On the Spectra of Gamma-Ray Bursts (*).

G. PIZZICHINI

*Istituto T.E.S.R.E./C.N.R. - Bologna

(ricevuto il 10 Agosto 1984)

Summary. — One of the possible interpretations of the spectra of gamma-ray bursts is in terms of synchrotron emissivity of mildly relativistic electrons. In this case, the shape of the spectra depends on the angle between the magnetic field and the observer. We show here that, although this angle can be important for single events, the statistical properties of gamma-ray bursts are determined essentially by those events for which this angle is near π/2, namely events observed in the direction of maximum emitted flux.

PACS. 94.40. – Cosmic rays.
PACS. 97.30. – Variable and peculiar stars (including novae).

1. – Introduction.

The spectra of gamma-ray bursts (GRB) have been interpreted in several ways: thermal bremsstrahlung (1), thermal synchrotron (2) or two- or more-component spectra (3,4). The experimental data available do not allow us to decide which model gives a better fit.

Arguments in favour of the thermal synchrotron spectra have been given, among others, by Liang (4). This interpretation, however, introduces an additional unknown parameter, namely the angle $\theta$ between the observer and the average magnetic-field direction. The photon number spectrum is (5)

$$\frac{dn}{dv} \text{(photons cm}^{-2} \text{s}^{-1} \text{sr}^{-1} \text{(keV)}^{-1}) \propto \exp \left[-\frac{(4.5v/(v_e \sin \theta))^4}{v_L/T^2} \right],$$

for $v \gg v_L/T$ and $\theta \gg 0$,

where $v_e = v_L T^2$,

$v_L = eB/2\pi mc$,

$T = kT_e/m_e^2$,

$T_e = \text{electron temperature}$,

$\theta = \text{angle between the observer and the average magnetic field}$,

$m = \text{electron mass}$.

By fitting the experimental data, we can determine only $v_e \sin \theta$. Let us define

$$v_a = v_e \sin \theta.$$

Spectral fits of GRB (5,6,8) have given $0.03 < v_a < 110$.

2. - Importance of the angle between the observer and the magnetic field.

We find that, for most practical purposes, one can indeed take $\theta \sim \pi/2$, as assumed for example in ref. (4). For this, we give the following reasons:

a) If the magnetic field axis of GRB sources is randomly distributed in the sky, the statistical weight will be proportional to $\sin \theta$, therefore $\theta \sim \pi/2$ is much more likely than $\theta \approx 0$.

We assume that the burst originates near the magnetic pole of the source.

b) The maximum emissivity corresponds to the direction $\theta = \pi/2$. In fig. 1 we give as an example the dependence of the number of photons emitted in the interval $(40-180) \text{keV}$ as a function of the angle $\theta$ for different values of $v_e$. As one can see from the figure, the angle dependence is more important for "soft" spectra. It will also depend on the energy range of the instrument.
