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STUDY OF IMPACT ON COSMIC RAY INTENSITY VARIATION AND SOLAR WIND SPEED TO SUN SPOTS

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***ABSTRACT*:-** In the present work we have taken solar wind a interplanetary feature to study the various periodic and a periodic variation in cosmic ray intensity. We have derived the effects of solar wind in association with several solar and interplanetary parameters on cosmic ray intensity variation on long-term as well as on short-term basis. To investigate the periodic behaviour and relationship of sunspot numbers with cosmic ray intensity and solar wind speed, we present analysis from daily data generated. Cross-correlation and wavelet transform tools were employed to carry out the investigation. The analyses confirmed that the cosmic ray intensity correlates negatively with the sunspot numbers, exhibiting an asynchronous phase relationship with a strong negative correlation. .e trend in cosmic ray intensity indicates that it undergoes the 11-year modulation that mainly depends on the solar activity in the heliosphere. On the other hand, the solar wind speed neither shows a clear phase relationship nor correlates with the sunspot numbers but shows a wide range of periodicities that could possibly be connected to the pattern of coronal hole configuration.

KEYWORDS:- Cosmic ray intensity, solar wind speed and Sun Spot.

INTRODUCTION:-

The cosmic ray intensity is largely isotropic and constant in time outside the heliosphere. Their interaction with the interplanetary magnetic field gives rise to spatial anisotropies and time variation in their intensity near the orbit of earth and beyond the boundary of heliosphere. Seasonal and diurnal variations are due to the differences in atmospheric structure between winter and summer seasons and day time and night time, respectively. This effect is significant for the muon component but small for the neutron component. The asymmetric shape of earth's magnetosphere result to a small diurnal change of local geomagnetic cutoff and correspondingly, to a small diurnal variation of CR intensity on the Earth's surface. We are interested in extra-terrestrial variations of CR intensity i.e. CR variations whose origin is outside the Earth's magnetosphere. There are periodic and sporadic extra-terrestrial cosmic ray variations.

SUN SPOTS AND SOLAR ACTIVITY CYCLE-

Sunspots are manifestations of magnetically disturbed conditions at the Sun’s visible surface. They are somewhat cooler (and thus darker) than their surroundings, being about 3800 K hot while the photosphere is typically at about 5800 K. Because of this and their size (about 1000 - 100 000 km in diameter), they can be observed visually from the Earth. Spots have a dark central region called umbra surrounded by a lighter region called penumbra. They grow over a few days and last from several days to a few months. They are also related to very strong magnetic fields, about 2000 - 4000 G (in photosphere only a few G).

Sunspot appear often in groups, and the sunspot number R is defined as $R = k (f + 10 g)$, where f is the total number of spots visible to the observer, g is the number of disturbed regions (single spots or groups of spots), and k is a constant for the observatory related to the sensitivity of the observing equipment. Sunspots display a clear 11-year cycle in their number and latitude. In addition, they (and their groups) occur often in pairs so that the other has positive polarity (magnetic south, into the sun) and the other negative polarity (magnetic north, out of the sun); changes in this polarity create a 22-year cycle. Sunspots indicate enhanced solar activity. For example, solar flares originate from the active region around the sunspots.

The main periodicity in the Sun's activity is the 11-year cycle called the solar cycle. The period is not constant, but varies between about 9.5 and 12.5 years; for discussion about the periodicity determination. During the cycle, changes occur in the Sun's internal magnetic field and in the surface disturbance level. It has been agreed that a cycle starts from an activity minimum. The last full solar cycle (1996-2006) is labeled to be 23 the "first" one was the 1755- 1766 cycle.

Solar Wind-

The solar wind is the supersonic outflow into interplanetary space of plasma from the Sun's corona, the region of the solar atmosphere beginning about 4000 km above the Sun's visible surface and extending several solar radii into space. It is composed of approximately equal numbers of ions and electrons; the ion component consists predominantly of protons (95%), with a small amount of doubly ionized helium and trace amounts of heavier ions. Embedded in the out flowing solar wind plasma is a weak magnetic field known as the interplanetary magnetic field (IMF). The solar wind varies--in density, velocity, temperature, and magnetic field properties--with the solar cycle, heliographic latitude, heliocentric distance, and rotational period. It also varies in response to shocks, waves, and turbulence that perturb the interplanetary flow. Average values for solar wind velocity, density, and magnetic field strength at the orbit of the Earth are 468 km per second; density, 8.7 protons per cubic centimeter, and 6.6 nT, respectively.

MATERIAL & METHODS:-

The period of investigation covers solar cycles using daily data. The obtained data were used to investigate the periodic variation of SSN with CRI and SWS. To derive the percent deviation of cosmic ray intensity for each day. We can apply the following equations.

