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LOG N-LOG S IS INCONCLUSIVE

(Expurgated Version of Title)

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ABSTRACT

The log N-log S data acquired by the Pioneer Venus Orbiter Gamma Burst Detector (PVO) are presented and compared to similar data from the Soviet KONUS experiment. Although the PVO data are consistent with and suggestive of a -3/2 power law distribution, the results are not adequate at this state of observations to differentiate between a -3/2 and a -1 power law slope.

INTRODUCTION

In an attempt to resolve the apparent inconsistencies between the PVO (and earlier IMP/Vela[1]) cosmic gamma-ray burst log N-log S data and the Soviet KONUS data[2] we have more critically evaluated the response of both the PVO and Vela instruments. Initially (as reported at the 157th meeting of the AAS, January 1981[3]) there appeared to be general agreement between PVO and KONUS data. Further, a careful reanalysis of in-flight calibration data from both PVO and ISEE-3, more extensive Monte Carlo analyses of instrument response functions, and additional intercomparisons of data (particularly for solar-flare X-ray bursts whose softer spectra enhance the ability to discern the thresholds of the measurements) verified that the PVO instrument is operating at almost exactly the intended sensitivity. We have also considered the methods of presentation of these data, and their effects on the comparisons of results from different experiments.

DISCUSSION

The latest analysis of the PVO data resulted in only minor variations from the original analysis. The PVO log N-log S data are shown graphically in Figure 1. The convention we employ is to plot a histogram of the integral event frequency with steps at the level of fluence observed for each event. A -3/2 power-law function is shown fit to the data at a level of fluence $\gtrsim 10^{-4}$ erg cm^{-2}. Below this level of fluence it is clear that the data diverge from a -3/2 power-law function, but it is also clear that instrumental threshold effects contribute heavily to this deviation. Also shown is the -3/2

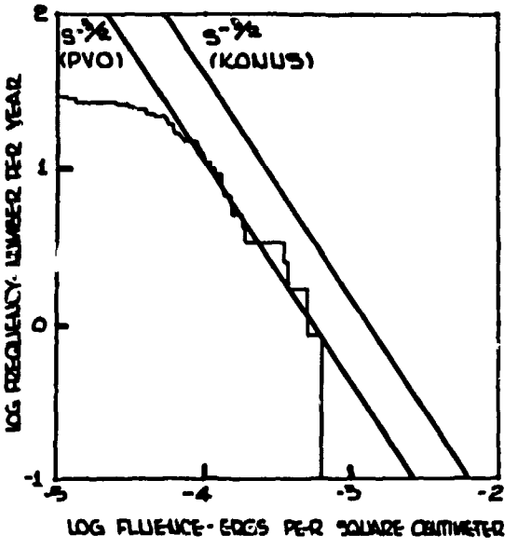

Figure 1. Log N-Log S for PVO data acquired through 1979. Power law functions with a slope of -3/2 as fit to these data and as have been fit to KONUS data[2] are included. (Note the impression that the KONUS data show a higher level of fluence than do the PVO data.)

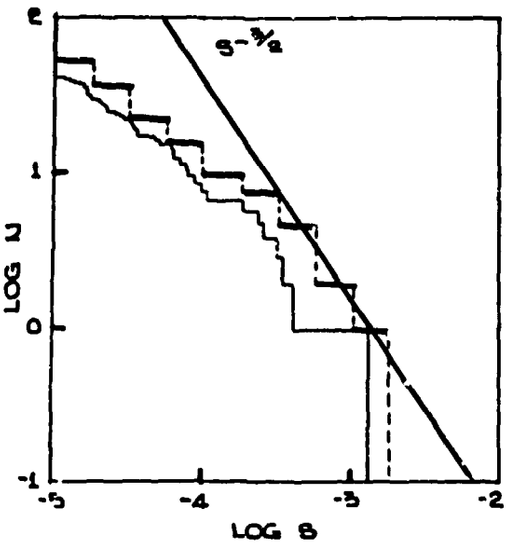

Figure 2. Two presentations of the KONUS data[2] for events with quoted levels of fluence $>10^{-5}$ erg cm^{-2}. Data taken from the tables[2] are plotted as the lighter, irregular curve using the same convention as in Figure 1. Also shown as the bold histogram are a portion of the binned data with the -3/2 power-law slope transcribed from Figure 168[2].

power law which has been presented with the KONUS data[2]. It is apparent that the KONUS -3/2 power-law approximation is not consistent with the PVO data. Note, however, that Mazets et al. do not present this function as a good fit to the data but, rather, claim that the slope is less than unity[2].

