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SOLAR ACTIVITY, 27 DAY VARIATION AND LONG TERM MODULATION OF COSMIC RAY INTENSITY (RESEARCH NOTE)

V. K. BALASUBRAHMANYAN
D. VENKATESAN

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SOLAR ACTIVITY, 27-DAY VARIATION AND LONG TERM MODULATION

OF COSMIC RAY INTENSITY

(RESEARCH NOTE)

V. K. Balasubrahmanyan
NASA/Goddard Space Flight Center
Greenbelt, Maryland U.S.A.

and

D. Venkatesan*
Physics Department, University of Calgary
Calgary, Alberta, Canada

(* on Sabbatical leave at NASA/GSFC)

The effect of the double maxima in the 11-year cycle of solar activity pointed out by Gnevyshev (1963, 1967) is detected both in the long term modulation and the 27-day variation in cosmic ray intensity. A linear relationship between the amplitude of the 27-day variation and the cosmic ray intensity is obtained. The constraints that this observation puts on theories of modulation of cosmic ray intensity are discussed.

A comparative study of the 11-year solar cycle of activity as represented by R, the Zurich Relative Sunspot Number and cosmic ray intensity; and the observation of a phase lag between the two has been made by many workers (Forbush (1958), Neher (1962), Simpson (1963), Dorman and Dorman (1965)).

Gnevyshev (1963, 1967) has shown that each solar cycle has two maxima, the earlier maximum occurring at high solar latitudes, and the later one at low latitudes. These maxima are seen in phenomena at various levels on the sun such as Coronal green line 5303 Å, proton flares, and occurrence of large sunspots (Sakurai (1967), Gnevyshev (1967)). Balasubrahmanyan (1968) points out that the effect of this double maxima can be seen in favorable circumstances, in cosmic ray intensity also. This is illustrated in Figure 1.

Venkatesan (1958) has observed that the amplitude of the 27-day variation has a structure quite different from the solar cycle as represented by R, the Zurich Relative sunspot number. This is shown in Figure 2. Actually the amplitude of the 27-day variation A and the mean annual geomagnetic activity as represented by the sum of the daily values of Kp, the planetary geomagnetic index, for 60 most disturbed days show the same behavior as the cosmic ray intensity.

Figure 3 shows the linear correlation between the amplitude of the 27-day variation in cosmic ray intensity and the annual mean cosmic ray intensity. The correlation coefficient is 0.8. In view of this close connection, we suggest that the long term variation takes place as a result of a superposition of many short term decreases. The studies of Balasubrahmanyan and Venkatesan (1969), McDonald and Webber (1960), McDonald (1959), and Meyer (1960) seem to suggest that the spectral changes during short term changes, including Forbush decreases and during long term changes are similar. Thus one can view that the long term variation in cosmic ray intensity is built up of a number of short term changes. During periods of high solar activity, a larger number of short term decreases occur, and these short term decreases are probably confined to small azimuthal regions. The rotation of the sun propagates these intensity changes around. Balasubrahmanyan et al. (1969) from a study of the cosmic ray intensities recorded by two spacecraft (IMP-C and Pioneer 6) separated by 60° in solar azimuth have shown that even during relatively quiet times, small changes in cosmic ray intensity exhibit co-rotation.

The fact that the cosmic ray intensity recovers to a value close to its maximum, right in the middle of the solar cycle, strongly argues against theories with long relaxation periods advocated by Dorman and Dorman (1967) and favors short relaxation and steady state approaches to the onset of modulation. The recent work of Hatton et al. (1967), Simpson and Wang (1967) and Pathak and Sarabhai (1969) on the absence of hysteresis between cosmic ray intensity variation and the Coronal green line intensity (5303 Å) supports the view presented here.

