COSMIC RAY POWER SPECTRAL VARIATIONS: 3. SOLAR ROTATION PERIODICITIES

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ABSTRACT

Earlier studies of the periodic changes in cosmic ray intensity by power spectral analysis provided some understanding of the daily variation in terms of ambient power. The solar rotation periodicities are investigated here using daily means of Calgary neutron monitor data during 1965-76. Significant peaks with periods of 27 and 13.5 days with varying magnitudes are observed.

1. Introduction. It is generally accepted that the galactic cosmic radiation is modulated by the continuously varying solar plasma and fields of the modulating region within the heliosphere. Most cosmic ray variational studies (1-1000 Gev), have used 4 decades of ground-based measurements. These include ~ eleven-year solar cycle variation, Forbush decreases, 27-day variation and the various harmonics of the daily variation.

The 27-day variation has direct bearing on the solar features, on or above the solar surface and remain stable for more than one solar rotation of average period 27 days. The solar modulation is a continuous process and any variations in solar output will affect the interplanetary plasma and field, and in turn upon the flow of cosmic rays. Thus a study of the 27-day recurrence in cosmic ray intensity can provide us with information on solar output and its propagation in the interplanetary medium. Here we derive the 27-day rotation periodicities by power spectral analysis during the interval 1965-76, using the procedure adopted by Lanzerotti et al., (1981).

2. Spectral analysis of cosmic ray data. Daily mean values of Calgary neutron monitor data have been used over the interval 1965-76, for power spectral analysis, to investigate the 27-day periodicies and its harmonics. The Galgary neutron monitor is an 18-NM-64 type detector with statistical fluctuations of 0.02% in daily means. Initially the computations were carried out using one year's data at a time; however the peaks under investigation, were not very clear. Hence we combined 2 3 years of data for deriving the power spectra. The choice of 2 years of data at a time was found optimum to look for individual peaks and to compare their variations during the solar cycle.

3. Results and Discussion. The results of the power spectral analysis are shown in Figure 1. Over a sunspot cycle, the cosmic ray intensity changes (at median energies ~ 10-15 Gev) by about 15-20%, and any two successive years combined here generally correspond to similar solar conditions, with very small changes in cosmic ray intensity. However, large changes in cosmic ray intensity, which occur over periods of days (Forbush type decreases), do affect to some extent the overall spectral

shape, but are not effective in modulating the peaks observed. The vertical dashed lines indicate frequencies corresponding to peaks at 27 and 13.5 days. Note that the main peaks occur for the 27-days period and is quite significant for all the years, except for 1973-74. However, the 13-14 day peak is not very significant for a number of years, such as 1965-66, 1967-68 and 1975-76. These results were essentially confirmed by Sulphur Mountain Cosmic ray data. The power associated with the 27-day peak in 1973-74 is quite low and indicates the possibility that even the stable periodic features of the solar surface were not effective in producing any significant changes in the cosmic ray intensity. Solar coronal holes are quite abundant during 1973-74 and also in 1975-76, and thus an absence of any solar rotation periodicity in 1973-74 perhaps indicated that some other solar feature may be responsible. Venkatesan et al., (1982) have shown that only small changes occur in cosmic rays due to coronal holes. The Chree type of analysis involving some specific solar features, in future, may provide the answer for the observations reported here. It is likely that the solar flares/solar active centres could be the source for the solar rotation periodicity observed. The reason for this is not obvious at present.

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5. References.

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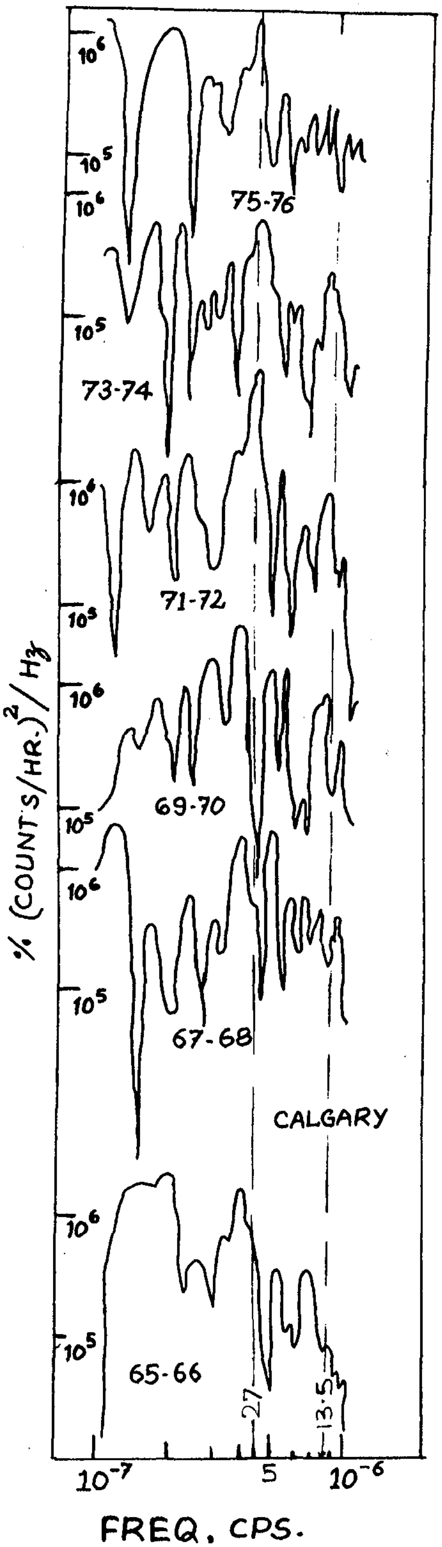

Figure 1. Power spectra for the Calgary neutron monitor for the interval 1965-76. Vertical dashed lines indicate the 27 and 13.5 day period.