source

SAN DIEGO—A stellar explosion in a galaxy 140 million light-years away might turn out to be the Rosetta stone for scientists trying to make sense of gamma ray bursts (GRBs). "This could well be the missing link" that astronomers have been looking for to explain these cataclysms, which occur at great distances and pump out staggering amounts of energy, says theorist Stan Woosley of the University of California, Santa Cruz. Woosley described the discovery and what it might mean here at the summer meeting of the American Astronomical Society (AAS).

The supernova, which two Dutch astronomers reported on 7 May in an International Astronomical Union circular, produced more than the usual cosmic fireworks. It also took place at about the same time and at the same point in the sky as a 25 April gamma ray burst, marking the first time that a burst has been linked with anything more specific than a bright spot in the sky. If the link between the supernova and the GRB holds up, it could favor a scenario proposed by Woosley and Bohdan Paczyński of Princeton University, in which the collapse of a massive star—a process akin to the one that triggers many supernovae—sparks the outpouring of gamma rays.

The match-up of the supernova and the burst has impressed some other astronomers as well. Chryssa Kouveliotou of the Universities Space Research Association at NASA's Marshall Space Flight Center in Huntsville, Alabama, says it is unlikely to be a chance alignment, but like most astronomers, she's not fully convinced. Ralph Wijers of the State University of New York, Stony Brook, is more skeptical, saying, "the connection [between the supernova and the GRB] is unclear."

Over the last year, the search for a GRB mechanism has heated up as astronomers have realized that many bursts occur in the far reaches of the observable universe, implying that they are unimaginably powerful. Indeed, a burst on 14 December of last year was so far off that it may have been the mightiest explosion ever glimpsed, aside from the big bang itself (*Science*, 24 April, p. 514). In one scenario, the bursts are triggered when two neutron stars (or a neutron star and a black hole) collide and merge. Woosley and Paczyński's theory instead attributes them to the sudden collapse of a very massive star into a black hole, a mechanism that Paczyński has dubbed a "hypernova."

The 25 April burst could tip the scale toward the hypernova or, as Woosley prefers, "collapsar" mechanism. Both the Italian-Dutch BeppoSAX satellite and NASA's Compton Gamma Ray Observatory picked up the burst, and one of BeppoSAX's wide-field x-ray cameras, built by the Utrecht laboratory of SRON (Space Research Organization Netherlands), was able to pinpoint its position. Titus Galama and Paul Vreeswijk, both from the University of Amsterdam, pointed an optical telescope at the European Southern Observatory at La Silla in Chile at the spot—and found a supernova at the same position.

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Flash of revelation? This supernova (bright spot near upper galaxy) may have had the same source as a gamma ray burst detected on 25 April.

The supernova, designated 1998bw, had flared up in a galaxy at a modest distance of 140 million light-years. Galama and Vreeswijk, who describe their discovery in a paper submitted to *Nature*, declined to comment on the exact timing of the supernova with respect to the burst, but according to Woosley, they coincided "within a few days." He says the chance that they are unrelated is only one in 100,000 or one in a million.

The 1998bw event appears to have been no ordinary supernova. Prompted by Galama and Vreeswijk's discovery, Mark Wieringa and his colleagues at the Australia Telescope National Facility observed it with a radio telescope and found that it far outshone other supernovae at radio wavelengths. Woosley adds that its visible-light spectrum, too, was "unlike that of any other supernova"—notably lacking the spectral lines of ionized hydrogen and helium.

The unusual appearance of the supernova suggests to Woosley and other theorists that it had an unusual mechanism, which could have sparked the gamma ray burst as well. The stellar implosion that triggers many supernovae generally stops when the core of the star has collapsed into a superdense neutron star; a shock wave, supercharged by a burst of neutrinos from the core, then blows off the outer layers of the star. But in a collapsar, the progenitor star is so massive—more than 25 times the mass of the sun—that the collapse would not stop at a neutron star; instead, it continues all the way to a black hole, which quickly swallows up almost all of the star's mass.

According to Paczyński and Woosley, the matter vanishing down the gullet of the black hole emits a titanic surge of energy—the gamma ray burst—and triggers a shock wave. The shock wave heats the sparse matter near the star, creating a supernovalike display—but with telltale differences, like those in 1998bw. Wijers, however, doubts that this mechanism can explain all GRBs, saying, "we would've seen earlier associations between gamma ray bursts and bright supernovae."

If the 25 April burst did come from 1998bw, a relatively nearby supernova, the gamma ray flash must have been 100,000 times less energetic than the burst of 14 December, which astronomers have nicknamed "Big Bang 2." To some astronomers, that implies that GRBs may have several different mechanisms. But Woosley thinks the collapsar model can explain such widely varying events. A magnetic field rooted in the rotating black hole could extract extra energy and deliver it to nearby matter to boost some events, or a torus of material around the equator of the black hole could channel energy in two directions, making a very distant burst look brighter if one happened to be aimed toward Earth.

Less direct support for the collapsar idea comes from hints that many GRBs occur in dusty, star-forming regions of galaxies. As Marc Metzger and George Djorgovski of the California Institute of Technology in Pasadena described at the AAS meeting, several bursts have actually been traced to distant star-forming galaxies, while others have very red optical afterglows, a sign that the light has traveled through dust. "Dust also might explain the complete absence of optical counterparts in other cases," says Djorgovski. Because the most massive stars—the ones that could spawn collapsars—live only for a few million years, they would be expected to die in the same star-forming regions in which they were born.

No one is convinced that supernova 1998bw has provided the answer to the GRB enigma. But in a year when the clues to the puzzle have come thick and fast, astronomers think their luck may be holding.

–Govert Schilling

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