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INVESTIGATION OF THE 27-DAY PERIODICITY IN THERMOSPHERIC DENSITY FLUCTUATIONS

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Thermospheric density fluctuations with 27-day periodicity are usually correlated with changes in the 10.7 cm solar flux intensity ($S_{10.7}$) and attributed to the variations in solar EUV flux. Recent continuous in situ measurements of the EUV variations do not confirm the strict correlation between the $S_{10.7}$ and EUV flux [1]. On the other hand, thermospheric density changes do not always follow the $S_{10.7}$ variation. Sometimes one or two maxima are missing on the $S_{10.7}$ curve showing a 27-day periodicity ("$S_{10.7}$ defect") but we can find the corresponding maxima in the density changes [2], [3]. According to Jacchia [4] such defects do not extend over more than one cycle, but our investigation of 22 satellites simultaneously in 1971-72 has proved that it may extend over several months [3]. Therefore we started a systematic investigation of the behaviour of the upper atmosphere during other intervals of typical $S_{10.7}$ defects on the basis of orbital decay of 59 satellites for 7 years continuously (1965-72). The perigee heights of the satellites range from 200 to 800 km while the perigee latitudes extend from -90^o to $+90^o$. A maximum of 23 satellites were available at any given time but 53% of the total 2456 days' interval was covered by 10-14 satellites. 4400 sets of orbital elements published by prediction centres, 10000 visual and 1000 photographic observations formed the starting point of our investigation. Although the time resolution in our PERLO program 5 , used for direction measurements, sometimes comes close to one day, in the case of orbital elements it rarely exceeds 3-5 days. We did not investigate satellites in time intervals when at least 5-10 days time resolution could not be guaranteed.
As the real profile of the 27-day density fluctuations cannot always be outlined, we determined statistically only the time of the density maxima within the 27-day effect. The constructed bar diagram displays in every 5 days what percentage of the satellites showed maxima on the $f^{27} = \rho_{obs}/\rho^{27}_{J71}$ curve within this 5 days. The ρ^{27}_{J71} values were calculated from the Jacchia-71 model replacing $S_{10.7}$ by its minimum value in the whole time interval. In Figs. 1 and 2, $S_{10.7}$, A_p, C_{DR} - the time variation of the galactic cosmic ray intensity measured by a super neutron monitor in Deep River [6] - and the bar diagram with its expectation value and upper limit, belonging to the 95% significance level (marked by continuous lines) are plotted. The cosmic ray intensity shows an obvious 27-day modulation. Sequences of C_{DR} and $S_{10.7}$ maxima with 27-day periodicities are indicated by arrows below the C_{DR} and above the $S_{10.7}$ curves respectively. Dashed line arrows indicate $S_{10.7}$ defects.

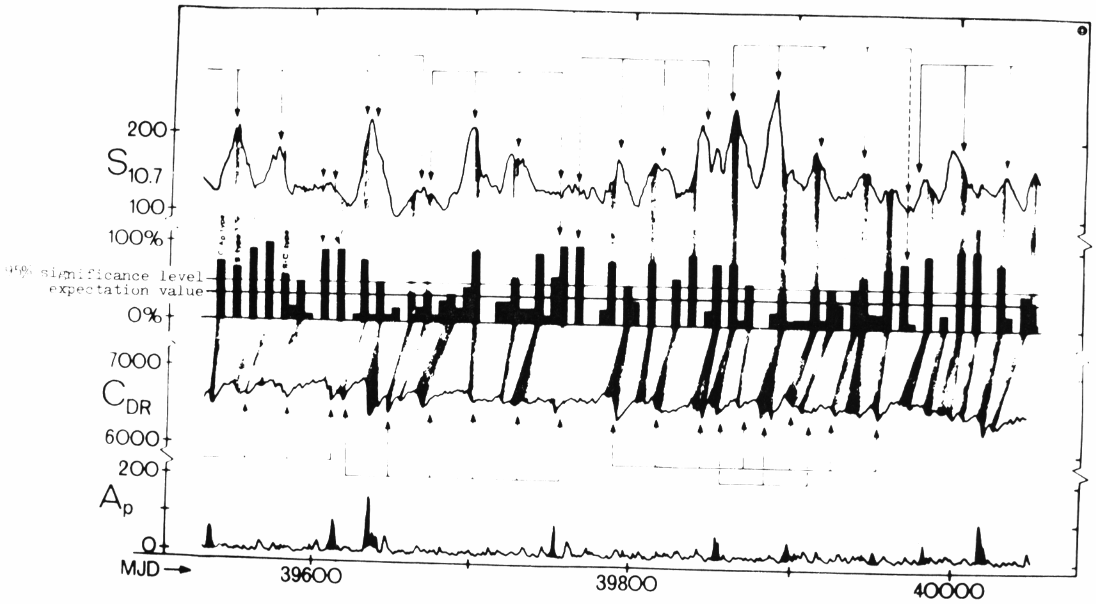
200
$S_{10.7}$
100
100%
significance level
expectation value
0%
7000
C_{DR}
6000
200
A_p
0
MJD
39600
39800
40000

