THE EFFECT OF ANISOTROPIC EMISSION ON THE LOG N-LOG S CURVE OF GAMMA-RAY BURSTS

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ABSTRACT

Some models for Gamma-Ray Burst spectra result in anisotropic emission. We consider here the effects of anisotropy on the log N-log S curve.

1. Introduction. Several authors have recently proposed anisotropic emission mechanisms for Gamma-Ray Bursts. Synchrotron emissivity (1) is maximum when the angle between the observer and the average magnetic field direction is $\theta = \pi/2$, while γ-γ pair production and annihilation (2) and the more complex model of Hameury et al. (3) have maximum emissivity for $\theta = 0$.

Assuming a random distribution for the direction of maximum emissivity of a Gamma-Ray Burst, we have computed the effects of anisotropy on the two log N-log S curves given by Jennings (ref. (4), fig. 8) for halo models. The fact that these two curves already take into account an intrinsic luminosity distribution for the events is not in conflict with considering a further dependence of the observed burst intensity on the angle between the observer and, for example, the magnetic field axis.

2. Method and results. We define as "original" the log N-log S curve that we would obtain if we could observe all events in the direction of maximum emissivity, and "averaged" the log N-log S which results from taking into account anisotropic emission. We also define as "original" and "apparent" the burst intensity in the direction of maximum emissivity and in the direction of the observer, respectively. Then the "averaged" log N-log S curve for an apparent burst intensity S is the weighted mean over all angles between 0 and $\pi/2$ of the "original" log N-log S curve, computed, for each angle, at the "original" intensity which will, at that angle, produce an apparent intensity S in the direction of the observer. In our case, the weight is simply $\sin\theta$. More details and the results obtained using a very simple log N-log S function are given in ref. (5).

As already stated, we have used as "original" log N-log S the curves given for halo models in fig. 8 of ref. (4) and the angular dependence for emissivity of refs. (1), (2) and (3). The results are given in figs. 1 and 2. The "averaged" log N-log S curve has not been renormalized at S = 10^{-3} ergs cm^{-2} in order to show the decrease in number of observed events per year due to anisotropic emission. The fact that all events at $\theta > \pi/2$, with the possible exception of a few just beyond $\theta = \pi/2$, would not be observed, will further lower the averaged curves by a factor of $\simeq$ 2 (not included here).

As it might be expected, in all cases the "averaged" log N-log S curve is lower and smoother than the original one, but only the "averaged" log N-log S curve obtained using the model of Hameury et al. (3) differs sensibly from the corresponding "original" curve in the normalization and, in fig. 2, also in the shape.

In fact, the angular dependence of the emerging flux calculated by

Carrigan and Katz for γ-γ pair production and annihilation is not strongly collimated, while the maximum emissivity of synchrotron radiation is at $\theta = \pi/2$, which also has the highest weight in the average. On the contrary, the emissivity in the model of Hameury et al. is strongly peaked at $\theta = 0$, where the weight goes to zero. We also note that in fig. 2 the "averaged" log N-log S for this model is much straighter than the "original" curve. In order to fit the experimental data well with the "averaged" curve, we would have to use an "original" log N-log S which is bent more and is bent at a higher burst intensity.