Deviation from n days mean = (Daily mean of cosmic rays/n days mean of cosmic rays) × 100
Percent deviation = 100 - Deviation from mean

The method of percent deviation is one of the most useful technique is cosmic ray research to draw the intensity deviation from its mean value. Daily sunspot numbers: the daily SSN used in this study was obtained from the Sunspot Index and Long-term Solar Observations. The World Data Center for the dissemination of international sunspot numbers is available at http://www.sidc.be/silso/datafiles. Daily solar wind: the daily SWS data used was generated by several spacecraft orbiting the Earth.

RESULTS AND DISCUSSION:-

Cosmic ray modulation on long-term as well as on short-term basis is still a interesting topic in interplanetary and space science studies. Identification of Coronal Mass Ejections since 1974 proved a new and key aspect in cosmic ray modulation. Propagation of large energy and mass from a CME event into interplanetary space casing geomagnetic field variation and large changes in cosmic ray intensity. Recent space craft observations of different categories of CMEs (i.e. Halo, partial halo, Bright loop etc.) enhance our information's regarding cosmic ray modulation process.

Relationship between solar activity and cosmic rays on long-term basis:

Long-term modulation of cosmic rays is still a interesting topic in space research. Solar modulation of cosmic rays were studied since last six to seven decades by a number of researchers (Shea and Smart, 1985; Shrivastava et al, 1993; Mavaromichalaki et al 2007) in this analysis, we have taken sunspot numbers as a solar activity measure to draw its relationship with cosmic rays on long-term basis. Cosmic rays are affected by electromagnetic disturbances while transporting from galactic space to earth surface. Forbush 1954 reported the anti-correlation between cosmic rays and sunspot numbers it is known that sunspots are the sites of intense magnetic fields are drawn into space by solar wind. Sunspots are known to produce solar wind to long distance in interplanetary medium in turn, affect the cosmic rays. In this work, we have done a correlative study to derive the relationship between cosmic rays and sunspot numbers for the period of 1996 to 2008.

To show the cosmic ray intensity variation in relation with solar activity for solar cycle 23, we plotted the yearly mean values of cosmic rays of Moscow station along with the sunspot numbers as shown in Figure 1. The figure shows the anti-phase of cosmic rays with sunspot numbers. Long minima are clearly seen during solar cycle 23 Figure 2 shows the cross plot between yearly mean values of sunspot number Rz and yearly mean values of Moscow neutrons. A negative and high correlation (Correlation coefficient -0.80) is observed for solar cycle 23.

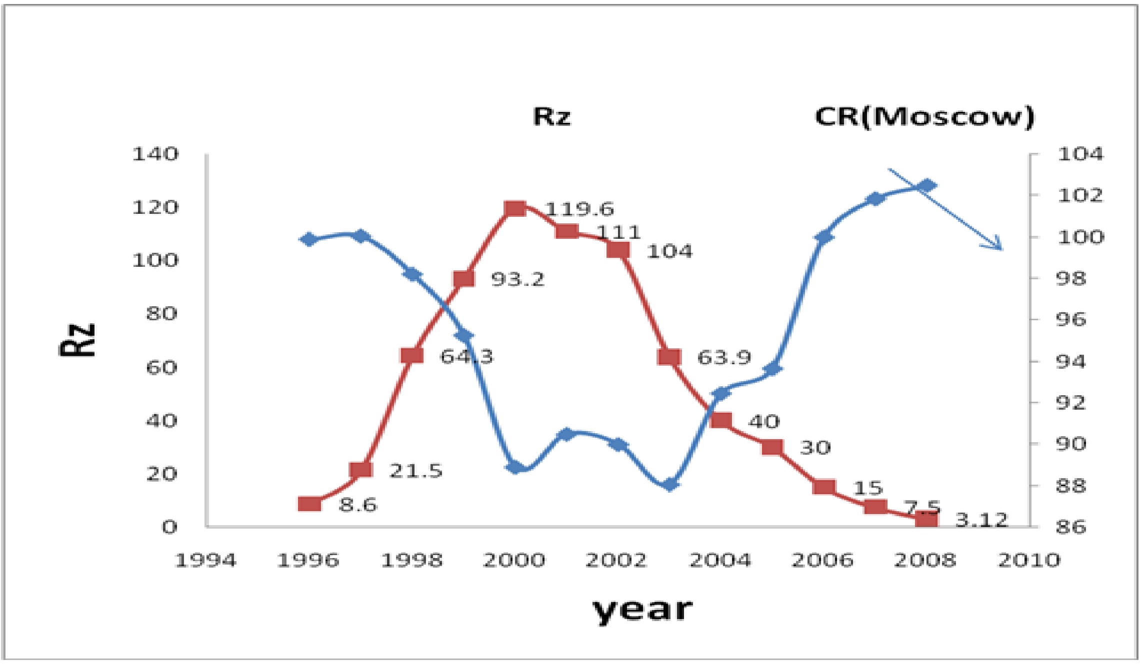

Fig.1 Shows yearly mean values of sunspot numbers along with cosmic rays for the Period of solar cycle 23.

