# SUBSTORM-RELATED ULF WAVES AT HIGH LATITUDES
Ionospheric Modification

Thomas Guido, Beket Tulegenov, and Anatoly V. Streltsov
Department of Physical Sciences, Embry-Riddle Aeronautical University
Daytona Beach, FL, USA.

Substorms are one of the most interesting and complex geophysical phenomena which include many different processes occurring simultaneously at different components of the magnetosphere-ionosphere system. Despite numerous theoretical and observational studies, a comprehensive and complete model of this phenomenon is not yet developed. Of the main features of a substorm, one of the most prominent is the strong electromagnetic oscillations in the ultra-low-frequency range detected at high latitudes with ground-based magnetometers, radars, and photometers. These oscillations have been studied for more than 50 years, but the question of the particular geophysical mechanism which is responsible for its generation is not yet answered. One particular mechanism related to these fluctuations is the discrete frequencies it resonates, which frequently demonstrates very well determined values over a large number of observations. Sometimes these values are even called “magic” frequencies, which are normally attributed to the frequency of the global magnetospheric cavity modes, magnetic field line resonance, ionospheric feedback instability, or plasma pressure variations in the solar wind interacting with the Earth’s magnetosphere.

We present results from a statistical study of the ULF waves observed with a fluxgate magnetometer in Gakona, Alaska during several experimental campaigns conducted on the High Frequency Active Auroral Research Program (HAARP) facility in 2012 and 2013. We analyzed spectral characteristics of ULF waves measured during 28 strong geomagnetic disturbances (substorms) at Gakona. