ISOTROPIC INTENSITY WAVES AND FEATURES OF THEIR OCCURRENCE.

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ABSTRACT

Waves of daily average cosmic ray intensity, dependent on IMF polarity, have been observed in 1982 (Jacklyn and Pomerantz, 1983) and again in 1983 and 1984. These waves at first appeared to be due to the North-South anisotropy. Further investigation has revealed that the waves comprise two components, a large isotropic and a smaller anisotropic component. The anisotropic part is attributed to the North-South anisotropy and is in phase with the larger isotropic component in the Southern hemisphere. Unlike the North-South anisotropy which is a permanent feature of cosmic ray modulation, the isotropic phenomenon appears to be episodic in character. When present it is clearly dependent on IMF polarity but does not correlate well with IMF field strength. It is conjectured that the phenomenon might indicate some difference between the intensity regimes above and below the neutral sheet.

Introduction.

Isotropic intensity waves were first observed in variations of neutron intensity which followed the cosmic ray storm of September 1978 (Pomerantz and Duggal, 1979). The spectrum of these waves was found to be similar to that for a Forbush decrease, namely p^{-1} (Duggal et al., 1981). Since that time no further examples of this phenomenon have been observed.

During the latter months of 1982, 1983 and 1984 waves of variation occurred again. On each of the three occasions the waves were similar to each other, but were different in character from the 1978 waves. They consisted of two components, one isotropic and a second smaller anisotropic component, each having a hard rigidity spectrum. The analysis of the 27-day waves observed in 1982 have been described earlier (Jacklyn and Pomerantz, 1983; Jacklyn and Duldig, 1983; Jacklyn et al., 1984a, 1984b). In this paper we reiterate the two-component structure of the 1982 intensity waves, describe the intensity waves observed in 1983 and 1984 and discuss the field dependence of the isotropic component.

The 1982 Two Component Intensity Waves.

The discovery of prominent 27-day waves of the daily average cosmic ray intensity between July and October 1982 was described at the Bangalore Conference (Jacklyn and Pomerantz, 1983). It was clear that these waves had a relatively hard spectrum and seemed to represent waves of the interplanetary North-South asymmetry. Furthermore there was a very strong linear correlation between the waves and the proven index of variation of the North-South asymmetry, namely GG Nagoya (Mori and Nagashima, 1979).

It was later realized that these waves, now referred to as A_1 waves, were far too large in relation to the GG variations to be due solely to the North-South asymmetry. By employing a constant of proportionality k_2, obtained from the CRRL tables of coupling coefficients for uni-directional anisotropies with a power index γ=0.0 and upper limiting rigidity Pu=200 GV, it was possible to remove the North-South asymmetry component through the GG variations (Jacklyn, Duldig and Pomerantz, 1984a and 1984b). The resulting residual variations, after p^{-1} isotropic and p^0 anisotropic variations had been removed, are referred to as A_2 variations and are given by

$$A_2 = A_1 - k_2 {}^{\Delta I}/_{I_o}(GG)$$

$$= {}^{\Delta I}/_{I_o}(MAW.UGN) - k_1 {}^{\Delta I}/_{I_o}(McMURDO\ NM) - k_2 {}^{\Delta I}/_{I_o}(GG)$$

A Chree method of superposition of epochs was employed (Figure 1) to compare the two wave components A_1 and A_2. Clearly the variation is mainly due to the A_2 component which is encompassed in the A_1 variations. Furthermore there was a strong correlation between sectorized field direction and the waves.

When underground data from the Misato multi-directional telescope system became available it appeared that, unlike the North-South asymmetry component, the A_2 variations were isotropic, being in phase worldwide. Using the appropriate coupling coefficients together with the GG data the asymmetric component was removed from 4 northern and 3 southern hemisphere asymptotic latitudes of viewing and the isotropic nature of the variations was confirmed (Figure 2).

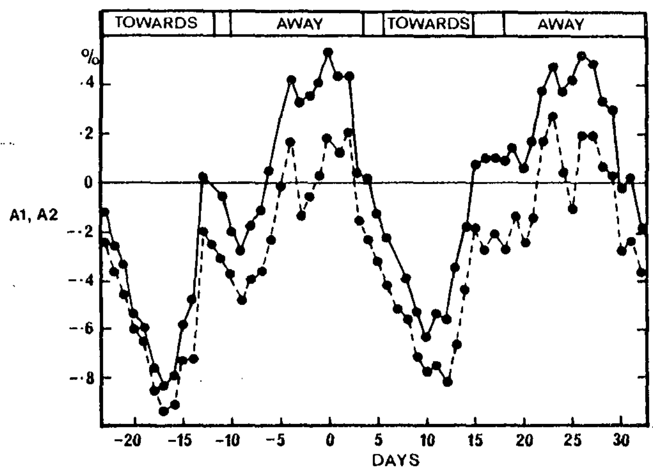

Figure 1. A 54-day Chree analysis of A_1 and A_2 using the days of maximum A_1 on 16 July and 12 August 1982 as key days. The averaged Towards and Away Periods are shown. A_1: full lines A_2: dashed lines.

