DIURNAL VARIATIONS OF COSMIC RAY GEOMAGNETIC CUT-OFF THRESHOLD RIGIDITIES

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Abstract. For the period 1 May-30 June 1972, using the method of spectrographic global survey we investigated the rigidity variations Rc of geomagnetic cut-off as a function of local time and the level of geomagnetic disturbance for a number of stations of the world-wide network.
It is shown that geomagnetic cut-off threshold rigidities undergo diurnal variations. The diurnal wave amplitude decreases with increasing threshold rigidity Rc, and the wave maximum occurs at 2-4 hr LT. The amplitude of diurnal variations increases with increasing geomagnetic activity.
The results obtained agree with those from trajectory calculations made for an asymmetric model of the magnetosphere during different geomagnetic fdisturbance conditions.

The study of cosmic ray (CR) intensity variations of magnetospheric origin observable on the ground is of interest for two reasons: first, we cannot study CR variations of interplanetary origin without making adequately allowing for the variations arising in the sphere of action of the magnetic field of the Earth and, second, the variations of magnetospheric origin themselves can be used as an additional source of information on processes occurring inside the magnetosphere at different distances from the Earth.

However, the study of the variations of this class becomes difficult because they are observed simultaneously with CR variations of a significantly larger amplitude which are associated with processes in interplanetary space. In order to separate these two types of variations, a method of spectrographic global survey (SGS) has been developed that makes it possible, using ground-based CR observations at the world-wide network of stations, to obtain information regarding the energy and pitch-angle distribution of primary CR in the interplanetary magnetic field (IMF), on the IMF orientation and on variations of the planetary system of geomagnetic cut-off rigidities (GCR). This method was used in /1/ to obtain information on GCR variations (Δ Rc) for a number of points of the world-wide network during the June 1972 geomagnetic storm; the latitude dependence of the amplitudes of these variations is studied and a quantitative estimation of parameters of current systems of disturbances made. The results obtained are consistent with current views of dynamical processes in the magnetosphere and agree with satellite measurements /2/.

This paper investigates GCR diurnal variations, their dependence on latitude and level of geomagnetic disturbance for the period 1 May - 30 June 1972.

The analysis employed data from 34 world network stations. In order to determine GCR variations at middle and lower-latitude stations it is necessary to have at least two detectors sensitive to these variations, with different coupling coefficients at threshold rigidity. Since many middle and lower-latitude stations lack complexes of detectors required to determine Rc, near-by stations were combined into such complexes and were ascribed equal (averaged) threshold GCR (R c). The

