# RELATIONSHIPS BETWEEN LOG N-LOG S AND CELESTIAL DISTRIBUTION OF GAMMA-RAY BUSRTS

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## ABSTRACT

We discuss the apparent conflict between log N-log S curve and isotropic celestial distribution of the gamma-ray bursts. We examined a possible selection effect due to the time profile of each burst, and showed the contradiction is due to this selection effect to the gamma-ray bursts.

## 1. INTRODUCTION

The apparent contradiction between the isotropic latitude distribution and the bending of log N-log S curve of gamma-ray bursts has been discussed for many years. To resolve this contradiction, an effect of intrinsic luminosity distribution of the bursts (T.L.Cline and U.D.Desai: 1976), a large scale halo model ( M.C.Jennings: 1984) etc. have been suggested so far. Based on the discussion in the reference (J.Nishimura and T.Yamagami: 1985), we showed, in disk model, latitue distribution of burst sources is directly related to the shape of log N-log S curve without referring to an explicit form of intrinsic luminocity function of the burst source. Then, we examined a possible selection effect in the data of Venera 11 and 12. (E.D.Mazet et al: 1981,1982). After analyzing the Venera data, we found a selection effect is arised from the different time profile of each burst. The contradiction is resolved if we take account of this selection effect.

## 2. RELATION BETWEEN LOG N-LOG S AND LATITUDE DISTRIBUTION OF GAMMA-RAY BURST IN THE DISK MODEL

Based on a general discussion of disk model for the spatial distribution of burst sources, we show latitude distribution of burst sources has a one to one correspondence with the form of log N-log S distribtuion without referring to the explicit form of intrinsic luminosity distribution and the form of distribution of the burst sources in height from the disk plane. In this treatement, we assume that the spatial distribution of the burst sources is given by a form of $G(Z)dZ$ , where $Z$ is the height of the burst source position from the disk plane. No azimuthal asymmetry is included. The following arguments, however, holds even in case some azimuthal asymmetry exists, if we redefine $G(Z)$ as an average over azimuthal angle, or a function of the azimuthal angle.

Also, an integral intrinsic luminosity distribution in each burst sources is assumed to be

$$f(L/4\pi),$$

where L is the total luminocity of a burst source. No dependence of the form of the intrinsic luminocity distribution on the position of the source is assumed here. Under these assumptions, we derive a simple relation between celestial distribution at latitude b per sterad., N1(>S,b), and observed frequency N(>S,b) as

$$N1(>S,b) = N2(S/\sin^2 b)/2\pi \sin^3 b,$$

where

$$N2(S) = -dSN(>S)/dS. \qquad (1)$$

This relation does not include any explicit forms of spatial distribution and intrinsic luminocity function , and then observed log N-log S curve can be directly compared with the observed latitude distribution of the burst sources. Any effects to celestial distribution due to the spatial distribution of the burst sources are included in the form of log N-log S curve. (J.Nishimura and T.Yamagami: 1985)

The latitude distribution derived by using eq.(1) from the observed log N-log S curve by Venera, PVO and others is shown in Fig.1. There is a large deviation from isotropic latitude distribution for $S < 10^{-5}$ erg/cm$^2$, which contradicts the observed evidence of located bursts of Venera 11 and 12.

