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14. Abstract/Notes

Theoretical investigations of supernova explosions predict a high emission of gamma rays ($\sim 10^{-2}$ photons cm^{-2} s^{-1}) beginning around 300 days after explosion. A balloon-borne experiment was flown in October, 1987, to observe this emission. The payload carried 4 phoswich detectors of BGO/CsI and NaI/CsI with areas 169 cm^2 and 100 cm^2, respectively. The detectors' sensitivity (for 10000 s at $3 g/cm^3$ with error bar of 3σ) is about $10^{-3} \sim 10^{-4}$ photons, cm^{-2}, s^{-1} at energies above 200 KeV. The detectors mounted on a stabilized platform observed the supernova for about 2 hours. The data are being analized for pulsations (≤ 0.5 ms) and gamma ray emission. Energy spectra and temporal analysis will be presented and discussed.

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GAMMA-RAY OBSERVATIONS OF SUPERNOVA SN 1987A

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ABSTRACT

Theoretical investigations of supernovae explosions predict a high emission of gamma rays ($\sim 10^{-2}$ photons cm^{-2} s^{-1}) beginning around 300 days after explosion. A balloon-borne experiment was flown in October, 1987, to observe this emission. The payload carried 4 phoswich detectors of BGO/CsI and NaI/CsI with areas 169 cm^2 and 100 cm^2, respectively. The detectors' sensitivity (for 10000 s at $3g/cm^3$ with error bar of 3σ) is about $10^{-3} \sim 10^{-4}$ photons. cm^{-2}. s^{-1} at energies above 200 KeV. The detectors mounted on a stabilized platform observed the supernova for about 2 hours. The data are being analized for pulsations (≤ 0.5 ms) and gamma ray emission. Energy spectra and temporal analysis will be presented and discussed.

I - THEORETICAL AND OBSERVATIONAL STATUS OF SN 1987A

The explosion of supernova SN 1987A has been, undoubtlessly, one of the most important astrophysical happenings of this century, because never could men observe this kind of event in such good conditions, using large optical telescopes, satellites and balloon-borne experiments. Considering the great development in astronomical instruments during last decades, and taking into account that Large Maggelanic Cloud (LMC), where supernova is located, is quite near our galaxy for astronomical standards (155000 light-years), SN 1987A can be observed in practically the whole range of the electromagnetic spectrum. The large amount of information that can be obtained will help astrophysicists to cover the gap between theory and observation and solve a number of problems concerning stellar evolution theory, neutron stars formation, nucleosynthesis during explosion and the proper physics of supernova explosions.

The progenitor star of SN 1987A was Sanduleak -69 202, located in LMC ($\alpha = 05^h35^m49.2^s$ and $\delta = -69^o17^m56.4^s$, supernova coordinates), determined with a coincidence better then 0.1". SN 1987A is about 155000 light-years far from the Earth,and it was $\sim$ 10000 times brighter then any other object in the LMC, at the time of its discovery. Its spectral type is B3I, a blue supergiant with mass between 15 and 25 M_0 . Stellar evolution calculations show that low-metallicity stars in this mass range, may reach carbon-burning stage as a blue supergiant, with metallicity Z=0.001, L $\sim$ 8x10 L_0 e T_{ef} $\sim$ 13000 - 16000 K . This value is consistent with metallicity observations of LMC.

The detection and analysis of nuclear decay lines from Co^{56} to Fe^{56} may also give an important contributions for stellar evolution theories, while the search for pulsations can confirm the collapse toward a neutron star, showing, as expected, a recently-born pulsar.

II - THE EXPERIMENT

The detectors' assembly (fig. 1) consisted of 4 phoswich detectors, fixed on a platform that was 40^o inclined in relation to zenith. The whole set, together with associated electronics was mounted over a stabilized gondola. This system permitted to follow supernova's path during the time it was in the collimator's field of view. The collimation system was a passive one, with lead sheets and an opening of about 10^o of field FWHM, and calibration during the flight was performed by means of a Na source. Another goal was to test BGO-CsI phoswich performance in X e γ ray astronomy.