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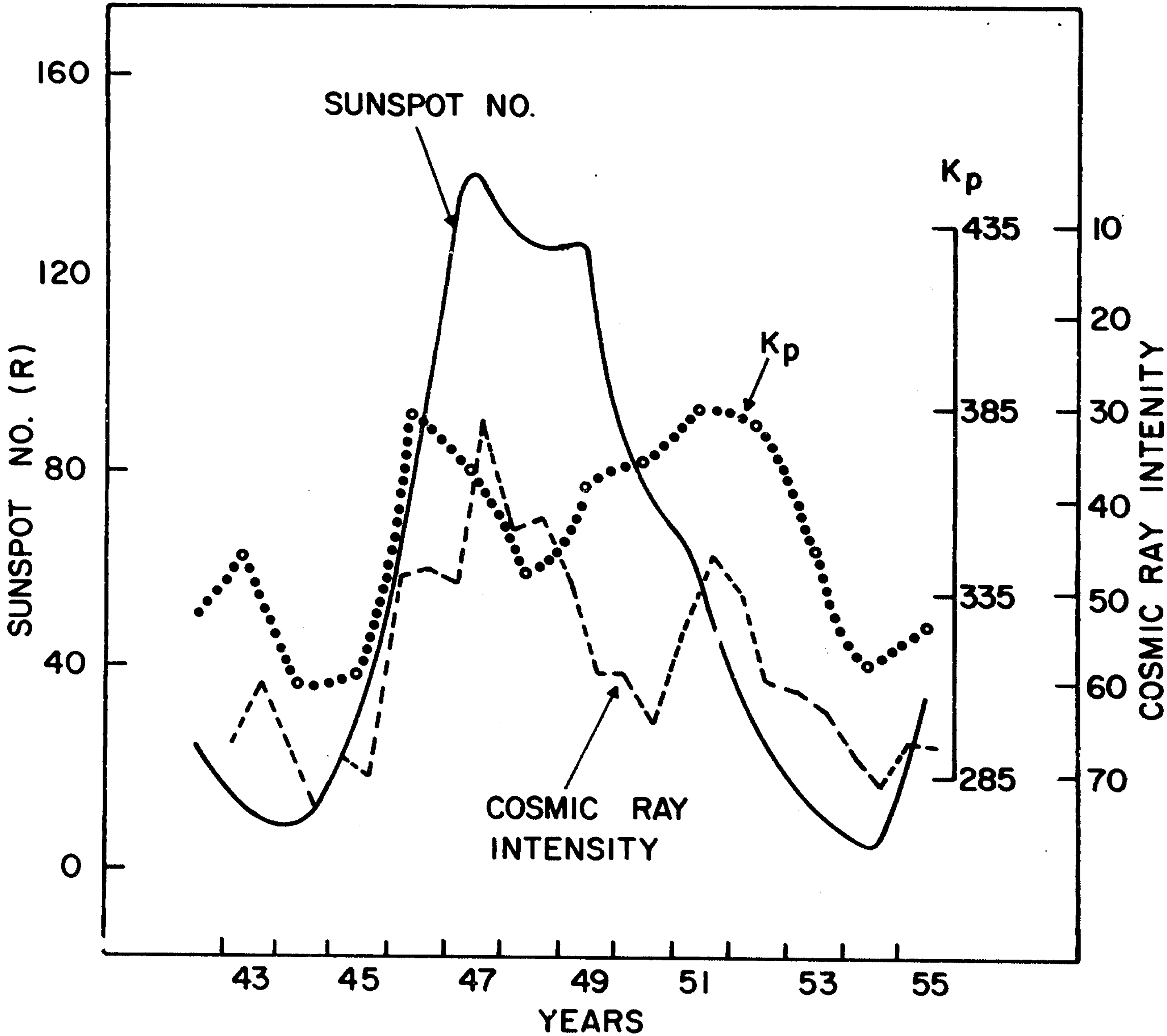
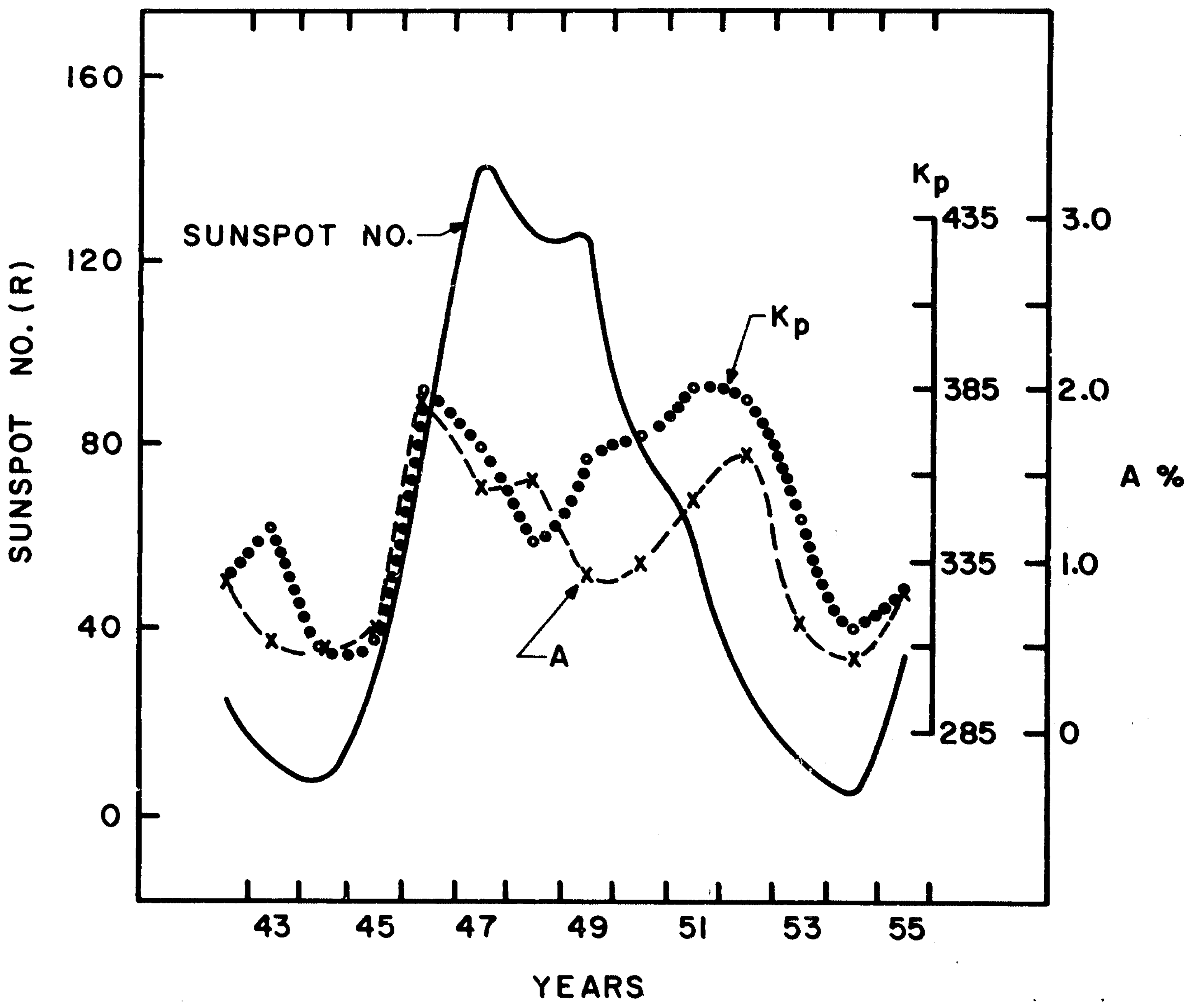
Figure 1: The cosmic ray intensity variation during the solar cycle No. 18. Also shown is the geomagnetic activity as given by the sum of the daily values of Kp, the geomagnetic planetary index, for 60 most disturbed days for each year. The cosmic ray intensity is from the ion chamber data of Forbush (1958). R refers to the annual means of the Zurich Relative Sunspot Number, R.