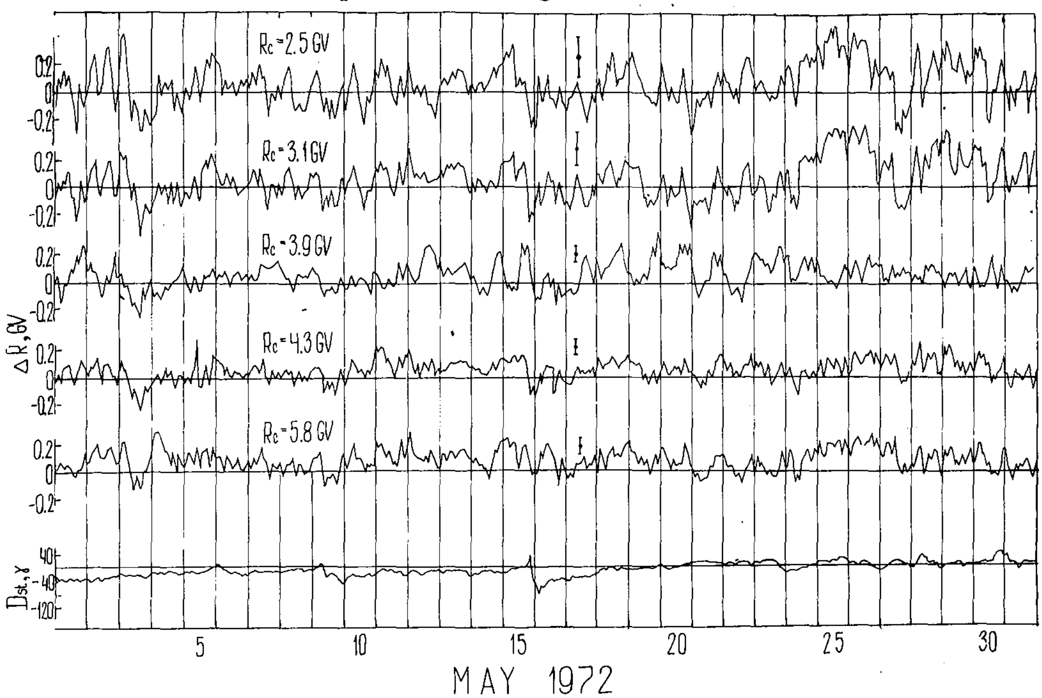

Fig. 1

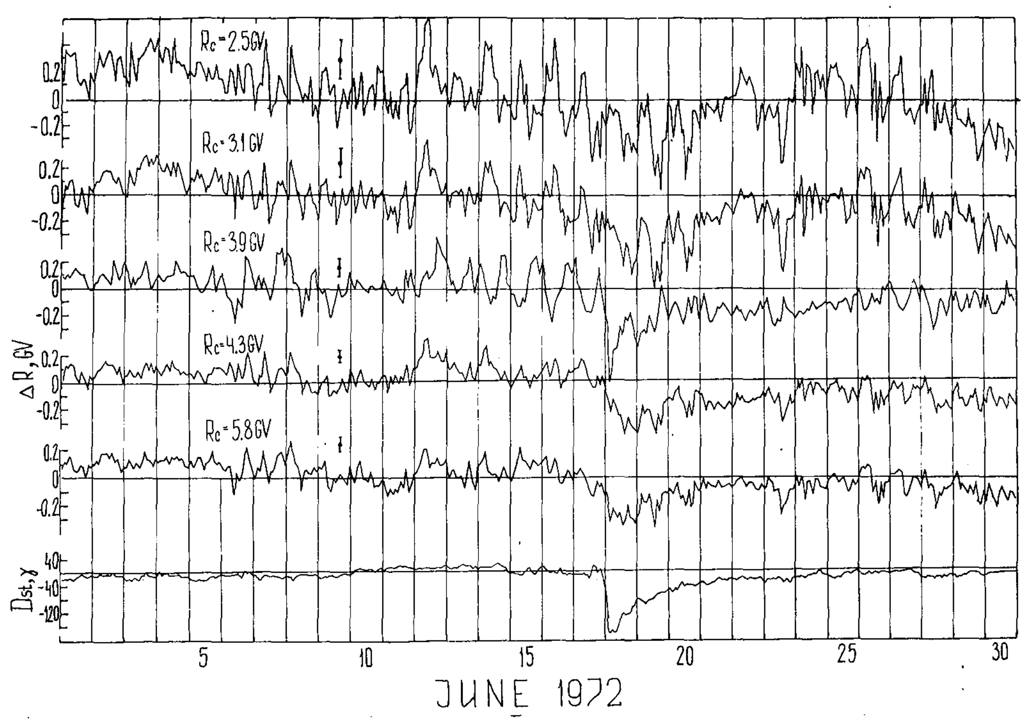

Fig. 2

analysis used observations from five such groups of stations: 1.Kiel and Utrecht ($\bar{R}c$=2.5GV); 2.Dourbes and Lindau ($\bar{R}c$=3.1 GV); 3.the Sayan spectrograph complex ($\bar{R}c$=3.9GV); 4.Hafelekar, Zugspitze, Jungfraujoch ($\bar{R}c$=4.3GV); 5.Rome and Pic-du-Midi ($\bar{R}c$=5.8GV). For each group of stations, we determined variations of threshold GCR using data averaged over a two-hour interval.

Figs 1 and 2 show the variations Rc as obtained by the SGS method, of threshold GCR for two months for each of the above groups of CR stations. The period of study includes intervals with both relatively weak geomagnetic activity (Kp $\sim$ 1) and high geomagnetic activity (Kp $>$ 3+). The mean Kp-index that defines the geomagnetic activity for the whole period considered is about 2+.

In order to separate the periodic part of the threshold GCR variation, we employed a numerical mathematical filter /3/ which was used to separate oscillations with a period T $\leq$ 24 hr and the filtered-out data were then averaged by the superposed epoch method. The results of the analysis made are presented in Fig. 3 showing the variations of threshold GCR during 24 hr as a function of LT (solid curve). The upper panel of the plots represents the variations of threshold GCR during 24 hr for a period with Kp $\sim$ 2 while the lower panel shows those for the period with Kp $\sim$ 5.