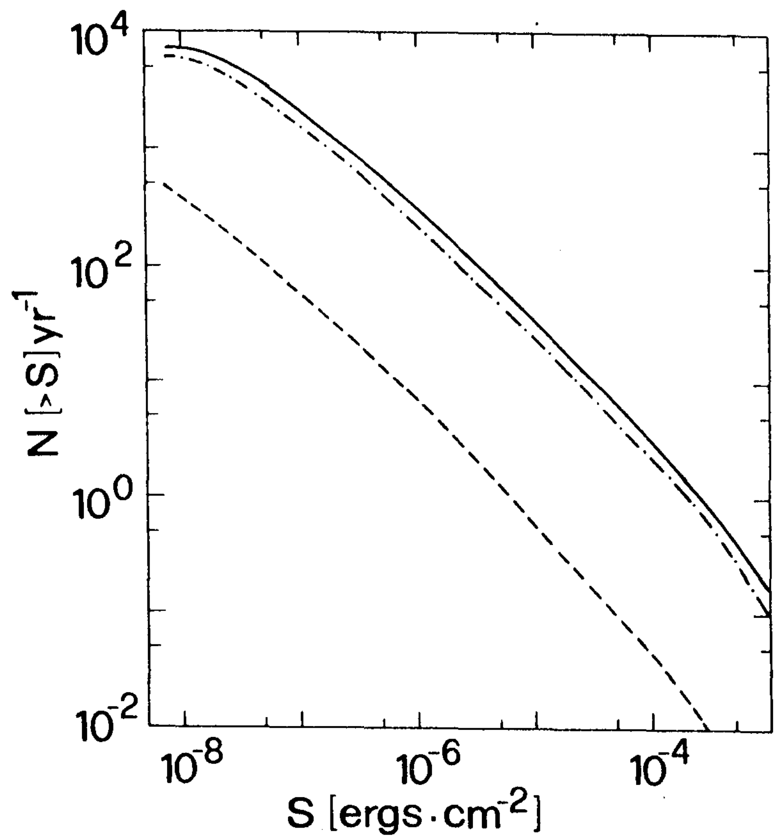

Fig. 1 Solid line: "original" log N-log S curve from ref. (4) fig. 8, halo model with $\alpha = -1.0$, $\zeta = 6\times10^{-5}$.
Dot-dashed line: corresponding "averaged" log N-log S curve for angular dependence of the emissivity derived from either ref. (2) or ref. (1) with $\nu_L T^2$ between 2 and 200. They are practically superimposed.
Dashed line: "averaged" log N-log S curve for the model of Hameury et al. (3).

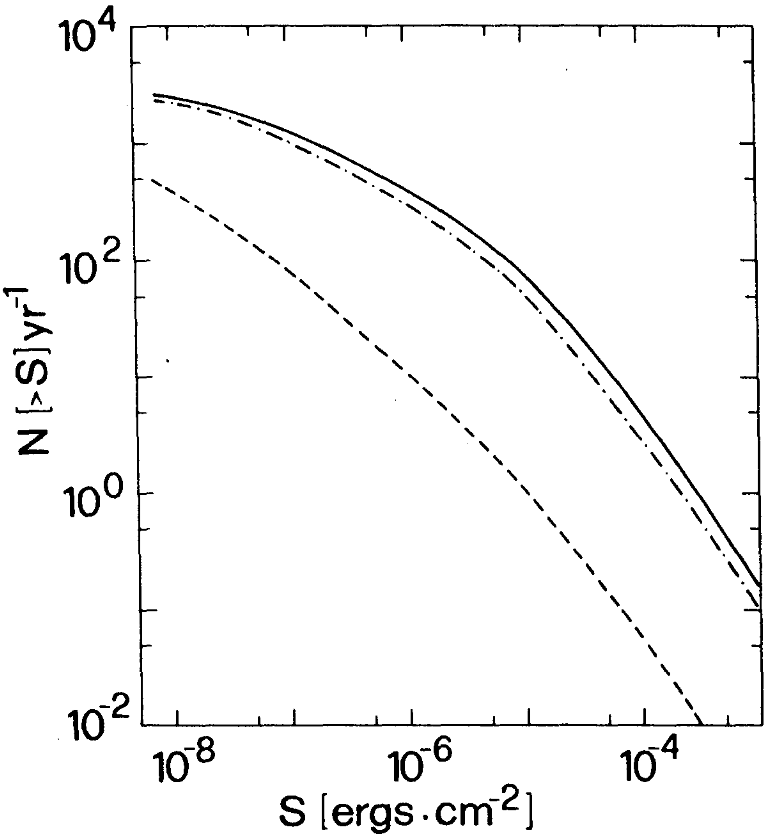

Fig. 2 Same as fig. 1, but with $\alpha = -0.5$ and $\eta = 7 \times 10^{-4}$.

References

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