

---

## Long-term cosmic ray modulation during solar cycles 19 to 23

---

Anil Kumar Tiwari,<sup>1</sup> U.K.Sharma,<sup>2</sup> Neelam Singh<sup>2</sup> and Pankaj K.Shrivastava<sup>2</sup>

1. Dept. of Physics, Govt. T.R.S. College, Rewa (M.P.)486001 INDIA

2. Dept.of Physics, Govt. New Science College, Rewa (M.P.)486001 INDIA

---

### Abstract

A correlative analysis has been done between cosmic ray intensity and sunspot numbers for the solar cycle 19 to ascending phase of recent solar cycle 23. Monthly mean values of Kiel neutrons have been taken in correlative analysis. Anti correlation between cosmic rays and sunspot numbers are reconfirmed for the recent periods. Values of coefficient of correlation support the odd-even hypothesis in cosmic ray modulation.

### 1. Introduction

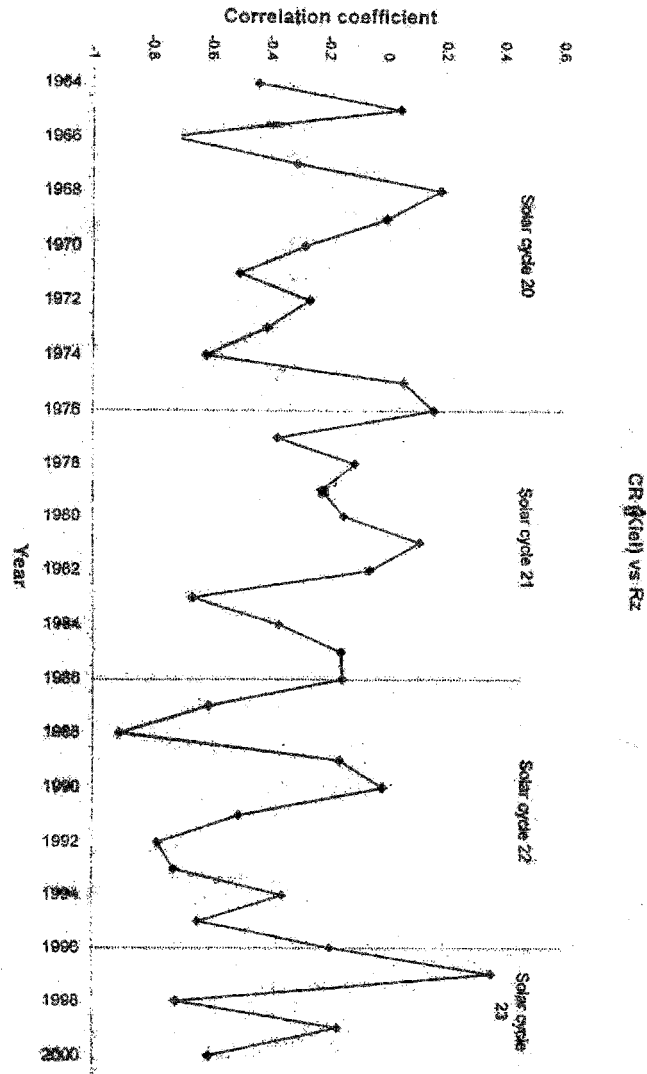
Relationship of cosmic ray intensity with solar activity has been studied since last four decades by a number of cosmic ray scientists (Kavalenko 1988; Shrivastava 1990; 1997; Shrivastava and Agrawal 1993; Shrivastava *et al* 1993;). However, long-term modulation studies have still its relevance in recent days, we have further extended the correlative study upto recent solar cycle 23.

### 2. Method

The monthly averages of the relative sunspot numbers (Rz) and the cosmic ray neutron intensity from Kiel, a high latitude neutron monitor station, have been used in our analysis for the period of 1964 to 2000.

### 3. Results and discussion

Using the twelve monthly mean values of sunspot numbers (Rz) and comic ray intensity, the correlation coefficients have been derived for the period of 1984 to 2000, which cover the solar cycle 20 to 23. Coefficient of correlation is found to be negative and high for the most of the period. However, it changes positive to negative and vice-versa quiet frequently. We have plotted the yearly values of correlation coefficient in Fig.1. Fig 1 reveals that shape of curve for even solar cycle 20 is similar to next even solar cycle 22 and similarly variation trend of solar cycle 23 seems to follow the previous odd cycle21. Our results indicate a odd-even hypothesis in this correlative analysis.



**Fig. 1.** Graph showing Correlation Coefficient between monthly values of Sun spot numbers and Cosmic ray (Kiel neutron monitor) from 1964–2000

#### 4. Conclusions

1. Correlation between sunspot number and cosmic ray is found negative and high.
2. Odd-even hypothesis is evident in correlative analysis.

#### Acknowledgements

The authors thank the World Data Centre — A of Solar Terrestrial Physics, Boulder, Colorado, USA for providing data.

## References

- (1) Kavalenko V.A., 1988, Planet Space Science, 36 No.12, 1343
- (2) Shrivastava P.K., 1990, Proc. 21<sup>st</sup> I.CRC., 6, 65
- (3) Shrivastava P.K., Shuckla R.P., Agrawal S.P.1993, Proc.Nat. Acad Sci. India, 63, IV, 663
- (4) Shrivastava P.K., Agrawal S.P.1993, Indian Journal of Radio & Space Physics, 22, 26.
- (5) Shrivastava P.K., 1997, Proc. 25<sup>th</sup> ICRC, 2, 65.