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The Schumann resonance eigenmodes in the Earth's ionosphere observed by Chibis-M microsatellite

Denys Dudkin
Lviv Centre of Institute for Space Research, Ukraine (dd@isr.lviv.ua)

The Schumann resonance (SR) occurs due to the global thunderstorm activity in the Earth-ionosphere cavity. The first five eigenmodes of the SR are 7.8, 14.3, 20.8, 27.3 and 33.8 Hz. This effect is well observed from ground-based electromagnetic (EM) sensors. However, the results of published numerical simulations show that the penetration depth into the ionosphere of EM fields, related to SR, is limited to 50-70 km for electric field and 120-240 km for magnetic field. From this follows, that SR can hardly ever be detected by the low Earth orbiting satellites.

In spite of this fact, SR has been found for the first time in data collected by the Communications/Navigation Outage Forecasting System (C/NOFS) satellite [Simoes et al., 2011]. C/NOFS observed SR signals in the altitude range 400-850 km at local night time, from three orthogonal pairs of 20 m tip-to-tip electric field double probes. The SR spectral density is about 0.3 (μV/m)/Hz$^{1/2}$, which is almost 3 orders of magnitudes lower than usually observed on the Earth's surface.

As well, the SR harmonics were observed by Russian Chibis-M microsatellite in 2013, also at local night time. The Chibis-M satellite has mass $\sim$40kg and was launched on January 24, 2012, at 23:14 UTC from the cargo ship "Progress M-13M" to circular orbit with altitude $\sim$500 km and inclination $\sim$52°. One of the mission goals is to study the plasma wave processes related to solar-magnetosphere-ionosphere-atmosphere connections in ULF-VLF range. The Chibis-M EM field sensors were developed and designed in Lviv Centre of Institute for Space Research, Ukraine. The electric field antenna of Chibis-M has very short base, $\sim$0.42 m, nevertheless the SR eigenfrequencies were reliably detected. The measured spectral density of first SR peak is about 0.5 (μV/m)/Hz$^{1/2}$, which is very close to value, obtained by C/NOFS satellite.

The fact of SR registration in the ionosphere suggests that the Earth-ionosphere waveguide should be described as a leaky cavity for ELF wave propagation. Perhaps the SR detection in ionosphere at local night can be explained by decreasing of plasma density in shadow zone. Thus, at study of ELF waves propagation, the model of the Earth-ionosphere structure should be refined.

Simoes, F. A., R. F. Pfaff, H. T. Freudenreich, Satellite observations of Schumann resonances in the Earth's ionosphere, Geophys. Res. Lett., 38, L22101, doi:10.1029/2011GL049668, 2011.