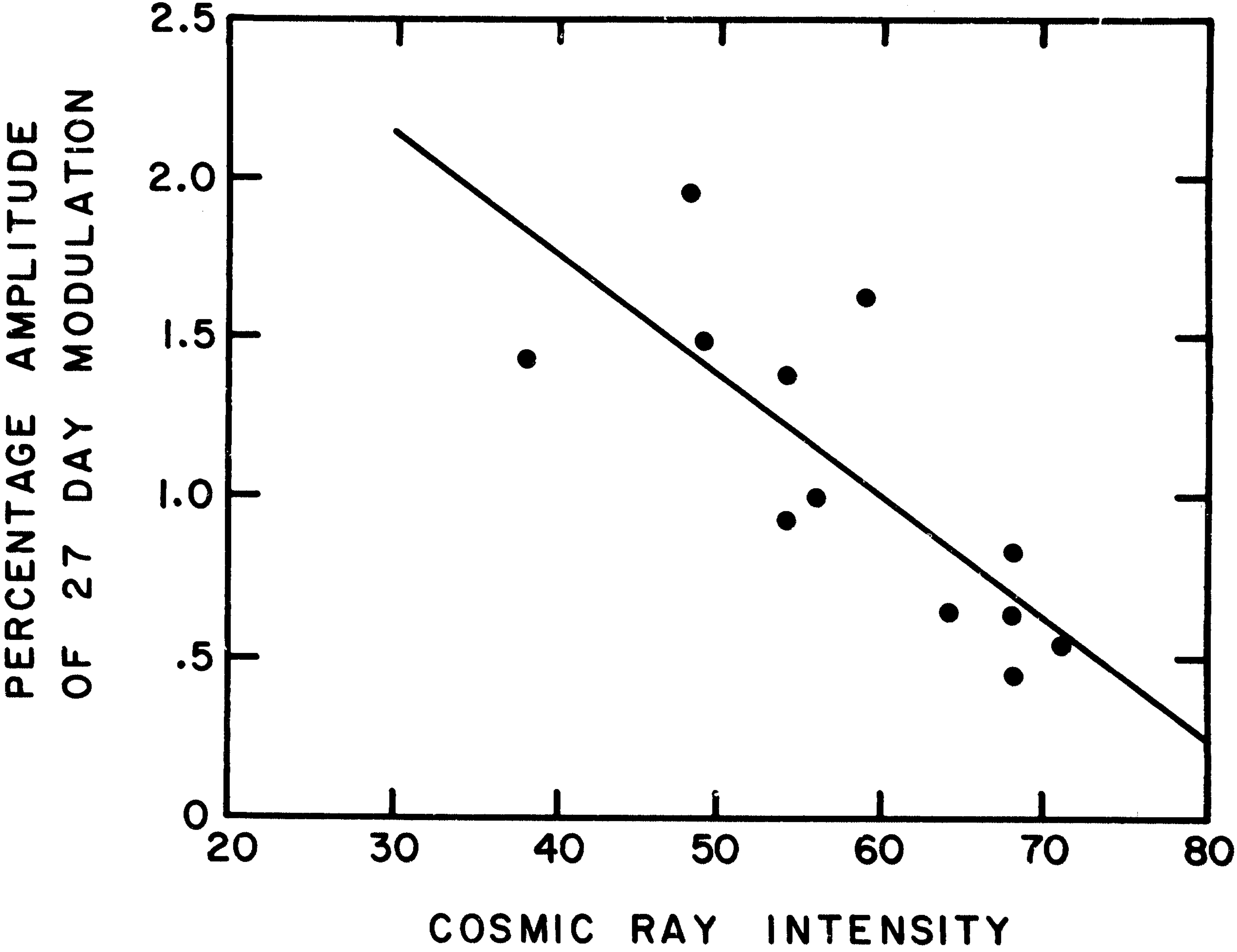
Figure 2: The variation of the amplitude of the 27-day variation during solar cycle 18, and geomagnetic activity and annual mean values of R.

Figure 3: The relationship between the amplitude of the 27-day variation of cosmic ray intensity and the annual means of cosmic ray intensity. The correlation coefficient is 0.8.



SUNSPOT NO.
Kp
Kp
COSMIC RAY
INTENSITY
SUNSPOT NO. (R)
COSMIC RAY INTENITY
YEARS
160
120
80
40
0
43
45
47
49
51
53
55
435
385
335
285
10
20
30
40
50
60
70


SUNSPOT NO. (R)
160
120
80
40
0
SUNSPOT NO.
Kp
A
43
45
47
49
51
53
55
YEARS
Kp
435
385
335
285
3.0
2.0
1.0
0
A %


PERCENTAGE AMPLITUDE
OF 27 DAY MODULATION
2.5
2.0
1.5
1.0
.5
0
20
30
40
50
60
70
80
COSMIC RAY INTENSITY