STATEMENT

The majority of variations in the cosmic ray intensity observed at the earth are known to be due to solar modulation of Galactic cosmic rays. The present thesis deals with a special class of diurnal anisotropy with maximum around 09 hour direction in the interplanetary space. The studies are made with the Gulmarg neutron monitor as well as with the worldwide network of neutron monitors. In addition a neutron multiplicity meter was attached to the Gulmarg neutron monitor to study the possibility of using the multiplicity spectrum as a representation of the primary spectrum during various cosmic ray intensity variations.

A ground based neutron monitor looks into a small region of the sky, determined by its 'Asymptotic cone of acceptance' and, as earth spins, it scans this region of the sky around the spin-axis in all directions during the course of a day. As a result, any spatial anisotropy in the cosmic ray intensity perpendicular to the spin-axis produces a diurnal variation in the monitor counting rate, the time of maximum being a function of the local time at the monitor. On the other hand, any isotropic change in intensity, like the Forbush decrease, causes a simultaneous change in the monitor counting rate at all longitudes and latitudes. To separate out these two different types of cosmic ray intensity variations, it is therefore necessary to use a
large number of cosmic ray monitors spaced at various longitudes and latitudes.

The neutron monitor at Gulmarg was set up in September 1967. The author was actively involved in this work. The monitor is of IGY type and has twenty Boron-tri-fluoride counters with a total counting rate of \( \approx 260,000 \) counters hour\(^{-1}\). The station of the monitor has geographic latitude \(34.07^\circ\)N and longitude \(74.42^\circ\)E and is located 2743 meters above sea level. The specialized location of the monitor, with the geomagnetic cutoff rigidity of 11.91 GV of the station, makes it an important station in the worldwide network of the monitors. The neutron multiplicity meter designed and built by the author has been operated in association with the Gulmarg neutron monitor for the period October, 1967 – October, 1971.

The salient features of the results presented in the thesis are as follows:

The investigation of the diurnal variation in the cosmic ray intensity on individual days has revealed a new class of diurnal variation showing a maximum around 09 hour direction in the interplanetary space. It is shown to occur during the recovery phase of Forbush decreases as well as during quiet periods. The amplitude of this anomalous diurnal variation is, in general, larger when preceded by a Forbush decrease. The rigidity spectrum of the anomalous
The diurnal variation has an exponent around zero, the same as that for the average diurnal variation exhibiting maximum around 18 hours in the interplanetary space.

It is shown that the Forbush decreases associated with the diurnal variation exhibiting morning maximum, are 27 day recurrent in nature and are preceded by east limb solar flares on most of the occasions. Recurrent Forbush decreases preceded by west limb flares exhibit only the average diurnal variation in their recovery phases. Further, the non-recurrent Forbush decreases also show predominantly the characteristics of the average diurnal variation during their recovery phase.

A qualitative model of the transient modulation by solar corotating corpuscular streams of enhanced solar wind velocity, emanating from the active regions on the solar disc, is proposed to explain the anomalous diurnal anisotropy in the recovery phase of 27 day recurrent Forbush decreases. The enhanced convection of the cosmic ray particles in the corotating stream, in a quasi-equilibrium state with the simultaneous inward diffusion from all sides, produces depression in cosmic ray intensity inside the stream.

When the earth is engulfed by such a corotating stream from east of the earth-sun line, it experiences a smaller transient modulation depth on the west than on the east of the earth-sun line. At this specialized location inside the stream, there is therefore a larger inward diffusion from the west than
from the east of the earth-sun line, which is shown to result in the anomalous diurnal variation in the cosmic ray intensity with maximum around the garden hose direction. From this model, the cosmic ray diffusion coefficients, parallel and perpendicular to the interplanetary magnetic field inside the corotating stream, are derived and compared with the average values. It is found that, while the value of the field perpendicular diffusion coefficient inside the stream is of the same order as quoted by Jokipii and Coleman (1968), the field parallel diffusion coefficient is smaller by a factor of two. The recent measurements on Pioneer 10, however, indicate that the average value of the field parallel diffusion coefficient is much higher than the value quoted by Jokipii and Coleman (1968). The smaller value inside the corotating stream is understandable in terms of the enhanced magnetic field irregularities associated with high velocity solar wind in the stream producing larger turbulence.

Modifications in the configuration of a corotating stream due to the occurrence of east limb flares in the long lived active regions or in nearby regions on the solar disc, are discussed to explain the increased probability for the anomalous diurnal variation to occur. If the flare occurs in the active region producing the corotating stream, it may widen the angular extent of the stream increasing the transient modulating depth on the east than on west of the
earth-sun line, when the stream engulfs the earth. Or, if the flare occurs in the nearby active regions on the solar disc, the plasma cloud from the flare may interact with the stream and again produce a larger modulating depth on east of the earth-sun line. On the other hand the plasma cloud from a west limb flare, preceding the Forbush decrease caused by the corotating stream, cannot interact with the stream unless the angular dimensions of the cloud are sufficiently large. But it does create a region of depressed cosmic ray intensity on the west of the stream, which results in less diffusion of cosmic ray particles from the west, producing the diurnal variation in the intensity with maximum around 18 hours in the interplanetary space.

In contrast to the anomalous diurnal variation during the recovery phase of recurrent Forbush decreases, the anomalous diurnal variation during the quiet periods is attributed to the enhanced flux of cosmic ray particles in the garden hose direction resulting from short circuiting of the heliolatitudinal density gradients by interplanetary magnetic field irregularities moving radially outward from the sun. The 27 day recurrence tendency of the quiet time anomalous diurnal variation also, has led us to postulate quasi-stable regions on the solar disc which produce a larger number of magnetic field irregularities.
To investigate the possibility of determining the energy spectra of cosmic ray intensity variations from a single station, a continuous record of neutron multiplicity spectrum in the Gulmarg neutron monitor is obtained for the period October, 1967 - October, 1971. The average multiplicity spectrum in the Gulmarg neutron monitor shows a mean multiplicity ≈ 1.4 for 12 Boron-tri-fluoride counters and is an increasing function of the number of counters used. The mean multiplicity measured in various other neutron monitors, when normalized to the cutoff rigidity of Gulmarg (11.91 GV), shows a systematic increase with the altitude of the station. Measurement of the multiplicity spectrum during Forbush decreases has not shown any significant change in the spectrum beyond statistical errors, when compared to the spectrum during quiet periods.

The thesis is divided into five chapters. The first chapter describes the present knowledge of the propagation of cosmic rays in the interplanetary medium and its relation to time variations in the cosmic ray intensity. The second chapter discusses the experimental and the analytical methods of relating the time variations in the intensity observed by ground based neutron monitors to the cosmic ray intensity variations in the interplanetary space. This essentially involves discussion of the atmospheric and geomagnetic effects on cosmic ray intensity and brings out
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