We have taken the liberty of presenting the portion of the KONUS data at fluences $> 10^{5}$ erg cm^{-2}, as derived from the tabular listings of Mazets et al.[2], and using the convention employed in presenting the PVO data. This is shown as Figure 2. Note that a dead-time correction is required in order to properly determine the effective event frequency. We have used the observing time as quoted by Mazets et al. [2]. The shape of the curve will be independent of this correction, and will be only a function of the fluences listed in the tables. This assumes that the fluences listed in the table are fully corrected for geometric and spectral effects, and that no further manipulation of the data is necessary before presentation in a graphical form.

Figure 2 also includes the curve transcribed from Mazets et al.[2] in which the <u>same</u> data are binned into quarter-decade intervals and

fit with the -3/2 power law that was shown in figure 1. The binned presentation tends to suggest a higher average level because the data are actually represented by the lower left-hand corner of each step rather than the mid-point. We are not able to explain why the binned histogram does not conform to the curve which we have plotted from the tabulated data. We have previously (from the preliminary version of the KONUS catalog) been successful in reproducing the binned form of the KONUS Log N-Log S curve from the tabular data, supporting our assumption that no further corrections are required. Note that we performed no editing in presenting the KONUS data, but have included every event with fluence quoted at a level $>10^{-5}$ erg cm^{-2}. It is also particularly interesting that there is no event listed in the KONUS catalog with a fluence in the range 5.6-10 x 10^{-4} erg cm^{-2} although preliminary versions of the catalog did include one event in this range.

In fact, KONUS and PVO results are in reasonable agreement when compared in a consistent manner. The data shown in Figures 1 and 2 have been combined and are shown in Figure 3. It was found that the effect of two events (GB791115 and GB791116, which were not recorded by the KONUS experiment) created a major impact in the comparison of the two curves. Therefore, another comparison was performed, including PVO data only for those events also observed by the KONUS experiment. This comparison is shown in Figure 4, and the agreement between KONUS and PVO is seen to be remarkably good. This is true in spite of the fact that the KONUS catalog contains a number of weak but long duration events (such as GB791101 and GB791230), for which

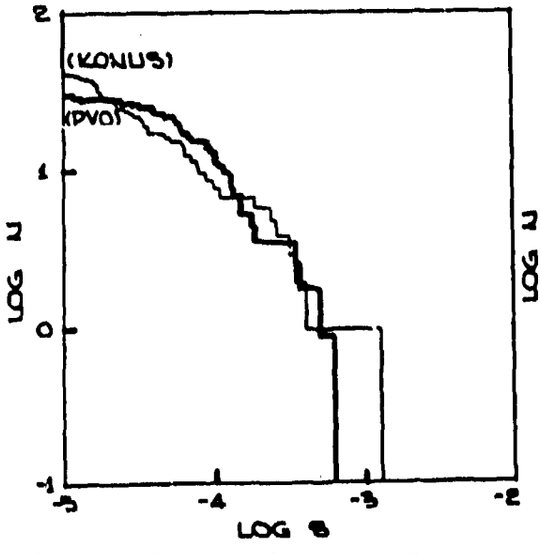

Figure 3. PVO (bold line) and KONUS (light line) data (from Figures 1 and 2, respectively) compared directly. Note the impression that the KONUS data define a smaller slope.

