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Gamma-ray burst measurements at low fluxes

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Recent measurements of the number of cosmic γ-ray bursts per year at small flux levels continue to show significant deviations from the $N(>S) \propto S^{-3/2}$ power law for the rate $N(>S)$ at size S, which would apply to a uniform source distribution. In particular Fishman *et al.* (1978) and Agrawal *et al.* (1979) find flux limits two orders of magnitude lower than those expected when the Vela (Strong & Klebesadel 1974) data are extrapolated by the $S^{-3/2}$-law to flux levels *ca.* 5×10^{-8} erg† cm^{-2}. Spherical halo, monoluminosity source distributions discussed by Jennings & White (1980) have failed to satisfy these data although they are consistent with triangulation results obtained by spacecraft networks on a few individual burst arrival directions (Hurley 1980). On the other hand, thick disc source models seem to satisfy the observed lg N–lg S distribution.

To obtain more data at the low flux end of the size spectrum and in particular to both lower the size limit of burst detection and look for a possible excess flux from the galactic centre region, large-area detector flights were undertaken from Australia. The apparatus consisted of plastic scintillators, 5 cm thick and 6.3 m^2 in effective area, arranged in six trays, two of which were horizontal and four of which were inclined at 30° to the horizontal so as to make up the four sloping sides of a box. Laboratory calibration gave a mean efficiency for the detection of 50 keV to 2 MeV photons of 0.404 when translated to 4 g cm^{-2} atmospheric depth and for all bursts arriving up to a cut-off zenith angle of 60°. Thirty-three hours of good data were obtained in total during flights in November 1977 and November 1978. Gamma-burst searches were made by demanding three successive 2σ increases in at least three of the six trays with a sampling interval of 1/16s. Two bursts were detected, one at 1978, 15 November, 22h14, in coincidence with Venera spacecraft observations of an event, and the second at 1978, 16 November, 13h40 at a flux level of 9.2×10^{-8} erg cm^{-2}. Directional determination for this second burst with the inclined tray rates gave $l = 82.5°$, $b = -71.4°$, with an error circle of 12°. A Venera event occurred on 19 November 1978, 24° away from this position. Correction of the flight results to an isotropic flux, missed short bursts, the flat detector response and missing energy being taken into account, on the assumption of the Apollo 16 (Mezger *et al.* 1974) spectrum, yielded a rate $(7^{+10}_{-6}) \times 10^3$ year^{-1} at sizes greater than or equal to 8.47×10^{-9} erg cm^{-2}. This point is plotted in figure 1, together with a compilation of other data (see Hurley 1980 for details).

Two theoretical curves are shown in figure 1, due to Jennings & White (1980). They are based on an axisymmetric space distribution of sources, $n(\rho) = N_{0c} \exp\,(\rho/\rho_0)$ where ρ is the galactocentric radius vector and β_0 is the half thickness of the disc to which they are confined. Our data favour $\rho_0 = \infty$, $\beta = 400$ pc. Another way of satisfying our data is found in the recent work of Jennings (1980) who has taken up a suggestion of Bewick *et al.* (1975) and Mazets & Golenetskii (1979) that the intrinsic source luminosity distribution is important. Jennings allows sources following a galactic halo distribution to lie in a luminosity range $L_1 \leqslant L \leqslant L_2$, where

† 1 erg = 10^{-7} J.

$L_1/L_2 = \zeta$ and $N(L) \propto (1-\zeta)^{-1} L^{\alpha-1}$. He shows that curves very similar to that labelled $\rho_0 = \infty$, $\beta = 400$ pc in figure 1 are obtained with $\alpha = -0.5$ or $\alpha = -1.0$, and $\zeta = 10^{-3}$. Physically the intrinsic luminosity distribution is soft and peaked towards low luminosities. At high apparent size S, the source distribution looks isotropic but as one approaches low S and notices the geometrical effect of the near edge of the halo, some compensation in source counts is experienced by the addition of low L sources in the intrinsic size distribution. The lowest S-values observed determine the spread or ζ-value. Jennings's model satisfies the isotropy of sources until now believed to be given by the triangulation data.

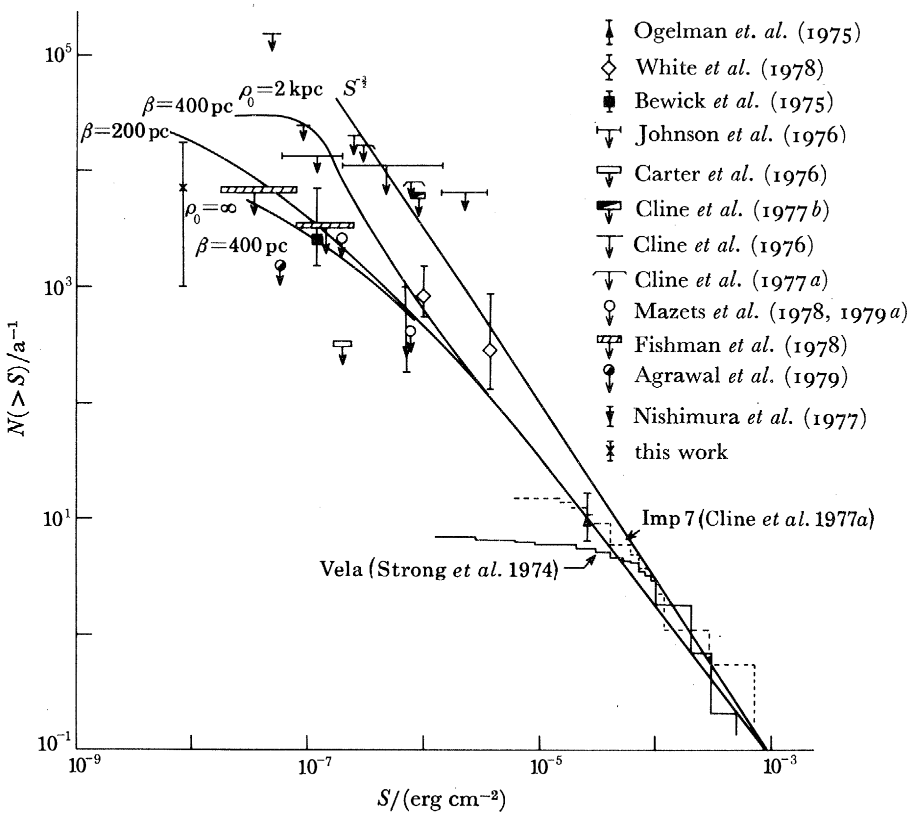

FIGURE 1. Integral size spectrum of γ-ray bursts. Theoretical curves refer to the work of Jennings & White (1980) with β as the half thickness of the galactic disc distribution of sources and ρ_0 is the e-folding distance from the galactic centre of the assumed source distribution. (For details of references, see Hurley 1980.)

Two recent pieces of evidence are at variance with both Jennings's model and the data discussed above. Vedrenne (1980, this symposium) has shown that Venera (Mazets & Golenetskii 1979) catalogue data on arrival directions now imply a strong anisotropy near and to the south of the galactic equator. Also at large S-values, Venera data appear to show a much higher number of events per year than did Vela and Imp 7 (see, for example, Jennings 1980, Vedrenne, this symposium). Both these sets of data need further assessment before firm conclusions on the source distribution can be made.

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