YU ISSN 0015—3206
FZKAAA 12 (3) 241 (1980)

RECURRENT TENDENCY IN COSMIC RAY INTENSITY THROUGH THE PERIOD 1958—1975

S. M. ABDEL WAHAB, A. H. GIRGIS

Physics Department, Faculty of Science

Ain Shams University, Cairo, Egypt

N. E. ABDEL AZIZ, A. A. MAWGOOD

National Institute of Standards, Dokki, Cairo, Egypt

Received 30 June

UDC 539.12

Original scientific paper

Investigation of cosmic ray intensity through the period 1958—1975 showed that the solar cycle dependence is highly pronounced for the transient variations, less pronounced for the 27-day recurrent tendency and almost missed for the 13.5-day variation. Decreasing and increasing phases of solar activity are characterized by significant coherence of the geomagnetic K_p-index with 27-day recurrent tendency in cosmic ray intensity.

1. Introduction

Several investigators observed that the 27-day recurent tendency in cosmic rays exhibits a solar cycle dependence. In this respect, Walt[1] found that the amplitude of this tendency reaches 3% during the maximum solar activity of 1957—1958 and 0.5% for the minimum solar activity of 1952—1953. Ruthberg and

Wahab[2] observed solar cycle dependence in the power spectrum peak corresponding to the square of the amplitude of the 27-day frequency. On the other hand, Wahab and Goned[3] investigated the solar cycle dependence of the different periodic variations in the geomagnetic K_p-index for the 1932—1969 period. They showed that the 27- and 13.5-day recurrent tendencies in the geomagnetic K_p-index, as well as other additional periodicities in the range 9—4 days, have solar cycle dependence. Moreover, the observed additional periodicities were shown to be related to the mechanism of the sector structure of the interplanetary magnetic field.

Many investigators have considered these variations from different points of view. Most of these studies follow a main line starting by considering the general characteristics of the experimental results for a given period, and then investigating the possible correlations with solar activity parameters. Finally, a general picture for such cosmic ray modulation may then be obtained on the basis of obtained informations from the former steps. In fact, it is not easy to achieve a definite conclusion from such studies.

However, several theories have been introduced to explain the cause of the 27-day recurrent tendency in cosmic ray intensity. Alfvén[4, 5] attributed this cause to solar plasma streams. These streams last for several solar rotations, and every time they intercept the earth, magnetic and cosmic ray intensity disturbances occur. Dorman[6] concluded that the 27-day recurrent tendency in case of geomagnetic activity could be interpreted as a result of direct interaction between the solar activity processes on the sun with the immediate vicinity of the earth, while it is a result of modulation in the interplanetary medium in case of cosmic rays.

In the present work, the solar cycle dependence of the 27- and 13.5-day recurrent tendencies are investigated for the nucleonic component recorded at Deep River, for the 1958—1975 period which covers one and a half solar cycle. Also, the correlation of the investigated recurrent tendencies with the corresponding ones in geomagnetic activity is studied by means of coherence analysis.

2. *Data treatment and method of analysis*

The selected cosmic ray data for the present investigation are the mean daily values of the nucleonic component counting rates. These data were obtained from hourly pressure-corrected nucleonic intensity recorded by the Deep River International Geophysical Year (*IGY*) and International Quiet Sun Year (*IQSY*)-neutron monitors. The geographic coordinates of this station are N. 46.10 and W. 77.50 with 145 meters height above the sea level. In fact, the low-cut off rigidity (1.02 Bev/c) of this station allows to observe the variations in the low energy range of cosmic ray primaries. The considered data cover the 1958—1975 period i. e. more than one and a half solar cycle.

Power spectrum analysis was applied to the cosmic ray nucleonic data on bi-yearly basis, taking a maximum lag of 25% of the number of points. Each peak density $P(f)$ in a power spectrum distribution was considered to be the sum of two parts: the »pulse« and the »background« as defined by Wahab and Goned[3].

