# II-4-27. The Diurnal Variation of the Intensity of the Nucleonic Component during Forbush Decreases

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It has been suggested, particularly by Dorman[1], that there are two types of solar streams modulating the intensity of the cosmic radiation, one being wide and of low magnetic field strength causing the normal diurnal variation, the second narrower and having a stronger field causing Forbush decreases when the stream envelops the earth. It is reasonable to expect that streams of this second type may cause an anomalous diurnal variation whilst the earth is enveloped and to investigate this possibility we have made an analysis of the diurnal variation of the intensity of the nucleonic component during 38 decreases of intensity for Leeds and Deep River (occurring during 1958, 59 and 60) and at Huancayo for 26 decreases during 1958 and 59.

For each station the observations have combined by the method of super-posed epochs, the epoch day being selected as the day on which the recovery from the Forbush decrease started. This day was chosen because on the days immediately previous, the distorting effect of the rapid decrease of intensity renders it impossible to make a reliable harmonic analysis of the data. During the recovery phase the slower increase of intensity has been corrected by using 24 hour moving averages.

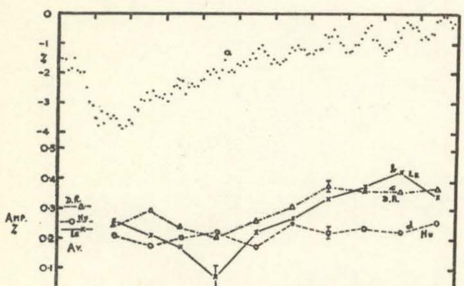

Fig. 1. Variation of amplitude of first harmonic. Curve a is the average Forbush decrease at Leeds.

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Fig. 1 curve a, shows the mean variation of the intensity for the 38 decreases recorded at Leeds, the epoch day being day 0. Curves b, c, d, show the variation of the amplitude of the first harmonic for Leeds, Deep River and Huancayo respectively during the recovery phase of the Forbush decrease. The mean amplitude during the years covered by this analysis is also shown for each station. For both Leeds and Deep River the amplitude is reduced falling to a minimum value around days 2 and 3, thereafter increasing steadily to a value greater than the average as the recovery from the storm becomes complete. For Huancayo the amplitude is only reduced slightly below the average value and is followed by a continuous increase, the overall variation being considerably smaller than for the other two stations.

Fig. 2 shows the variation in the time of maximum of the first harmonic during the

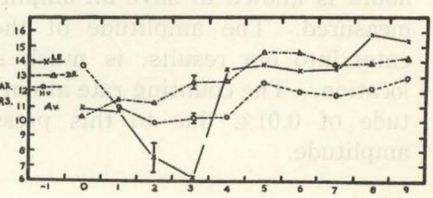

Fig. 2. Variation of the phase of the first harmonic.

same period. The average values are also shown. All stations start immediately with an earlier time of maximum than normal and then during the recovery, the time of maximum moves later.

The effects reported here are thought to be connected with the movement of the earth into the middle of a strong stream *i.e.* one causing a Forbush decrease. This position is reached on days 2-3 and is followed by the earth moving towards the trailing edge as the recovery becomes complete. The field strength of the beam may well be such[2] that when the earth is in the middle of the stream the particles which cause the normal nucleonic diurnal variations are deflected away from the earth, whereas the higher energy particles are still able to reach the earth from a direction giving an early phase. Later, as the earth moves towards the edge of the beam, the amplitude and phase return more nearly to normal as particles of successively lower energy are able to penetrate to the earth.

The above results are in contrast to previous work using meson data[3], which show an increased amplitude and early phase immediately after the onset of magnetic storms. This may be explained by the greater sensitivity of meson telescopes to particles of higher energy, which penetrate the stream more easily than those causing the neutron monitor response. This may cause an increase in the meson amplitude when the earth is in the stream owing to the larger effective solid angle subtended at the earth by the stream.

**References**


1) L. I. Dorman: *Cosmic Ray Variations*, (1957) 430.
2) L. I. Dorman: *Cosmic Ray Variations*, (1957) 493.
3) Y. Sekido, and S. Yoshida: Rep. Ions, Res, Jap. **4** (1950) 37.


### *Discussion*

**Kane, R.P.:** Before proceeding towards examining models that could explain experimental facts, it is necessary to confirm the genuineness of the latter. In my results I find that there is no consistent relationship between Forbush decreases and daily variation which is outside actual standard deviation.