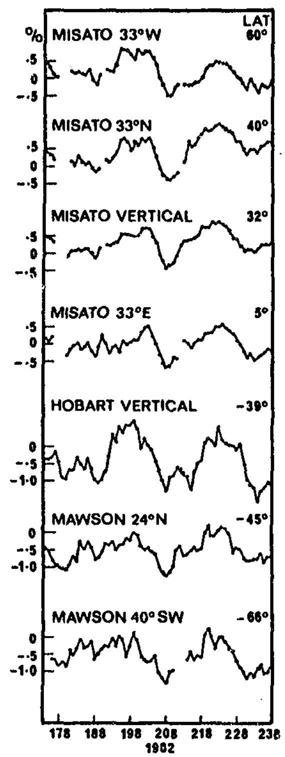

Figure 2. The A_2 intensity waves, derived from observations underground at depths of 40-60 hg cm^{-2}, July - August 1982. The asymptotic latitudes of viewing at the median rigidities of response are shown at the right of the figure.

The Intensity Waves of 1983 and 1984.

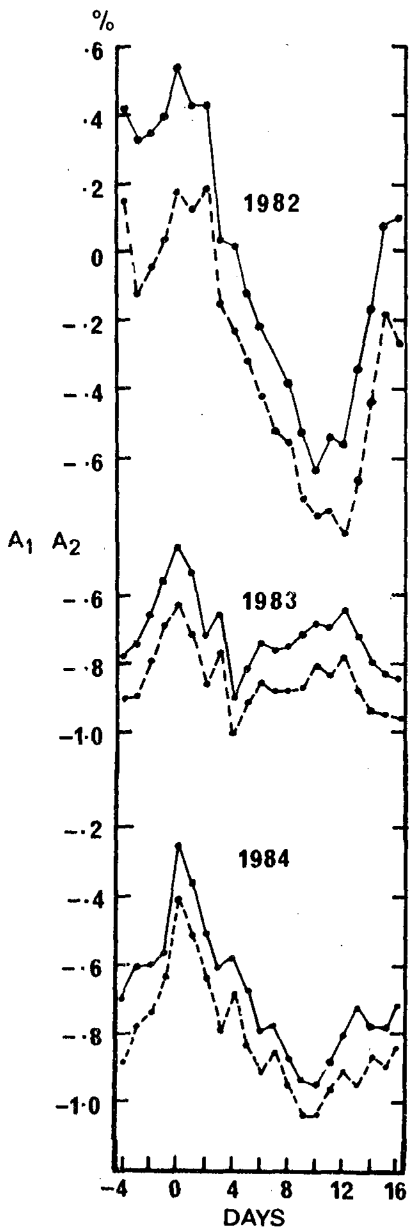

Figure 3. A 21-day Chree analysis of A_1 and A_2 in 1983 and 1984, compared with the results from 1982 (see Fig.1). Peak days in the waves of A_1 are used as key days.
A_1: full lines
A_2: dashed lines.

Figure 3 shows the 21-day Chree analysis of A_1 and A_2 waves for 1982, 1983 and 1984, on the same scale. The 1983 intensity waves were of the same intrinsic character as those of 1982 given that a 4-sector IMF structure had replaced the earlier 2-sector structure. Thus in 1983 the waves show a periodicity of 13.5 days. In 1984 a two-sector structure was again apparent. However, the A_1 and A_2 waves were significantly smaller than those of 1982.

Summary and Discussion.

Two kinds of intensity wave occuring together have been observed over the last 3 years. The first is due to the well known North-South asymmetry and can be extracted from the combined (A_1) wave. The residual waves (A_2) are much larger and are isotropic with a hard ($\gamma \gtrsim 0$) rigidity spectrum. These isotropic waves correlate well with the IMF sector direction.

Attempts to correlate the A_2 intensity waves with IMF field strength gave conflicting results. Over short time scales (single periods of waves) the correlation was good but over several periods the correlation disappeared. The delay required to optimize the correlation was different for each period. Furthermore, periods of strong IMF field strength with clearly defined sector structure early in 1983 and 1984 showed no A_2 waves in the daily average cosmic ray observations from Mawson.

A possible explanation may relate to the extent of the IMF sector structure away from the heliomagnetic equator and to an omnidirectional cosmic ray intensity that is presumed to be greater at times below the neutral sheet than above it. During periods of large amplitude of the waves in the neutral sheet, the particle radiation would tend to be confined within the wave boundary of a sector and to exhibit the intensity characteristics of either the southern or northern space of the helio-sphere. When the wave amplitude of the neutral sheet is small, particle modulation should be less effective (Yasue, 1980) and confinement to a particular helio hemisphere should be less pronounced within a sector. Thus the size of the A_2 waves may give some indication of the neutral sheet amplitude.

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