The »pulse« refers to the contribution of the concerned frequency in the investigated data and the »background« is mainly due to noise interactions and transient variations at that frequency. To separate these two parts, linear extrapolation was applied by using three weighted mean points just before and after the peak. The corresponding amplitudes of the peak, pulse and background are then calculated according to the treatment described by Martinic et al.[7]. On the other hand, coherence analysis between the nucleonic component and the daily sums of the geomagnetic K_p-index was carried out. The coherence $H(f)$ and the corresponding phase shift $\Phi(f)$ were calculated according to Granger[8] as

$$H(f) = [\Phi^2(f) + Q^2(f)]/P_x(f)\,P_y(f)$$

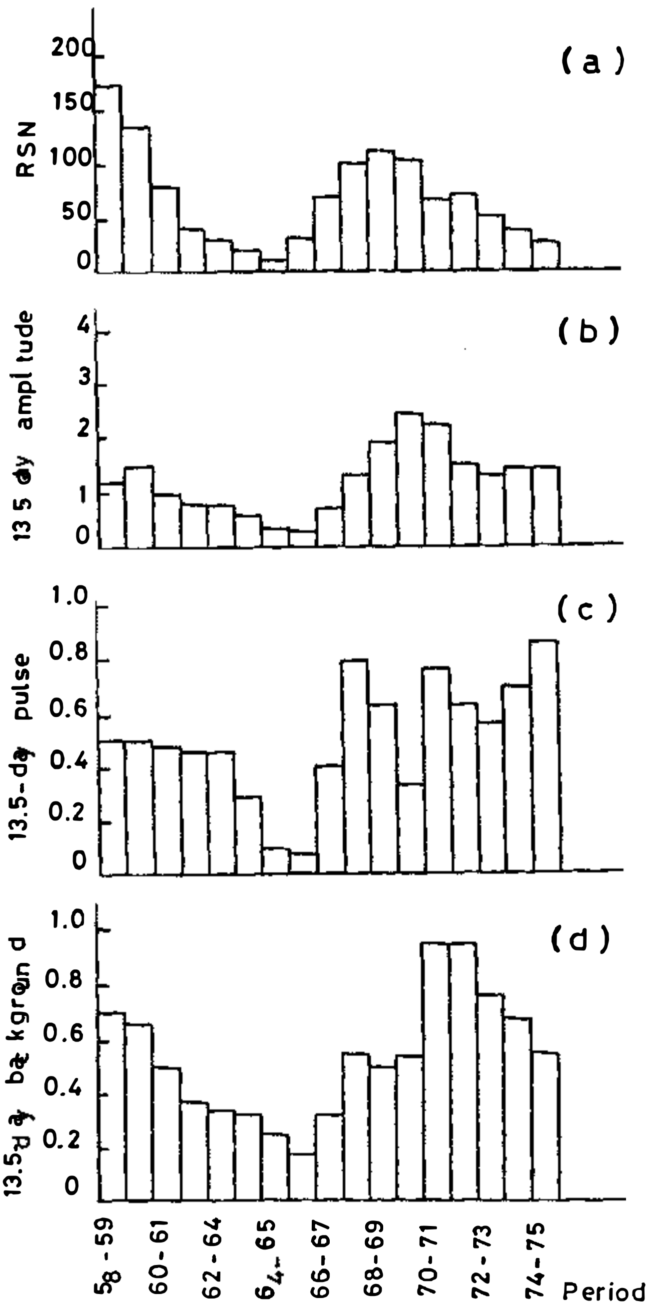
$$\Phi(f) = \tan^{-1}[Q(f)/\Phi(f)]$$

where $P_x(f)$ and $P_y(f)$ are the calculated spectral densities of the input time series $x(t)$ and $y(t)$ respectively. $\Phi(f)$ and $Q(f)$ are the co- and quadratic spectra of the $x(t)$ and $y(t)$ respectively.

