COSMIC GAMMA-RAY BURSTS

The recent discovery of short, intense gamma-ray bursts of cosmic origin by Klebesadel, Strong and Olson (*Ap. J.*, (*Letters*), **182,** L 85, 1973 ; see also *Bull. Ast. Soc. India*, **1,** 11, 1973) has caused a flurry of excitement among high energy astrophysicists. The initial detection was made with small ($\approx$ 11 cm^3) scintillation counters on the U. S. Vela satellite system, where order-of-magnitude increases in counting rates due to gamma rays above ≈ 0.2 MeV occurred in fractions of a second and lasted for a few tens of seconds. Simultaneous observation on as many as four widely separated spacecraft (the Vela system, designed for detection of nuclear tests in space, consists of a spacecraft network in $\approx$ 18 earth radii circular orbits) confirmed the reality of the events and eliminated instrumental or local charged particle artifacts. Inter-satellite event timing, accurate to a $\approx$ 16 ms over a 10^5 km baseline, determines celestial location to within a few degrees on a circle of positions for two spacecraft coincidences, or to $\sim 5°$ regions in case of three coincidences.

Twenty events have been detected since 1969 (Klebesadel, Strong, Olson, preprint 1973, submitted to *Ap. J.*) having gamma-ray fluxes $> 5\times10^{-5}$ ergs/cm^2. Seven are sufficiently well timed, and observed by at least three Vela spacecrafts, so a distribution in galactic latitude can be constructed. This suggests isotropy; clearly the events are not concentrated in the galactic plane. Origin in a local galactic region ($d < 100$ pc) implies the phenomena represents an energy release of $\approx 10^{37}$ ergs in gamma-rays alone. If they are of extragalactic origin, the requirement is $> 10^{44}$ ergs. The fast and multiple time structure often observed imply a source region clearly less than 10^{11} cm, and perhaps less than 10^8cm.

The discovery led workers with suitable detectors on other spacecrafts scurrying through records for additional observations. Six of the Vela events, detected simultaneously on IMP-6 (Cline, et al, *Ap. J.* (*Letters*), **185,** L1, 1973) have provided spectral information. The typical burst is characterized by $I(E) \sim \exp(-E/E_0)$, with $E_0 \approx 150$ keV. Eight events during UHURU lifetime confirm that the spectrum does not contain a significant additional component in the 10 keV range. The 0328 UT 14 May 1972 event, because of its longer duration and greater intensity, was observed by atleast eight spacecrafts, including the IMP-6 and OSO-7 (Wheaton, et al, *Ap. J.* (*Letters*), **185,** L57, 1973). Details of the time evolving spectra from 10 keV to 1 MeV are available for this event. A burst at 1058 UT 27 April 1972, not included in the original Vela list, was observed by Metzger and his collaborators (*Bull. Am. Ast. Soc.*, **5,** 395, 1973) during the return transearth coast phase of Apollo 16. The precision gamma-ray spectrometer recorded atleast 6 distinct spikes of 1 to 2 sec duration, and showed no obvious gamma-ray line features.

Theorists have not been slow to provide explanations. Colgate had long ago (*Can. J. Phys.*, **46,** 476, 1968) predicted gamma-ray bursts of <10 ms duration due to relativistic shocks associated with supernovae explosions, and indeed he motivated the Vela workers to search their records. The multiple time structure and longer duration seem incompatible with his original concept, although a modification may maintain (Colgate, *Ap. J.*, 1974 in press). Comets crashing into neutron stars (Harwit and Salpeter, *Ap. J.* (*Letters*), **106,** L37, 1973), stellar "superflares" (Stecker and Frost, *Nature Phy. Sci.*, **245,** 70, 1973), rapidly cooling neutron stras (Cohen and Ramaty, 1973 in press), and enhanced accretion on a neutron star in a binary system due to outbursts of its more "normal" companion (Lamb, Lamb and Pines, *Nature. Phy. Sci.* **246,** 52 1973) have all been suggested.

If the events are isotropically distributed, the number observed will vary as the detection threshold to the 3/2 power (ln N-ln S). Hence a detector with a sensitivity only 1/20 that in Vela should see $\sim$ 1/day, instead of $\sim$ 5/year now catalogued. Several such instruments are already orbited ; selection of true cosmic events from spurious rate increases poses a serious problem. Specifically designed balloon-borne detectors, and modifications to satellite instruments now under construction, will increase the event "catalog" dramatically in the years to come. A "gamma-ray burst" spacecraft network in solar orbit, with enough detector sensitivity to permit millisecond interspacecraft timing, will obtain positions to arc-second accuracy, and therefore unambiguous optical or radio identification.

L. E. Peterson*

Tata Institute of Fundamental Research
Bombay 400 005

* On leave from University of California, San Diego.

THE LABORATORY AND SOLAR SPECTRUM OF IRON HYDRIDE

The study of absorption lines in solar photospheric spectrum is very important for understanding the physical situation of the photosphere. However, many absorption lines still remain unidentified. Some of these unidentified lines may be due to molecules expected to be abundant in the solar photosphere, but not studied in the laboratory spectroscopically. Iron hydride (FeH) is one such molecule. Schadee (*Bull. Astr. Inst. Netherlands*, **17,** 311, 1963) argued that the lines of FeH will be observable in the solar photospheric spectrum, if the dissociation energy is greater than 1.75 eV and the oscillator strength is not smaller than 5×10^{-3}. His analysis assumed that the ground state of FeH is $^2\Sigma$ and the elemental abundance of Fe relative to hydrogen is 3.72×10^{-6} (Goldberg, Müller and Aller, *Ap. J. Suppl.*, **5,** 1, 1960). Recently an approximate Hartree-Fock calculation shows that the ground state of FeH is $^6\Sigma^+$ and the dissociation energy is 2.43 eV (Walker, Walker and Kelly, *J. Chem. Phys.*, **57,** 2094, 1972). Moreover, the elemental abundance of Fe relative to hydrogen has been revised upwards to 3.98×10^{-5} by Garz, Holweger, Kock and Richter (*Astr. and Ap.*, **2,** 446, 1969). All these strengthen the argument of Schadee and increase the expectation of finding lines of

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