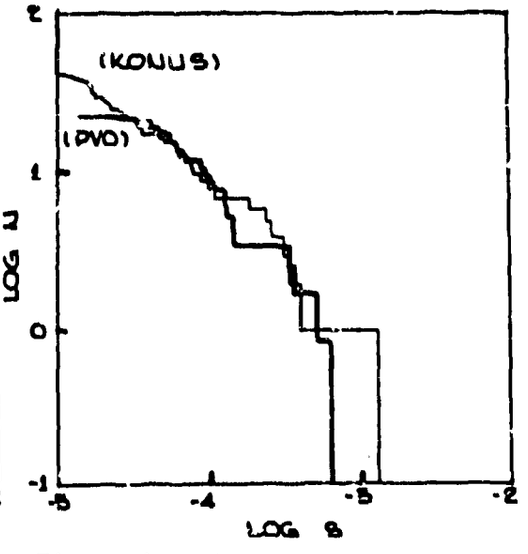

Figure 4. The subset of PVO data representing only those events also observed by the KONUS experiment compared directly to the KONUS data from Figure 2.

are ted rather high levels of fluence but which were not recorded or rec ded at only a very low level by the PVO instrument. It is also n eworthy that there is not general agreement in the levels of fluence quoted from the two data sets for individual events but, rather, variations over a range of a factor of ~40 are observed.

Thus, the impression created by the log N-log S is very sensitive to the effects of only a few large events if one is allowed to be misled by the upper end of the curve, which is poorly defined, statistically. Since these events are expected to occur in a stochastic fashion, we have attempted to model such observations and characterize the statistical significance of the data through Monte Carlo simulations. The results of a family of such simulations, for an input distribution conforming to a -3/2 power law, is shown in Figure 5. This was intended to represent the present (145 events) state of observations. The uncertainty of ±0.15 in fitting the slope implies that there can be expected to be observed only a marginally significant (3σ) difference between a -1 and a -3/2 power-law slope, even if the observations are unperturbed by thresholding effects. Further, the threshold effects are likely to create an impact over a large range of the data, since a number of instantaneously weak but long duration events (particularly in the KONUS data) contribute toward the distribution at high fluences. Similar events only slightly weaker may be below the threshold of detection, creating a deficiency at moderate and lower fluences[4].

Several miscellaneous points should be mentioned. First, presenting the log N-log S data in differential form would be less likely to be misleading; however, the number of events available for analysis is yet so small that a problem exists in subdividing the data into more than a few intervals. Actually, this problem is only

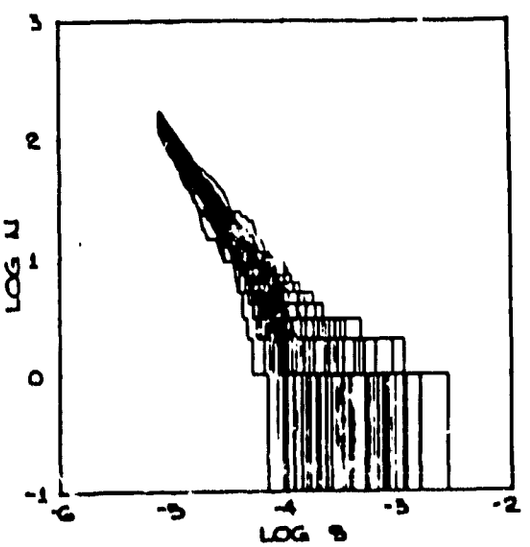

Figure 5. A family of Monte Carlo simulations representing 145 events per year drawn from an $N \propto S^{-3/2}$ distribution. The average slope of the simulated observatons was found to be -1.48 ±0.15.

masked by using the integral form. In any case, the low frequency of events observed at the sensitivity of present long-duration (satellite borne) gamma burst monitors precludes resolution of the shape of the Log N-Log S curve in the near future. Second, the frequency of events as a function of maximum intensity (Log N-log P) is much less sensitive to distortions caused by the instrument threshold effects. Both PVO and KONUS Log N-Log P curves much more nearly conform to a -3/2 power law. Third, measurements made by balloon-borne instruments, ostensibly having much greater sensitivity than present satellite-borne experiments, imply an upper limit for event frequency at very low fluences which is well below an extrapolation downward at a slope of -3/2. Although there is some uncertainty in relating the balloon and satellite data, the balloon data seem internally to deny a -3/2 power-law distribution at very low levels of fluence[5].

CONCLUSIONS

In summary, we feel that PVO and KONUS log N-log S data are in reasonable agreement. The impression of disagreement has been created in part by the differing methods of data presentation and in part by the statistics of the observations (instrumental duty cycle and statistics of occurrence). The data appear to be consistent with a -3/2 power-law distribution, however, the present state of the observations has not produced sufficient data to allow the slope or shape of the curve to be clearly defined.

ACKNOWLEDGMENT

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