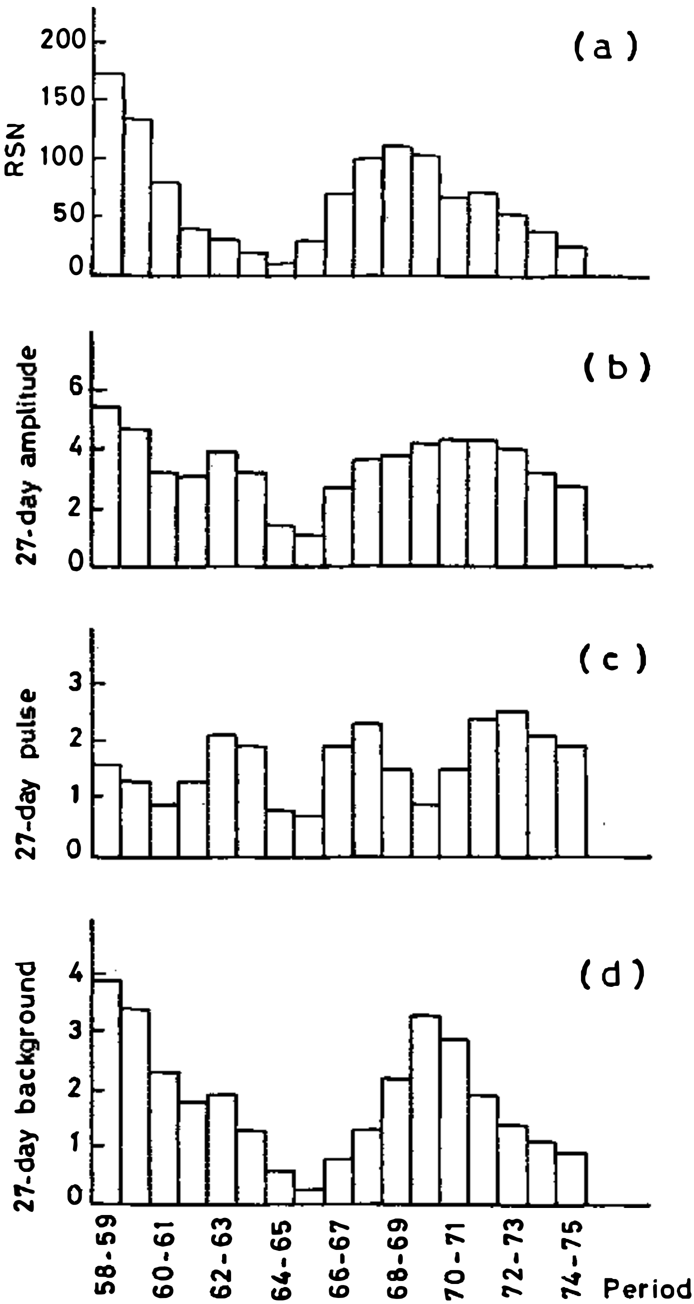
3. *Results and discussion*

Figure la represents the bi-yearly relative sunspot numbers (RSN) obtained from the solar geographical data published by the world-wide data center A, Boulder, Colorado, U. S. A. Figures 1b, c, d represent the 27-day recurrent tendency of the amplitude pulse and background of the RSN respectively. Corresponding representations for the 13.5-day are shown in Figures 2a, b, c, d. From these two sets of figures, it can be seen that:

1) The amplitudes of the 27- and 13.5-day (Figure 1 b and 2 b respectively) reveal similar solar cycle dependence which is not in phase with the relative sunspot number.
2) The extracted 27-day background (Figure 1d) shows better solar cycle dependence than the corresponding total 27-day amplitudes. Such observation is almost missed for the background of the 13.5-day recurrent tendency.
3) No obvious solar cycle dependence can be observed for either the 27- or the 13.5-day pulses as shown in Figure lc and 2c respectively. However, there are periods of higher pulses as for example the 1962—1963, 1966—1967 and 1970—1972 periods. This would indicate a recurrent tendency which has a high amplitude and/or a quite stable phase angle. In other words, the interplanetary medium was characterized by quite stable conditions which would persist for several solar rotations. Recalling Bame et al.[9] observations that the solar wind velocity does not exhibit a solar cycle dependence and a similar conclusion for the interplanetary magnetic field reported by King[10], one may state that the 27- and 13.5-day recurrent tendencies in cosmic ray intensities are more related to the interplanetary conditions than the solar activity parameters, at least during decreasing and increasing phases of solar activity.
4) Coherence analysis for the geomagnetic K_p-index and the mean daily intensity of cosmic rays showed high 27-day pulses.

