Five-minute pulsation of hard gamma radiation intensity in the atmosphere

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Quasiperiodic pulsations have been observed in the intensity of atmospheric gamma rays (energy greater than 40 MeV) with a period of about 5 minutes, characteristic of oscillations of the solar surface. The pulsations were observed in a series of high-altitude balloons at different geomagnetic latitudes.

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The discovery of quasiperiodic pulsations in the intensity of gamma radiation in the upper layers of the atmosphere in the range of periods 10–40 min was reported earlied.[1] In the present work a substantially larger volume of experimental data is treated and the frequency region under investigation is broadened.

The gamma radiation was detected by a γ-ray telescope with spark chambers. The energy threshold of the instrument was 40 MeV, the geometrical factor was 115 cm^2 sterad, and the aperture $\pm 40°$. A more detailed description is given in Ref. 2. In the period from 1972 to 1979 five high-altitude balloon flights were carried out. The results of the measurements pertain to altitudes of 4–10 g/cm^2 of residual atmosphere. The duration of measurements on an individual flight was from 5 to 12 hours.

The analysis of the time variations was carried out for periods in the range 4–60 min. We used a method for calculating the spectral density $I(\omega_k)$ over a finite time interval.[3] The data were first subjected to high-frequency filtering, as a result of which variations with periods greater than 90 min were excluded from the experimental sequence. To compare the periodograms for flights of different duration the analysis was carried out over a time segment of standard length, which was picked to be three hours. Moreover, it was possible to follow the dynamics of the processes studied during a flight for which the spectral density was calculated over a moving three-hour segment with a time step of 30 min. The integral spectral density $J = \Sigma_k I(\omega_k)$, where k is the number of the harmonic in a Fourier series ($k = 1,2,...,43$), was used as the most general characteristic for the fluctuation level.

For the flights which had the longest duration it was shown that changes in J over time could not be explained by random "white noise" fluctuations. Thus, for further analysis we chose nonoverlapping time intervals for which J exceeded the expected level by no less than two standard deviations. The data for all the flights comprised five such three-hour intervals. The result from averaging the five corresponding periodograms is shown in Fig. 1a. The most reliable period is about five minutes. Also present are oscillations with larger periods, which have been discussed in Ref. 4. The five-minute pulsations are reliably and discretely distinguished in most of the flights,

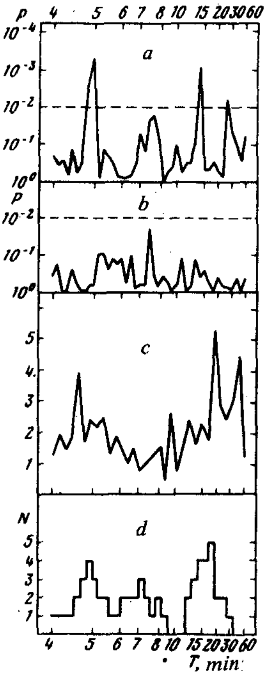

FIG. 1a-periodogram of intensity fluctuations in hard gamma radiation in the upper layers of the atmosphere; b-periodogram obtained in a controlled experiment at sea level; (in a and b the probability P for the random occurrence of the observed or larger value of the spectral density for an individual harmonic is plotted along the y-axis); c-spectrum of oscillations in the solar radius,[8] relative units along the y-axis; d-quasiperiodic fluctuations in the solar radio emission,[10] where N is the number of occurrences of a given reliable period.

and also in the averaging of independent periodograms over all the data. Their amplitude varied, reaching 20% for individual time segments.

An analysis of the balloon flight information did not indicate possible methodological reasons for the oscillations in the instrumental counting rate. A methodological experiment was also set up under laboratory conditions in which the γ-ray telescope was adjusted to detect cosmic muons. The resulting periodograms did not show clear periods; the result of their averaging is shown in Fig. 1b.

Five-minute oscillations in the solar atmosphere are well-known from optical observations.[5] Evidence has recently been obtained for their large-scale character, i.e., it has been shown that there are radial oscillations of the sun as a whole with this period.

The dominant position of a period of about five minutes in our observations and in oscillations of the sun indicates a genetic relationship between the five-minute pulsations in the intensity of atmospheric gamma radiation and processes occurring on the sun.

In addition to the five-minute oscillations, other solar oscillations with periods in the range 10–60 min have also been reported in a number of papers[7–9] (Fig. 1c), which apparently have an unstable nature. Attention is also drawn to the distinct periods for fluctuations in the solar radio emission in the 10-m wavelength region[10] (Fig. 1d).

The question of the mechanism for transmitting oscillations from the sun to the earth remains open. We only note that the flight of 7 May, 1976, from which gamma radiation pulsations were absent, differs from the remaining flights by an exceptionally low solar activity during that period.

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