FRACTAL ANALYSIS OF ULF GEOMAGNETIC FIELDS IN RELATION TO THE SOLAR ECLIPSE ON 26 JANUARY 2009

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The observational geophysical data are usually represented by an irregular time series. To obtain a quantitative estimation of the time series irregularity, the power spectrum analysis has been conventionally used. In the case when the power spectral density follows a power law, the spectral exponent can be considered as one of the indexes for representing the irregularity of a time series. The long-term evolution of scaling (fractal) characteristics of the ULF geomagnetic fields is studied in relation to solar eclipse of 26 January 2009. The selected period covers 1 month before and 2 months after the solar eclipse. The FFT method has been applied to calculate the scaling exponents and fractal dimensions of the ULF time series.
It is found that the spectrum of ULF emissions exhibits, on average, a power law behaviour S(f) ∞ f EMBED Equation.3 , which is a fingerprint of the typical fractal (self-affine) time series. The spectrum slope ß fluctuates quasi-periodically during the course of time in a range of ß = 2 - 0.7, which corresponds to the fractional Brownian motion with both persistent and antipersistent behaviour. Fractal dimension D0, which characterises the rate of the irregularity of the time series (how smooth or crinkly is the representing the observational data), can be calculated from the spectral exponent using the well-known Berry's equation: D0 = (5 - ß)/2. We divide the raw data along local time intervals, thus forming for every day 24 sets of 1-hour time series, having N = 720 variables (H, D, Z components) and different local time sectors: night (00:00-01:00 LT), dawn (06:00-07:00 LT), noon (12:00-13:00 LT), and dusk (18:00-19:00 LT). Then we analysed the evolution of the slope ß of the spectrum in different local times, under a variety of geomagnetic conditions and on the different time distances from the solar eclipse. It is seen that the tendency for fractal dimension to decrease before the solar eclipse is manifested itself at all local time intervals. An tendency is also found for the spectrum slope to increase gradually when approaching the solar eclipse date. Such a tendency manifests itself at all local times, showing a gradual evolution of the structure of the ULF noise to a typical flicker noise structure in proximity to the solar eclipse event. One more effect related to the solar eclipse is revealed: the longest quasiperiod, which is 14 days, disappeared from the variations of the ULF emission spectrum slope during the solar eclipse, and it reappeared 7 days after the event. Physical interpretation of the peculiarities revealed has been done on the basis of the SOC (self-organized criticality) concept.

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