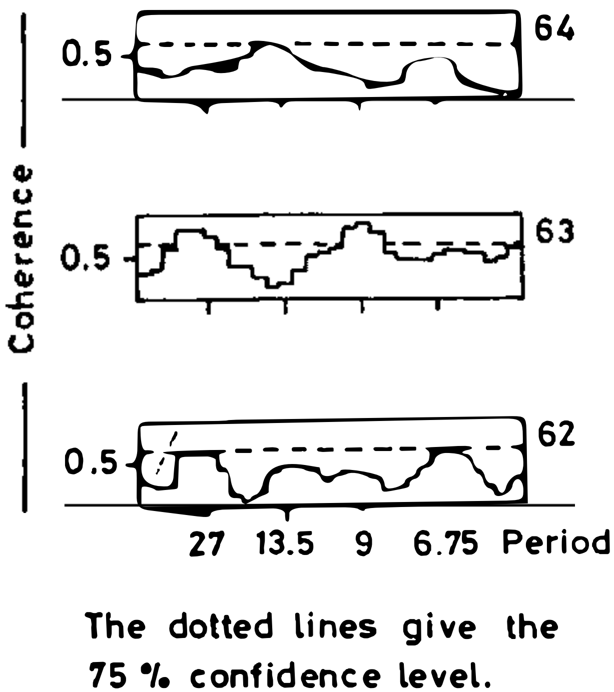


Figs. 1a, b, c, d. The bi-yearly relative sunspot numbers, amplitude, pulse and background of the 27-day recurrent tendency, respectively.



Figs. (2a, b, c, d) The bi-yearly relative sunspot numbers, amplitude, pulse and background of the 13.5-day recurrent tendency, respectively.

Figure 3 gives an example of these analyses obtained for the years 1962, 1963 and 1964. In this figure, the 75% confidence level was determined according to Ruthberg and Wahab[2]. The whole obtained results of the coherence analysis reveal, in general, high coherence over a broad band of the investigated frequencies which again reflects the effect of the transient variations all over the concerned frequency band. The average phase shift was found to be 1—3 days ar the 27-day frequency where the coherence is significantly higher than the 75% confidence level. This would lead to suggest that the recurrent tendencies in both cosmic rays and K_p-index are originated, through these periods, by the same source which controls the interplanetary structure.



Figs. 3. An example of the coherence analysis for the years 1962, 1963 and 1964.

4. Conclusion

The solar cycle dependence is observed only for the backgrounds of the 27- and 13.5-day recurrent tendencies of cosmic ray intensity. Recurrent tendencies in K_p-index and cosmic rays may be originated by the same source which modulates the interplanetary structure through some periods of increasing and decreasing phases of solar activity.

References

1) R. Walt: Nuovo Cimento, **13** (1959) 936;
2) S. Ruthberg and S. Abdel Wahab: Scientific report, UU, CRG, 71—3 (1971);
3) S. Abdel Wahab and A. Goned: Planet Space Sci., **22** (1971) 537;
4) H. Alfvén: Tellus, **8** (1956) 1;
5) H. Alfvén: Electromagnetic phenomena in cosmical physics, edited by B. Lehnert, Cambridge, P. 284, (1958);
6) L' I. Dorman: In Progress in elementary particles and cosmic ray physics; Vol VII, ed. by J. G. Wilson and S. A. Wouthuysen, North Holland Publishing (company, Amsterdam), (1963)
7) N. Martinic, S. Lindgren and S. Abdel Wahab: Scientific report, UU/CRG 7—2, Upsala University, (1971);
8) W. J. Granger: Princ. Univ. Press, New Jersy, (1964);
9) S. J. Bame J. R. Asbridge, W. C. Feldman and J. T. Gosling: EOS, **57** (1976) 318;
10) J. H. King: J. Geophys. Res., **81** (1976) 653.

POVRATNA TENDENCIJA U INTENZITETU KOZMIČKIH ZRAKA U PERIODU 1958—1975

S. M. ABDEL AHAB, A. H. GIRGIS

Physics Department, Faculty of Science, Ain Shams University, Kairo, Egipat

N. E. ABDEL AZIZ, A. A. MAWGOOD

National Institute of Standards, Dokki, Kairo, Egipat

UDK 539.12

Originalni znanstveni rad

Istraživanja intenziteta kozmičkih zraka u periodu 1958—1975 pokazala su da je ovisnost solarnog ciklusa jako izražena za kratkotrajne promjene, manje izražena za 27-dnevnu povratnu tendenciju i gotovo odsustvujuća za 13.5-dnevnu promjenu. Opadajuće i rastuće faze solarne aktivnosti karakterizirane su značajnom koherencijom geomagnetskog K_p indeksa sa 27-dnevnom povratnom tendencijom u intenzitetu kozmičkih zraka.