Fig. 1

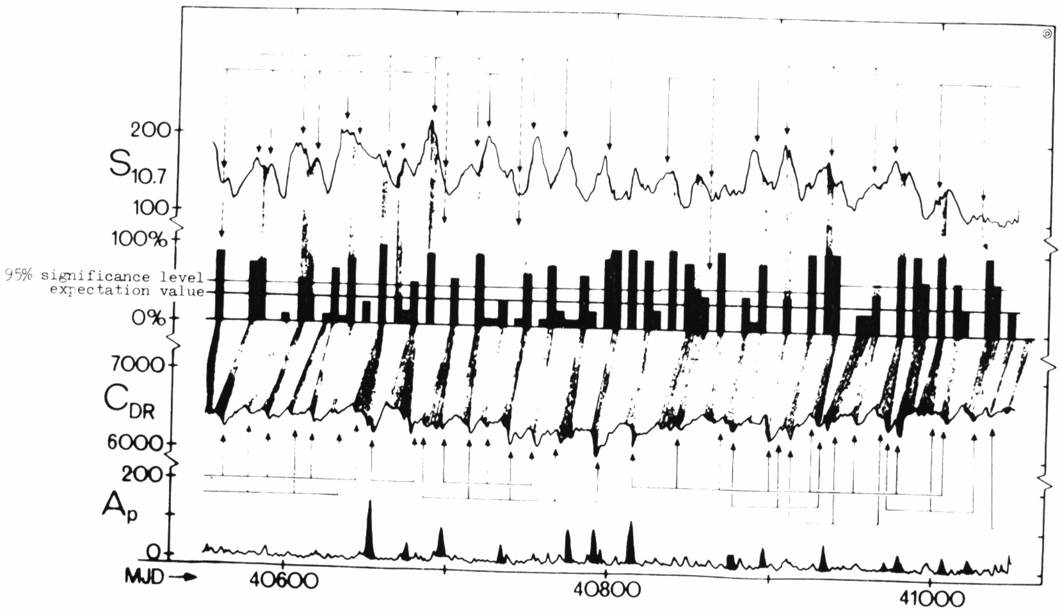
200
$S_{10.7}$
100
100%
95% significance level
expectation value
0%
7000
C_{DR}
6000
200
A_p
0
MJD
40600
40800
41000

Fig. 2

During this 7 years there are 74 maxima on the $S_{10.7}$ curve; this number of maxima is expected on the bar diagram. The 158 maxima on the 95% significance level cannot only be due to the unfortunate choice of the $S_{10.7}$ index but may point to the existence of another kind of heating (e.g. corpuscular streams). During geomagnetic storms the magnetosphere is able to tap energy from fast corpuscular streams [7]. It is reasonable to suggest that a similar mechanism is acting in connection with corotating streams as well. The decrease in count rate of galactic cosmic rays of low energy measured by neutron monitors is closely connected with magnetic fields carried by solar corpuscular streams; consequently the decrease in count rate could be used to indicate the presence of such streams around the Earth.

Taking into consideration that the time resolution of the bar diagram is 5 days, it was established that

1. every $S_{10.7}$ maximum, as expected, is followed by a density maximum in 0-5 days: S type maximum (74 cases);

2. every C_{DR} minimum is followed by a density maximum in 5-10 days: C type maximum (125 cases). Sometimes S and C type maxima coincide (35 cases);

3. another 11 density maxima occurred; they were preceded neither by $S_{10.7}$ maxima nor by C_{DR} minima but always observed during $S_{10.7}$ defects: S^- type maxima. (Altogether there are 26 such $S_{10.7}$ defects in the interval, and 22 of them were followed by density maxima).

Fig. 3 is a Bartels type presentation of all density maxima in the bar diagram exceeding the 95% significance level. Their suggested correlations with a) $S_{10.7}$ maxima, and b) $S_{10.7}$ maxima and/or C_{DR} minima are evident; a periodicity of about 14 days is also apparent.

To sum up, 47% of the observed density maxima can be explained by $S_{10.7}$ maxima; 93% by $S_{10.7}$ maxima and/or C_{DR} minima together; 100% by $S_{10.7}$ maxima and/or C_{DR} and/or $S_{10.7}$ defects together. We can conclude that density variations with a characteristic time interval of 5-27 days

1. indicate a more regular pulsation than suggested by the commonly used $S_{10.7}$ index,

2. are caused not only by changes in the EUV heating but also by some other heating mechanism, controlled through the geo-magnetic field and represented by an index of galactic cosmic rays of low energy.

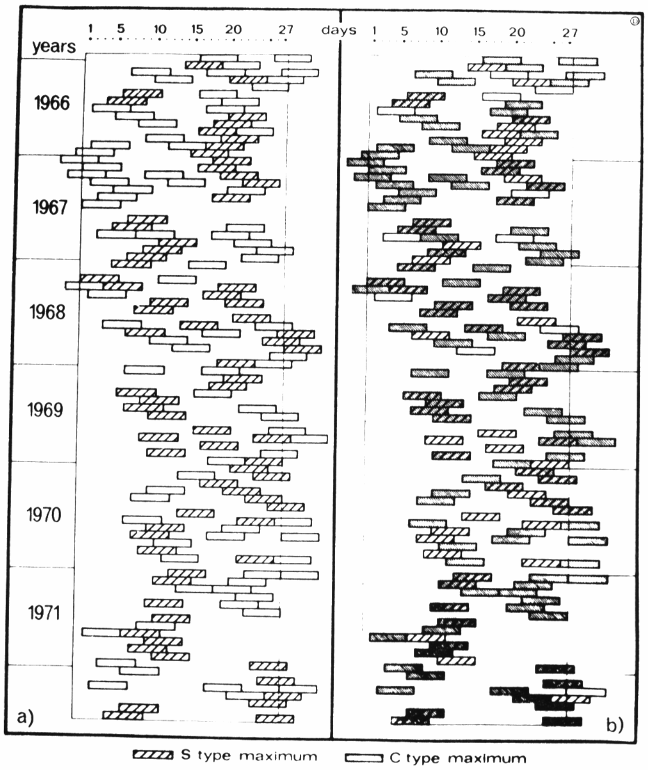

Fig. 3

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