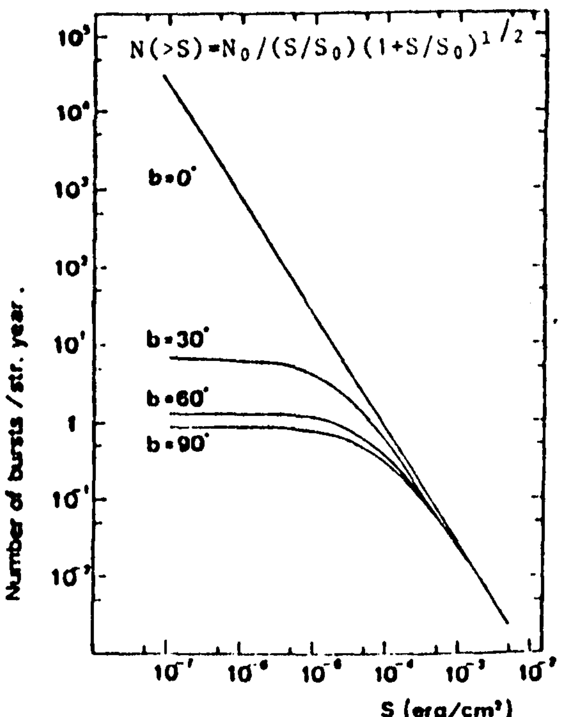


Fig.1. Latitude distribution of burst sources derived by eq(1) and log N - log S curve.

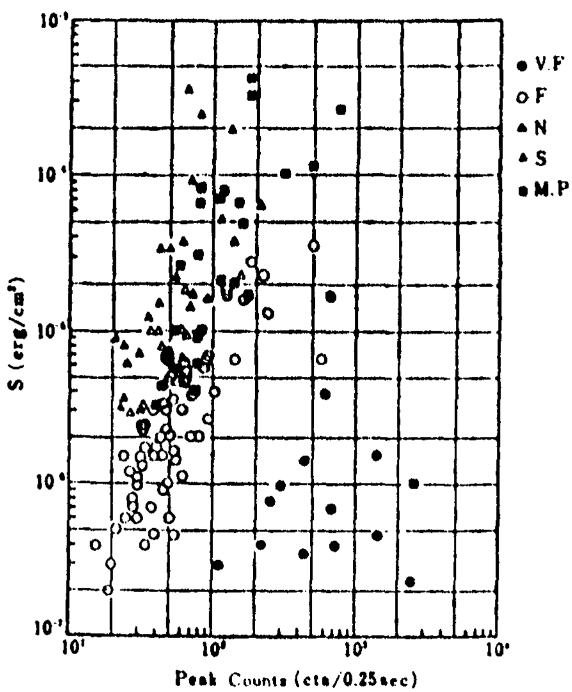


Fig.2. Scattered plot of the burst observed by Venera for fluence S vs Peak count P.

## 3. SELECTION EFFECT IN THE BURST OBSERVATION

From the arguments in section 2, it is quite possible that the contradiction arises from a selection effect for smaller bursts below $10^{-5}$ erg/cm . The selection effect may arise from the different time profile of each burst, and we examine the effect by classifying the bursts according to their time profiles. We tentatively classify the bursts with respect to their time profiles as :

- VF : Single peak burst with FWMH of its peak is less than 1/4 sec.
- F : Single peak burst with FWMH betweem 1/4 to 5 sec.
- N : Sigle peak burst with FWMH of larger than 5 sec.
- S : Burst lasting for more than 15 sec without clear peak.
- MP : Burst with many spiky peaks.

The bursts obseved by Venera 11 and 12 are plotted in Fig.2, referring to their peak count, P, and the fluence S.
Clearly two types of detection threshold are observed, i.e., for peak count, P, and for fluence , S, of a burst. These threshold values depend on the type of time profile of each burst. Quantitatively, the deviation from S in log N-log S starts at around ;

S = 7.8x10-7 erg/cm2 for VF type
S = 5.0x10-6 erg/cm2 for F type
S = 7.0x10-6 erg/cm2 for N type
S = 4.0x10-5 erg/cm2 for S type
S = 4.8x10-5 erg/cm2 for MP type.