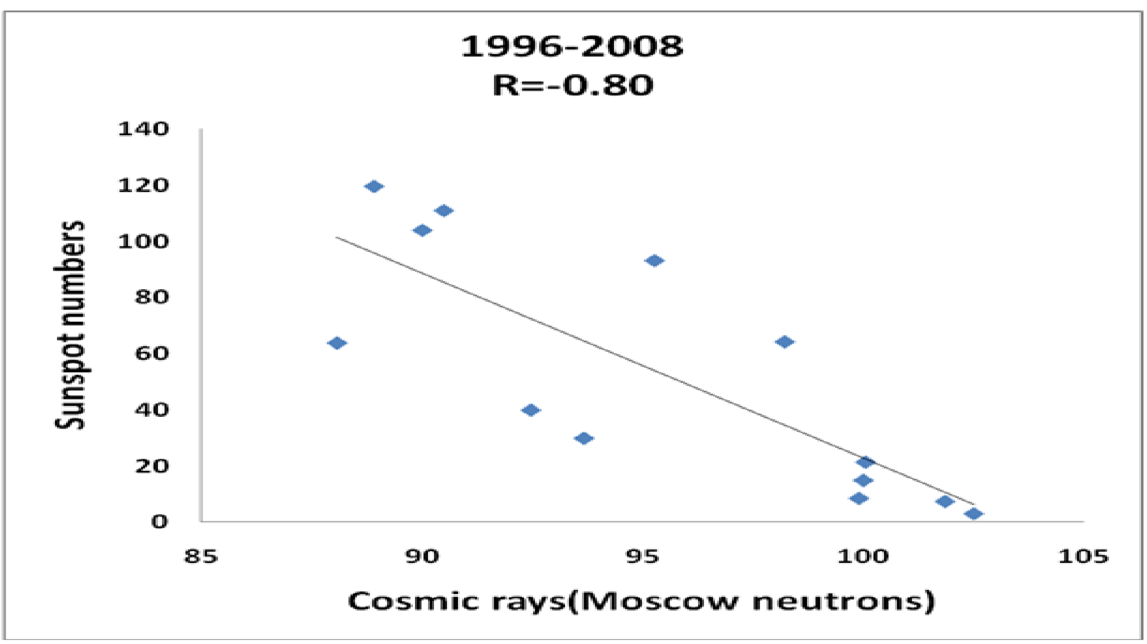

Fig.2 Shows the cross plot between yearly mean values of sunspot numbers and cosmic rays for the period of solar cycle

