Studies of a sudden ionospheric disturbance using the Schumann resonances

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Extremely low frequency (ELF) electromagnetic waves in the Earth-ionosphere cavity are generated mainly by lightning discharges, originating from the tropical thunderstorm centres. The Earth-ionosphere spherical cavity forms a global resonator for the ELF waves, as predicted by Schumann in 1952. The resonance and the propagation properties of the ELF waves depend on the physical properties of the cavity. The lower ionospheric layers are created by the UV radiation form the Sun. They are modulated by the Sun's 11-year cycle, but sometimes the rapid changes are caused by the solar flares and related sudden ionospheric disturbance (SID) phenomena. During the SID event the development of the ionospheric D layer is observed, which leads to strong damping of the radio waves in the high frequency (HF) band. However, for the ELF waves the attenuation rate decreases significantly and the changes in the resonant frequencies should be observed.

In this study, the influence of the SID event on the Earth-ionosphere cavity is analyzed using the ELF electromagnetic waves. The ELF data were collected by the *Hylaty* ELF station located in Poland (49.19^{o} N, 22.55^{o} E). We apply the Schumann Resonance spectral decomposition method (Kułak et al., J*ournal of Geophysical Research* (Space Physics), **111**, 2006, A10304) for measuring time variations of the resonant frequencies during the SID. This method, in contrast to symmetric Lorentz curves, enable decomposing the observational power spectra into the symmetric part (standing waves) and the asymmetric part (travelling waves). The extracted intrinsic resonant frequencies do not depend on the source-observer distance, in contrast with the Lorentzian frequencies, which are distance-dependent and evolve during the day due to thunderstorm centres migrations along the globe.

We investigate the evolution in time of the SR modes. We show that significant frequency variations accompanying the SID are strictly related to the solar flare high-energy radiation: X-rays and γ-rays, rather then the UV flux. These analyses also allow for derivation of the recombination time constant for the ionospheric D layer. The recombination time constant, as inferred from the SR modes shows monotonic behaviour and it ranges from 5 to 11 minutes. Moreover, using the two altitude nonuniform model for ELF radiowave propagation in the Earth-ionosphere waveguide, with day/night asymmetry, the magnetic altitude parameter was calculated. The obtained results show the magnetic altitude decrease during the SID generated by the solar flare. These results are consistent with findings available in the literature, based on different approaches.