Bursting a Theory on Gamma-Ray Flashes

Typically lasting only a few seconds, gamma-ray bursters act like cosmic flash-bulbs: The previously unseen objects unleash a flood of high-energy photons and then vanish – apparently forever. With no counterpart in any other band of the electromagnetic spectrum, including visible light, these ephemeral enigmas have intrigued and confounded scientists ever since their discovery in 1973.

And the mystery continues. A new survey of these bursters, reported this week, appears to dash the prevailing theory about what type of cosmic power-house might briefly spew such energetic emissions.

Although astronomers have tried in vain to match the locations of bursters with the positions of particular stars or galaxies, previous data seemed to suggest that these celestial beacons emanate from observable objects in the Milky Way – most likely from violent outbursts on or near neutron stars, condensed stellar objects that tend to cluster near the center of our galaxy (SN: 6/8/91, p.365).

But gamma-ray bursters occur uniformly throughout the sky, not in an expected clustering either toward the center of the Milky Way or along its disk, scientists working with NASA's Gamma Ray Observatory (GRO) revealed this week. That finding leaves astronomers with two equally unsettling – and exciting – explanations for the bursters, says GRO investigator Gerald J. Fishman of NASA's Marshall Space Flight Center in Huntsville, Ala. The 117 flashes observed with GRO since its launch in April came either from a cloud of small exotic objects a few light-years from Earth or from powerful sources – perhaps a new form of matter – near the edge of the observable universe.

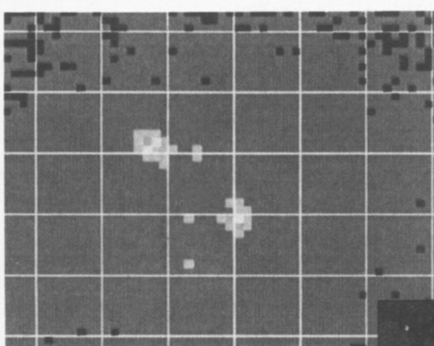
"[Our finding] will upset a lot of people because most theories of the past 10 or 15 years have centered around neutron stars as the source of gamma-ray bursts," Fishman says. "This surprising result indicates that gamma-ray bursts are not associated with the large-scale structure of our galaxy."

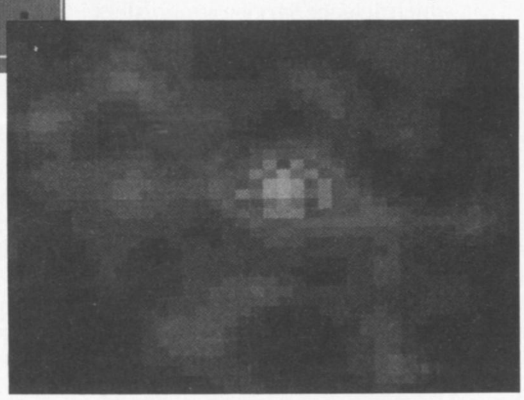
Fishman and other astronomers point out that an unusual feature of the surveyed bursts argues against a relatively nearby source for the gamma-ray emissions. GRO carries a group of eight detectors – collectively known as the Burst and Transient Source Experiment (BATSE) – that can spot gamma-ray bursters 10 times weaker than those observed by previous space-borne detectors.

BATSE observed relatively few low-intensity events, however. If nearby objects produced the bulk of the bursters, Fishman says, researchers should also have seen a substantial number of faint flares, presumably coming from more distant sources.

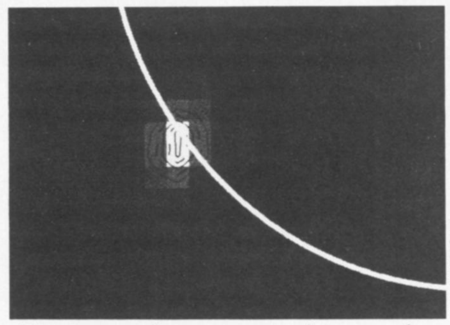
Another possibility – that the brief outbursts arise from objects somewhat farther away in the halo of material that orbits the outskirts and central bulge of our galaxy – also seems unlikely, says Bohdan Paczynski, a theoretical astrophysicist at Princeton University. To match the distribution of bursters cataloged by GRO, he says, the distribution of gamma-ray-emitting halo objects would have to be highly uniform – a feature unlike any exhibited by known collections of stars in that region.

Since 1986, Paczynski and a few other researchers have favored an extragalactic origin for the flashes. In an article in the July 1 ASTROPHYSICAL JOURNAL – written before GRO's launch – he and his co-workers anticipated the new BATSE results and suggested that stars in distant galaxies might account for the distribution of these mysterious gamma-ray outbursts. "It's sensational; it's truly a revolutionary result in astrophysics," he says of the GRO finding.





Top: Image taken with the highest-energy gamma-ray detector on GRO depicts the Gemini and Taurus constellations, revealing the Crab nebula (below and right of center) and a mysterious source called Geminga (upper left). Right: Only the Crab appears in this image taken with a lower-energy GRO detector, indicating that Geminga primarily emits high-energy gammas.



Photos: NASA

First image of a gamma-ray burster, taken May 3 by GRO. The burster lies somewhere on the indicated arc.

If the extragalactic model proves accurate, Paczynski notes, gamma-ray bursters may represent ancient objects billions of light-years from Earth, whose intense flashes of energy signify events in the very early history of the universe. In the same article, his group proposes that collisions between hypothetical, super-dense objects called strange stars might produce the extragalactic radiation.

Though colliding neutron stars in distant galaxies would create similar bursts, he says that most of the gamma rays would probably be unleashed inside the stars and might not reach Earth. However, collisions among strange stars – objects so dense that neutrons and protons would break into their constituent quarks – should create gamma rays on their surfaces. Such photons would stand a greater chance of reaching Earth relatively unimpeded, he says.

The speculation about such a new class of stars may seem like pie in the sky. But Fishman notes that at present this explanation for the bursts seems as reasonable as any other. Paczynski adds that a key test could validate the notion of distant sources, although it could not differentiate between strange stars and ordinary matter. Gravity would bend some of the light rays from distant, individual bursters, delaying their arrival at Earth. Thus, over a period of years, GRO might detect "repeaters" – a pair of identical gamma-ray bursts separated by days or months, Paczynski says.

Researchers also announced this week that GRO's Compton Gamma Ray Telescope captured the first image of a gamma-ray burster. The telescope used a layered pair of detectors to render the portrait. Researchers relied on a small gamma-ray detector aboard the Jupiter-bound Ulysses spacecraft, which also observed the intense burster, to help pinpoint the source's position in the sky.

– R. Cowen