RECENT STUDIES OF SCHUMANN RESONANCE AND ELF TRANSIENTS

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ABSTRACT

Schumann resonance (SR) is the global electromagnetic phenomenon occurring in the Earth – ionosphere cavity at frequencies of 8, 14, 20 Hz, etc (the ELF band). Phenomenon was named after the author of the pioneer publication on the planetary resonance. Since natural electromagnetic signal originates from lightning strokes distributed worldwide, parameters of oscillations reflect the average condition of ionospheric plasma, spatial distribution and current intensity of thunderstorms. 'Regular' lightning strokes occur at a rate of 50 events per second, and their electromagnetic radiation forms the SR background. An irregular or transient component exists caused by relatively rare powerful strokes (the rate is about one event per minute or even less) that provide pulses ten times higher than an ordinary discharge. Three orthogonal field components (vertical electric and two crossed horizontal magnetic fields) are recorded at a Schumann resonance field site, and the power spectra are obtained in the frequency band up to 40 Hz averaged over a few minutes with the typical frequency resolution of 0.1 Hz.

The main objective of report is to review the recent results in the Schumann resonance studies. The report consists of two parts; one of them summarizes the experimental data obtained during last 3 – 5 years, while the second describes model studies of ELF radio propagation. We try to mention the most important results in the Schumann resonance.

The report surveys the data obtained by using 'classical' power spectra acquired at different observatories. Power spectra give information on the properties of the lower ionosphere boundary and on the dynamics of the global thunderstorms. For instance, the sudden changes can be detected in the space weather such as Solar Proton Events (SPE); the regular seasonal motion of thunderstorms is monitored, which is associated with the ground surface temperature; unusual changes might be found in the SR spectra prior to disastrous earthquakes, etc.

The cross-spectra of both magnetic fields and magnetic and electric fields (Poynting vector) might be obtained when three field components are recorded. Cross-spectra enhance the coherent fields and reduce the noise thus presenting a more exact information on both the source location and the SR parameters. Elliptical polarization of horizontal magnetic field is measured via the cross-spectra technique, and recent comparison with the model computations proved the detection of Schumann resonance line splitting.

Accumulated experimental data present a wide area for resolving the inverse electromagnetic problems directed to establishing an unknown instant distribution of the global lightning activity. Resonance parameters measured worldwide allowed for constructing the effective globally averaged models of the lower ionosphere and the dispersion relation for ELF radio waves.

Recent model developments are connected with applications of finite element methods to the resonance problem. Simultaneously, the 'classical' spectral field representation was transformed into the time domain providing an effective computational algorithm. Analytical time domain solution allowed generating the quasi–random pulse successions modeling the ELF radio noise. The model time domain ELF signals might be synthesized with predetermined properties.

In the conclusion of review, we note a renewal of interest towards the extra-terrestrial Schumann resonance studies. The Huygens probe mission on Titan stimulated interest to distant detection of feasible lightning strokes at the planets and their global location by using the planetary resonance concurrently with studies of ionospheres.