Letter to the Editor

Based on a presentation made at the 92nd Spring Meeting of the AAVSO, April 24, 2003

"Hypernovae, Gamma-Ray Bursts, and Very Low Frequency Radios"

Huge blasts of very-high-energy photons are often recorded by satellites such as HETE II or INTEGRAL, and within the last couple of decades, theoretical understanding of these outbursts has made progress, thanks to the older experiments of BATSE on the Gamma-Ray Observatory and the Dutch-Italian satellite, Beppo-SAX. Hypernovae and gamma-ray bursts are perhaps the largest explosions since the Big Bang. The energy involved in just the gamma-rays alone is 10^{53} to 10^{54} ergs. It may be that the gamma-rays are channeled along a beam and our satellites are fortunate to detect these events which typically last from milliseconds to 100s of seconds. Consider for a moment the energy equivalent of the Sun's mass, calculated using Einstein's equation $E = mc^2$ to be about 2×10^{54} ergs. It takes the core of a massive star, one that is about to go through a gravitational collapse with the mass of our Sun, to convert all this mass into gamma-ray energy within at most a minute or two (Cassé 2003).

So, is it possible that we can detect the effect of these huge explosions in stars so very far away on the upper layers of our ionosphere with Very Low Frequency radios? The answer is, perhaps. There is a good chance that Peter Schnoor of Kiel, Germany, on March 29, 2003, detected the gamma-ray burst GRB030329, at 11:37:40 Universal Time (Schnoor *et al.* 2003). This GRB was what astrophysicists call a strong hard burst, and it lasted for 35 seconds. Not only that, the progenitor star was not so far away, perhaps a red shift of 0.1685 (Greiner *et al.* 2003). Relative to many of the other gamma-ray bursts that satellites have detected over the years, GRB030329 was nearby. Schnoor is alone in the detection of this GRB, but there is good evidence that his 75 kHz VLF radio picked up the signal. The most important fact was that he was using a computer to record data at a one-second sampling rate, because when we record data with a computer, it's possible to have others review and analyze those data and compare with data and graphs from the satellites. Satellites, which have known positions, can help calculate the direction of the incoming burst. Studies done by Stanford's HAIL project on the detection of SGR 1900+14 (Inan *et al.* 1999) show that the direction of the high-energy gamma photons as they hit the ionosphere is very important. To determine whether the VLF radio and the VLF transmitter it is tuned to are located in the correct orientation and location on the ground, it takes knowledge from the satellites about where the GRB is in the sky and from what direction the high-energy photons arrived in the ionosphere.

For those interested in using their VLF receivers to detect long, strong, hard gamma-ray bursts and X-ray transients, it will be necessary to record data with computers. The detection equipment does not have to be complex or expensive, but there does need to be the ability to share data with the professionals who can help determine whether there has been a real detection. If there are VLF receivers scattered over both hemispheres recording at the same sampling rate, it may be possible to confirm detection and help scientists determine the effect of these huge explosions on our ionosphere. For more information, see: Fishman, G. J., and Inan, U. S. 1988, *Nature*, **331**, 418; Peterson, B. A., and Price, A. 2003, *GRB Coordinates Network*, No. 1985; http://space.mit.edu/HETE/Bursts/GRB030329; and http://www.star.stanford.edu/~vlf/hail/hail.htm.

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