IAU SYMPOSIUM ON FAST TRANSIENTS IN X-AND GAMMA RAYS

This COSPAR/IAU symposium was held at Varna, Bulgaria between May 29-31, 1975. A number of interesting new experimental observations on Gamma-Ray Bursts (GRB) and Transient X-ray sources by groups from the USA, USSR, UK, W. Germany, Netherlands and Japan, from the satellite experiments, and some observations from balloon-borne detectors by groups from GSFC/NASA, USA, and Japan were reported. Theoretical aspects of these phenomena was presented by Dr. Pacini in a review paper. Other theoretical work were reported by Dr. Fabian (UK) and Dr. Usov (USSR). In the panel discussion on GRB a future coordinated observational programme using experiments on satellites and space probes to obtain accurate directions and some planned balloon experiments were discussed.

Gamma Ray Bursts (GRB):

After the first discovery of GRB by Klebesadel, Strong and Olson, a total of 39 GRB events observed by at least two spacecrafts, have been recorded, from May 1969 through 1973. (There are, however, a large number of " candidate " events recorded by individual satellite experiments). Sixteen groups of experimenters have reported response to one or more of these events. The observations on different events have been made by Vela Satellite system, and other satellites/spacecrafts, IMP-6, and IMP-7, OSO-6, OSO-7, TD-1, OGO-5, Apollo-16, COSMOS-461 and UHURU. Dr. Klebesadel gave an interesting review talk, mainly based on Vela-Satellite observations. Dr. Cline reviewed the results mainly based on IMP-6 and IMP-7 satellite observations and also reported preliminary results of the balloon experiments.

The general features of GRB are summarized in table 1.

Following are some of the more important features on duration, substructure, spectral measurements, distribution over the sky and size spectrum.

The briefest event so far (October 10, 1967 event 69-3) has a duration of 0.1 second. Significant variations within the total duration, not fully resolved by 16 ms definition available from Vela record, are observed. This implies emitting regions of size less than 5000 km. The longest duration single event (event 71-01, of January 2, 1971), shows very little substructure. However, more typical events of 3 to 5 seconds duration show significant structure within an event. (For example, OGO-5 results for December 18, 1972 event and Apollo-16 results for April 27, 1972 event).

The IMP-6, IMP-7 observations provide spectral information on many events. From this data alone it appears that most of the events have similar overall spectra, an exponential distribution with characteristic energy of about 200 keV. (However, combined OSO-7 IMP-6, and Apollo-16 data suggest a power law fit for at least two events). The spectral measurements for two events (event 72-04 of May 14, 1972 and event 72-06 of April 27, 1972) have been extended down to 10 keV and upto 4 MeV by observations from OSO-7 and Apollo-16 and the latter provides the most definitive measurements of spectral distributions available at present. For the data integrated over the entire event a reasonable fit is achieved by two power law curves intersecting at 200 keV. $E^{-1.38}$ type differential spectrum below 200 keV and $E^{-2.63}$ type differential spectrum for 0.3 MeV to 3 MeV except for an apparent excess of counts at about 4 MeV (Apollo-16 data). The distribution otherwise appears continuous with no evidence for line structure. There are however temporal changes in the enrgy distribution (within an event) that have been observed for a few events.

Table 1

	Units	Range	Typical
Total Enery Density	ergs cm^{-2}	$3x10^{-6}$ to $5x10^{-4}$	10^{-4}
Peak intensity	ergs cm^{-2} sec^{-1}	$5x10^{-5}$ to $5x10^{-4}$	10^{-4}
Total duration	sec	0.1 to 100	3
Duration of single Pulse*	sec	0.02 to 10	1
Rise time	sec	0.02 to 1	

*Fine structure (called microbursts) observed within the GRB; the spectrum during microbursts, not necessarily same as the overall event spectrum. In some cases the spectrum appears to evolve—hard intially, and softer later on, opposite is seen in other cases.

Dr. G. Share of NRL reported the discovery of two new cosmic GRB events in 1970, (25 January, 1970 and October 1, 1970 events) from NRL experiment on OSO-6. These events are confirmed by hard X-ray spectrometer on OGO-5. Both the events appear to have considerably softer spectra than typical gamma ray bursts and may therefore be termed as cosmic X-ray bursts, perhaps indicating a different type of objects/mechanism than those giving rise to gamma ray bursts.

The precise location over the sky of the GRB events is not yet possible for all the events. The Vela system of satellite provides two possible directions for a limited number of cases while OSO-7 and Apollo-16 data give directions for event 72-04 and 72-06. At the moment directions have been established for 16 of the established 39 events. The distribution of these sources in the galactic co-ordinates (within error boxes of source locations) does not suggest any association with the galactic plane. Rather it seems to be consistent with isotropic distribution over the galactic latitudes. However, with the present observations, it is not possible to say whether the GRB origin is galactic or extragalactic.

The size spectrum of the GRB—that is number of events vs. the integrated energy density—is another important parameter that could provide a clue to the origin of these events. For an isotropic distribution with no apparent galactic cut-off, one expects a 3/2 power law for the size spectrum. The Vela data alone suggests that the 3/2 power law is valid upto 10^{-5} ergs/cm^2 and appears to follow a flatter spectrum below this value. On the other hand the IMP-6 data suggests less flattening. If one includes the preliminary results of the balloon experiment these 3/2 power law seems to be valid down to 10^{-7} ergs/cm^2. However, the most recent balloon experiment results reduce the fit for this size somewhat.

