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Statistical aspects of energetic particle intensity variations between 1974 and 2000

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Abstract. IMP-8 data provide long-term 1 AU baselines for energetic particle intensities in the Heliosphere. The available time series are distorted by various kinds of cross-talk and backgrounds, changes in thresholds, and discreteness effects due to low counts. The impact of distortions on various data sets will be compared. Quantiles and extremal statistics will be invoked to emphasize different aspects of the temporal dependence of proton and electron intensity distributions.

1 Introduction

Differential intensity of energetic particles as measured by solid state detector telescopes is distorted and contaminated by various effects. The purpose of such measurements is to determine the free-space intensity, i.e. the ambient one not influenced by the presence of any instrument or of the spacecraft body. In most cases, however, some secondaries (e.g. gammas and neutrons) do penetrate even the best anticoincidence shield, and cause contamination or 'background'. The random, Poissonian nature of particle arrival is also a distorting effect, particularly when typical counts during the integration time are not much higher than unity. This is often the case for MeV proton, He and electron measurements during quiet-time intervals near solar activity minimum. As the nominal integration time of intensity measurements is occasionally much lower than the actual on-time, one has to be careful about the interpretation of very low or zero nominal intensity values. In fact, when the purpose of research is the better understanding of the statistics of genuinely low intensities, one needs to go back to actually measured counts, and the on-times are needed even in the case of zero counts. The latter information is not always readily available in public data archives.

The statistical description of the variation of particle intensities at low solar activity is important for a better understanding of the processes giving rise to quiet-time fluxes. Some preliminary results on intensity variations were published e.g. by Király et al. (1995), and by Király and Kecskeméty (1998). It appears that quiet-time fluxes arise partly from CIRs, partly from the solar corona (possibly from reconnection). The study of anisotropic streaming and of the radial variation of quiet-time fluxes provide important clues for the relative importance of the two sources (Marshall and Stone, 1978, and Kecskeméty et al., 2001).

In this contribution attention will be confined to statistical aspects of some IMP-8 data sets.

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2 Data sets

The IMP-8 satellite was launched on 26 October 1973, and is still operational. It spends more than half of its time in the solar wind, outside the terrestrial bow shock. It provides the longest near-Earth energetic particle intensity time series.

The Charged Particle Measurement Experiment (CPME) proton-electron telescope (PET) of the Johns Hopkins University Applied Physics Laboratory is a 3-element solid state telescope, surrounded by an anticoincidence cup. Up to 2 MeV, protons are absorbed in the 1st detector. The plastic coincidence cup finally broke down in 1989, but it operated somewhat irregularly for some time before. The instrument itself is still working. The geometry factor below 15 MeV is 1.51 $cm^2 sr$.

The Caltech Electron/Isotope spectrometer (EIS) consisted of a stack of 11 silicon detectors. The instrument, including its anticoincidence cup, survived until its complete breakdown in 1992. Its geometric factor was 0.23 $cm^2 sr$.

The Cosmic Ray Nuclear Composition (CRNC) Spectrometer of the University of Chicago consists of two telescopes, the main telescope and the Low Energy Telescope (LET). The latter consists of 3 silicon detectors, 2 of which are electronically tied together and serve as a guard counter, roughly equivalent to the plastic anticoincidence cups of the other telescopes. However, it is still working, thus providing the only complete data set of an actively shielded telescope for about 1 MeV protons over the whole duration of the mission. The geometry factor of LET is about 0.4 $cm^2 sr$.

3 Discussion

Data sets of the above three instruments are of great importance as 1 AU baselines of long-term MeV particle intensities. Statistical aspects of those time series will be discussed at the Conference from different aspects.

First, the frequency of zero and other low hourly counts will be discussed, with particular regard to actual on-times (or live times) for periods when low counts were found. It is established that around 1 MeV the counts are zero or very low only in periods with low on-times, i.e. there is no evidence for very large downward fluctuations of the intensities themselves. This is particularly true for the instrument with the largest geometrical factor. Correlations between on-times and low intensity data will be compared with expectations based on Poissonian statistics.

Then distributions of log intensities will be compared for different phases of the solar cycle. It will be discussed to what extent background and saturation effects should distort the distributions.

Finally, methods of averaging and other methods of data cleaning will be compared, and applied both to ion and electron data. It will be shown how subtle effects like upstream influences (Király 2001) and Jupiter electrons become conspicuous when the proper methods of data treatment are applied.

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References

Király, P. et al., Proc. of the 25th ICRC, Vol. 2. p. 477 (1995)
Király, P. and Kecskeméty, K., Proc. of 16th European Cosmic Ray Symposium, p. 173 (Ed. J. Medina, 1998)
Marshall, F.E. and Stone, E.C., J. Geophys. Res. 83, 3289 (1978)
Kecskeméty, K. Müller-Mellin, and Kunow, H., this conference (2001)
Király, P., this conference (2001)