**Marsden, P.L.:** The variations in the diurnal variation revealed in this period show a statistically significant variation especially for the high latitude stations. I cannot reconcile your observations with the data we have recorded although it should be remembered your data were selected in a different manner.

**Sandström, A.E.:** In one of the storms during IGY, I do not remember the time, there are three days displaying a very funny daily variation with big amplitudes. These days happened at the end of the cosmic-ray storm. They were geomagnetically calm days. Have you made any day by day study thereby finding them? They will certainly not affect your averages very much. However, it would be interesting if you have found them. I do not know what to make of them.

**Marsden:** During the subsequent discussion it was reported that the days refered to by Dr. Sandström occurred in December 1957 and were therefore not included in the analysis which only covered 1958, 59 and 60. We have not made a day by day analysis as in general the statistical uncertainty of the data do not make this worthwhile.

**Kondō, I.:** There is a possibility that we can observe a rather large diurnal variation on a geomagnetically quiet day, when a solar flare occures on, say east limb of the sun. Then the plasma cloud emitted may not hit the earth, so no magnetic storm or cosmic-ray storm are observed but yet produces cosmic-ray anisotropy. This was already studied to some extent by Dr. Murakami and Kudo.

**Wada, M.:** On December 23, 1957, the amplitude of diurnal variation was very large, and the direction of anisotropy was almost opposite to those of usual days. The day was in the phase of the end of a Forbush decrease. There are several cases of such effect.

**Marsden:** In the analysis presented here 38 Forbush decreases were considered, so that possibly days of the type mentioned by Dr. Wada, which have a phase of the maximum of the diurnal variation opposite to that we have found do not play a large part in the average effect.

**Sarabhai, V.A.:** (1) Looking at your data as well as some shown by Carmichael, I have the feeling that something interesting is taking place in the 2nd recovering phase of the Forbush decrease. But these are probably sharp changes and do not appear well in the diurnal component.

(2) I do not see why the changes at the equator are small.

**Marsden:** (1) It is possible that the diurnal variation found here during the recovery phase of Forbush decreases is due to sudden intensity changes in L.S.T. which are revealed over several days. The fitting of harmonic curves to the data recorded on such days will reduce the different amplitude of the effect.

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# II-4-28. A Lunar Cosmic Ray Intensity Variation II

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By averaging the pressure corrected meson and neutron intensity data for Kiel (10° 08′ 52″ E/54° 20′ 28″ N geomagnetic latitude) from July 1957 to June 1961, we receive for the mean meson *vs.* neutron lunar day intensity wave the relative amplitudes: 0.012 *vs.* 0.025% of the mean intensities. The maxima occur at about 12–14 hours after moon culmination at Greenwich. There are also indications for second harmonics in these waves.

## §1. An Introduction

At the Moscow Cosmic Ray Conference we reported about a lunar day intensity variation of cosmic radiation[1]. The analysis showed a $24^h\ 50^m$ sinusoidal period with an intensity maximum about 18 hours after moon culmination at Greenwich.

This small intensity oscillation is different from that one which was observed by Duperier[2]. Analysing the time variations of cosmic ray intensity for the period May 1941–April 1944, Duperier received a lunar half day wave with an amplitude of 0.02% which is in direct correlation to the lunar produced vertical movements of the meson producing atmospheric layers.

For the time July 1, 1957–June 30, 1961 we have evaluated in the meantime the variations of cosmic ray intensities for mesons and neutrons at Kiel (10° 08′ 52″*E*/54° 20′ 28″ *N* geomag. *L*) in a way which is described in our previous paper[1] with only little alterations. The results of these investigations are described below. They show that also for this long period of 4 year's observations there remains a clear lunar day intensity wave of cosmic radiation, now with a maximum about 15 hours after moon culmination at Greenwich and with an amplitude of 0.012% of the mean meson intensity.

## §2. The Method of Analysing the Recordings

While we took at the previous procedure for evaluating our recordings the 15 minutes intensity values starting with that one which is nearest to the time of moon culmination of Greenwich (England) for the 24 hours 50 min. of each moon-day and averaging these values for a total of consecutive 30 days in the earlier paper we did it now for only 29 moon-days. This was done because in this way the time interval of averaging can be arranged in such a way that it concerns always the same consequence of moon phases starting with the moon day for which the moon phase is in the first quarter. By this way phase shifts are avoided with respect to the moon phases.

## §3. Results of the Analyses

*a) The lunar wave of the meson intensity*

Fig. 1 shows the quarterly annual mean