Anyhow at present it is not clearly established what is the nature of size spectrum below 10^{-5} ergs/cm^2 and here future balloon experiments could provide more useful data.

Prior to this conference, a number of theoretical models had been proposed. (For example, a rapidly cooling black body model of Ramaty and Cohen, comet infall on to the neutron star model of Salpeter et al., white hole model due to Apparao and Narlikar, accretion model due to Lamb, Lamb and Pines). In this conference, some more tentative models were proposed. Dr. Fabian proposed a model in which an "earthquake" on a neutron star surface is considered to give rise to GRB. Dr. Usov proposed a nuclear explosion on star (in binary system) surface giving rise to large ejection of matter when accreted by the dense object like neutron star could give rise to gamma-ray bursts. However, none of the models can explain all the observed features.

In the panel discussion at the end of meeting, future plans for observations in this field were discussed. It is reported that a number of satellite experiments to be launched in future have been now modified to suit gamma-ray bursts observations. To get accurate directions, a number of missions incorporating long base line observations from two widely spaced spacecrafts (typically one experiment on near earth satellite and the other on inter-planetary probe) are planned: Russian-French collaboration experiment on a near earth satellite and two interplanetary probes, planned for 1977 launch and the NASA experiments on HELIOS-B (for example) in conjunction with some earth orbiter such as ISEE-Mother, planned for launch in 1976. The capabilities of COS-B satellite (launch in September 1975) to measure GRB events were also discussed.

A number of groups from the USA (GSFC/NASA), UK (Southampton & Birmingham University), W. Germany, (Max Planck Inst.), Japan and India (Tata Institute of Fundamental Research) are planning balloon experiments with large area detectors. Damle presented the proposed TIFR balloon experiment in the panel discussion. Clearly, Gamma Ray Burst Astronomy holds considerable promise.

Transient X-ray Sources:

Several new observations on Transient X-ray sources were reported by University of Leicester, University of Birmingham, University College, London and Imperial College, London, based on results from UK Ariel-V Satellite launched in October 1974 in near circular equatorial orbit. All the experiments in the satellite are reported to be functioning satisfactorily. The most important results from the low energy X-ray telescope of Leicester groups were presented by Dr. Pounds. Some 91 new X-ray sources which were not earlier observed by UHURU, have been seen by Aerial-V. Also 16 other sources reported by UHURU seemed to have now disappeared. Thus it appears that there is a class of X-ray sources that are transient and some of the theoretical models predict that the now extinguished sources may reappear. The improved sensitivity of Leicester X-ray experiment, compared to UHURU is expected to provide exciting data in future on transient sources and other interesting X-ray sources. Aerial-V discovered a new transient source near Crab called Tau XF, in April 1975. The source gradually brightened and the peak intensity some three times the Crab level was observed in latter part of April 1975.

Some new OSO-7 results on Lup. nova 2U1543-47 and other interesting sources like Cen-A, NGC 5253 were reported by MIT group.

A theoretical model for the new transitent X-ray source discovered by Ariel-V and nicknamed Cen X-mas, has been proposed by Appa Rao and Chitre (TIFR). In this model the observed 6.75 minutes periodicity is thought to be somewhat like solar cycle periodicity for a rotating magnetic white dwarf and the transient nature of the source can be explained by pushing the solar analogy further and suggesting that the source resembles the solar activity with high and low activity periods.

The transient nature of X-ray sources seems to be well established. There is, however, no unique behaviour as regards temporal changes, spectral characteristic and intensity levels. A number of theoretical models have been proposed, mainly in terms of a binary system and accretion of matter on to compact companion object and most of them explain some of the observed features, but the field is wide open for theoreticians.

Miscellaneous:

Observations in the soft X-ray region (0.12 to 0.28 keV) from experiment on ANS (Astronomical Netherland Satellite) were reported. A search for soft X-ray emission from a number of stellar objects like dwarf novae, spectroscopic binaries, peculiar star (e.g. Eta Carine), coronas of supergiants, normal giants and of main sequence stars was made. The search revealed no evidence of soft X-ray emission above the instrument background (1 count sec^{-1}). There are, however, some positive results. A giant X-ray flare was observed in YZ-CM on October 19, 1974. Some four flares in optical and soft X-rays were seen on UV Ceti; for one X-ray flare there was no corresponding optical or radio flare.

There are now at least two satellites in orbit (Copernicus and ANS) that have capability for soft X-ray studies.

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THE 14TH INTERNATIONAL CONFERENCE ON COSMIC RAYS

The 14th in the series of International Conference on Cosmic Rays was held at Munich during August 15-29, 1975. In what follows the highlights of the Conference, of relevance to astronomy and astrophysics, are very briefly summarised.

In the field of X-ray astronomy the most spectacular achievement reported was the exciting findings on transient X-ray sources from the satellite Ariel 5. Though several transient X-ray sources have been seen before this satellite became operational, the unexpected