Analysis of ULF Waves During Substorms Observed in the Ionosphere from the Dayside Ground Magnetometer and in the Solar Wind from the Satellite

M. Alimaganbetov*, A.V. Streltsov
Embry-Riddle Aeronautical University, Physical Sciences Department,
Daytona Beach, FL, 32114-3900, USA.

Magnetospheric substorm is one of the most interesting and complicated phenomena of solar-terrestrial interactions. Despite numerous theoretical and experimental studies conducted during last 50 years, its several important phenomena are not completely understood yet. One of them are intense, ultra-low-frequency, ULF, (from 0.5 mHz to 100 mHz), electromagnetic pulsations which are always observed during the substorms with the ground-based magnetometers and radars at high latitudes.

During substorms, having the largest amplitudes in the power spectral densities, PSD, these waves are the most effective drivers of such mechanisms as high-latitude ionosphere energization, ion outflow production, formation of plasma density cavities, etc. In our study, we focus on the waves with frequencies 0.5-1.0 mHz, which is the lowest part of the frequency spectra observed during the substorm. The questions of what phenomena cause these oscillations and what are their spatiotemporal properties are among the most important ones about the physics of the substorm.

To answer these questions, we analyzed disturbances of the magnetic field obtained from the two sources for the period from October 2015 to April 2017 during several substorms. One source is the fluxgate magnetometer in Poker Flat, Alaska. Another is the NASA Advanced Composite Explorer satellite in the Lagrangian L1 point that detects most of the solar wind from the Sun. The goal of our project is to find correlations between the disturbances observed from these sources, which will be a convincing argument that the solar wind has a strong influence on the electromagnetic coupling between the ionosphere and magnetosphere of the Earth during the substorms.

We observed 75 substorms during the abovementioned period. Our findings show that 1) the dominant frequency of the large-amplitude ULF waves observed during the substorms is 1 mHz or less; 2) the same frequencies are frequently observed in the waves detected from the both sources, 30% of cases yield very good correlation in respective PSDs; 3) the trend of repeating dominant frequencies is consistent throughout the whole period of observation, with about 0.60 mHz being the most frequent value in each of the two sources. However, there are also some cases of either mismatch of expectation and occurrence of substorm or weak correlation of frequencies. While this work is only considering 75 events within a year and half, and utilizes data from a single ground station, it constitutes a firm foundation to investigate theoretical reasoning behind substorm development further.