For log N-log P, the curve starts to bend at around

$P = 100 ct/cm^2.sec.,$

for all types of the bursts except for VF type bursts, which almost corresponds to the fluence of $10^{-6}$ $erg/cm^2.sec$. Higher thresholds of the fluence for S and MP type bursts are due to the detection criteria for a burst, in which a burst is selected by the increase of counts exceeding a certain value within a fixed duration. While , the threshold for the peak count is due to the fact that the burst with small fluence less than $4x10^{-7}$ $erg/cm^2$ is not detected. This seriousely affects the detection of a short duration burst of VF type. Considering these detection criteria, it is better to use log N-log P instead of using log N-log S to see the consistency with the observed celestial distribution of the bursts.
In Fig.3, observed log N-log P curve is shown down to $10^{-6}$ $erg/cm^2.sec.$ by using Venera and PVO data (R.W.Klebesadel et al: 1985). Here we do not include VF type bursts. Slight deviation from $P^{-3/2}$ is observed near 10-6 $erg/cm^2.sec.$
We approximate the log N-log P in Fig.3 as

$$N(>P) = No/[(Po/P)(1+P/P0)^{1/2}],$$

where we put $No = 6240/cm^2.yr.$ and $Po = 4x10^{-7} erg/cm^2.sec.$
We then derive the latitude distribution from this log N-log P using eq.(1), and show them in Fig.4. The result seems to be consistent with the observed latitude

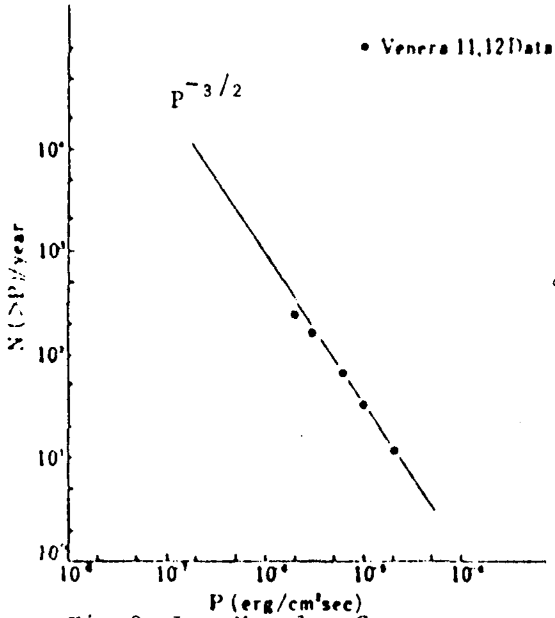


Fig.3. Log N - log S curve. VF Type is excluded.

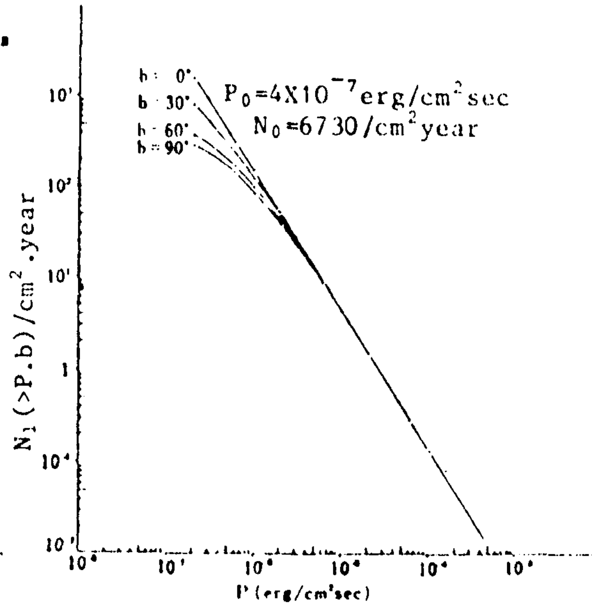


Fig.4. Latitude distribution derived eq(1) and log N - log P curve.

distribution. $X^2$ fitting with observed latitude distribution deviding the latitude as $|b| < 30°$ and $30° < |b| < 90°$ gives the value of $X^2 = 0.09$.

## 4. DISCUSSIONS

The selection effect for the gamma-ray bursts is analyzed on the bases of a different time profile of each burst. It is found that threshold for fluence depends seriousely on the type of each burst, but, for peak counts does not depend on their type except for VF type bursts. We thus use log N-log P instead of log N-log S and derive latitude distribution of burst sources. The result is consistent with the observed latitude distribution.

The apparent conflict between log N-log S curve and latitude distribution of the burst source is resolved by considering the selection effect for burst observations.

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