As follows from the plots, the variations of threshold GCR involve a diurnal variation with its maximum occurring at 2-4 hr LT. For the group of stations with $\bar{R}c$=2.5GV, the amplitude of variations in threshold GCR during 24 hr is $\sim$ 0.12GV for a period with Kp $\sim$ 2 and $\sim$ 0.3 GV for a period with Kp $\sim$ 5; for the group of stations with $\bar{R}c$=3.1 GV, these variations are $\sim$ 0.12GV and $\sim$ 0.2GV, respectively, with $\bar{R}c$=3.9GV, $\sim$ 0.1GV and $\sim$ 0.16GV, with $\bar{R}c$=4.3GV – $\sim$ 0.06GV and $\sim$ 0.1GV, with $\bar{R}c$=5.8GV, $\sim$ 0.05GV and $\sim$ 0.08GV.

Thus, the amplitude of the diurnal variation in threshold GCR depends on threshold GCR, decreases with increasing

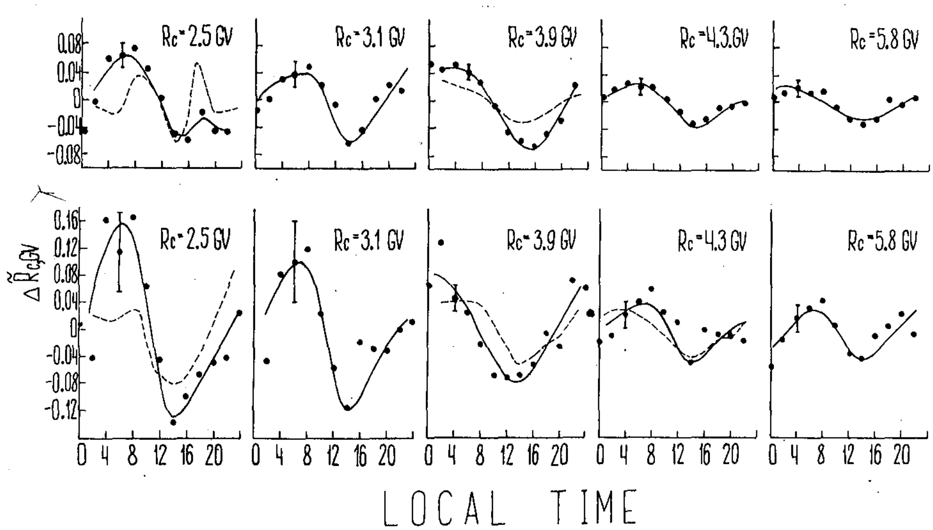

Fig. 3

Rc and increases with an enhancement of geomagnetic activity.

This diurnal variation in threshold GCR can be due to several reasons, in particular to an asymmetry of the magnetosphere as a consequence of its being compressed by the SW.

Since the diurnal wave in the threshold GCR variations was obt ined from CR observations covering a rather long period, this indicates that the asymmetry source for threshold GCR in the magnetosphere is quasi-stationary.

In order to confirm this, we made numerical trajectory calculations of the motion of charged particles in a real geomagnetic field. The real geomagnetic field was specified in the calculations in terms of a model reported by Tsyganenko N.A. et al. /4/, in which a separate description is made of magnetic fields from each current system of the magnetosphere showing a substantially different spatial structure. The parameters of the model depend on the level of geomagnetic activity that is characterized by the Kp-index.

A dotted line in Fig. 3 shows the results from the numerical calculations of the dependence of threshold GCR on LT. The upper panel refers to a quiet period ($Kp \sim 0$) and the lower panel corresponds to the period with $Kp > 3+$. The numerical calculation results confirm the presence of a diurnal wave obtained from experimental data, the dependence of its amplitude on threshold GCR at the observation point and on the level of geomagnetic activity.

Conclusions. It is demonstrated both experimentally and theoretically that diurnal variations of CR threshold GCR do exist at middle and lower latitudes. The diurnal wave amplitude of threshold GCR decreases with increasing threshold GCR and increases with increasing geomagnetic activity. Diurnal wave maximum occurs at 2-4 hr LT. The trajectory calculations of the motion of charged particles in the geomagnetic field showed that the experimentally found diurnal wave in threshold GCR is due to the asymmetry of the magnetosphere because of its being compressed by the SW.

R E F E R E N C E S

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