Four phoswich detectors were used: a BGO-CsI(Tl) with 81 cm area, two BGO-CsI(Tl) with 44 cm^2 area and a NaI-CSI(Tl) with 100 cm area. They had different geometries and their sensitivities, estimated for nuclear events (for 10000 s at $3g/cm^3$ and 3 σ) are:

Co^{56}	847 keV	$4.5x10^{-3}$ photons.cm^{-2}.s^{-1}
e+ e-	511 keV	$2.8x10^{-3}$ photons.cm^{-2}.s^{-1}
Co	120 keV	$5.1x10^{-4}$ photons.cm^{-2}.s^{-1}

Its main limitation is a low light yield, if compared to other scintillators (11% of NaI light yield), presenting, on the other side, an excellent photopeak efficiency. The phoswich BGO-CsI is indicated to search for low-intensity sources in high background environments, as X and γ ray astronomy (E ≤ 10^2 keV), in particular when a high energy resolution is not required.

There are some details that must be kept in mind for the phoswich BGO-CsI. The most important is its temperature-de pendent response. Temperature variations can modify its light yield and decay time, demanding some attention. A rigorous thermal check-out should be made, keeping temperature within a range where the phoswich does not suffer significant linearity or proportionality variations; or the kind of variation must be very well determined, in order to perform the exact corrections later. These temperature variations are mainly concerned to BGO (CsI is not subdued to expressive variations in gain, within the temperature intervals commonly observed in balloon flights - 275 K to 315 K).

The gain variation in BGO is defined as the ratio between pulse amplitude and the energy of incident photons. It decreases at the ratio of 1.0% - 1.2% / K ; the decay time of the pulses increases at the ratio of 6 ns/K . It comes to change dramatically the phoswich performance, as it will start to measure a varying background level, depending on the temperature.

Pulse discrimination system was performed by means of an ORTEC 467/552, composed of a double constant fraction discriminator and a time to amplitude converter (TAC). The signal coming from this system enters an analogical-digital converter (ADC) and goes to a multichannel analyser (SILENA 7000).

The telemetry was in a FM-FM mode, using 9 channels IRIG; on the ground the data was sent to a PCM decoder and a bit synchronizer, being recorded in analogic tape recorders. The experiment baud rate was 62.5 kbps, which converted into frame words give 0.256 ms/word. We used this value for system dead time.

III - FLIGHT SCHEDULE

The launching site was Poços de Caldas (MG), choosen because of its localization in the center of the country, and meteorological conditions ("turn-around" epoch). The payload was launched at 00:25 LT (03:25 UT), October, 10, 1987, on board of a WINZEN stratospheric balloon, with 231.990 m^3, and the flight lasted 14:35 (separation at 15:00 LT). Sources selected for pointing were SN 1987A, CEN A, VELA X-1, CRAB NEBULA AND GALACTIC CENTER, and we had almost 2 hours of supernova. The detectors were pointed to supernova at different hours, in a mode "ON-OFF".

The two-hour delay in the initial time choosen for launching accounted for a thin layer of H_2O over the balloon, due to atmospheric condensation. This problem reduced the balloon speed, which ascended more slowly. It arrived at the ceiling at 5:30 LT.

For data analysis, we selected those tapes recorded when the balloon was at the ceiling (pressure < 4 mb). In figure 1 is displayed a counts x channel curve, for the period between 5:35 and 5:55 LT.

IV - DATA REDUCTION AND PRE-ANALYSIS

We selected mainly 3 tapes for quick analysis: one only for supernova observation, one only for background observation and the third for both (supernova+background). The SITIM (Image Handling System) from Astrophysics Department was used to read the tapes and we worked on IBM-PC compatible microcomputers. Almost all the software necessary was developed during the reduction, in Basic and C languages.

Some preliminary results will be presented. We tried to detect the 847 keV line from Co^{56} decay, and some search for pulsations with a FFT (Fast Fourier Transform) algoritm, using 4 million points, with no results until the present moment.

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