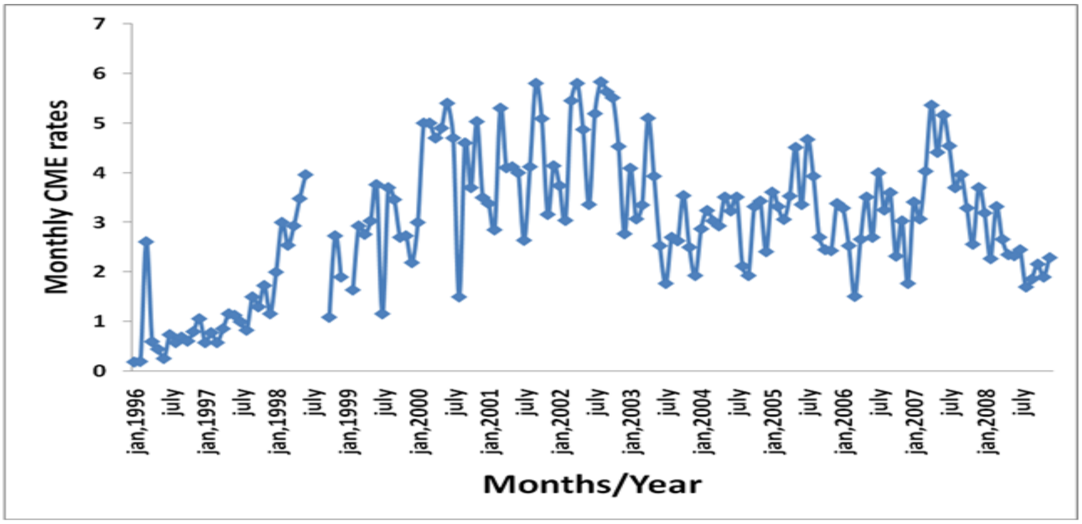

Fig.3.Shows the monthly mean values of CME rates for the solar cycle 23

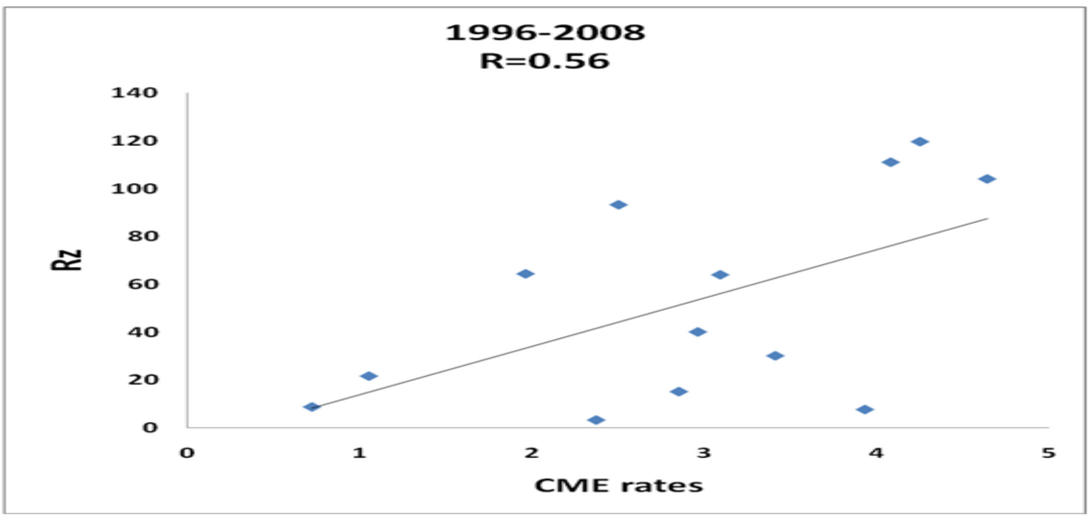

Fig.4 Shows the cross plot between yearly mean values of CME rates and Rz.

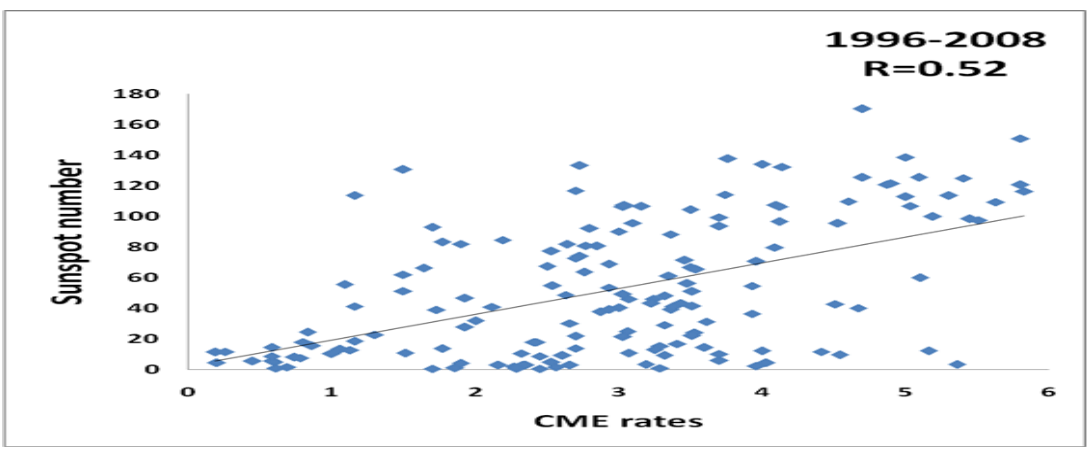

Fig-5 Shows the cross plot between monthly mean values of CME rates and Rz

CONCLUSION -:

In the present work we have taken solar wind a interplanetary feature to study the various periodic and a periodic variation in cosmic ray intensity. We have derived the effects of solar wind in association with several solar and interplanetary parameters on cosmic ray intensity variation on long-term as well as on short-term basis. The important finding conclusions are given below. All the solar indices i.e. sunspot numbers, group solar flares, solar flux show 11-year long-term variability. Sunspot numbers show positive and high correlation with solar flux. Sunspot numbers show negative and high correlation with cosmic ray intensity on long-term basis. Cosmic ray intensity shows negative and high correlation with solar parameter.

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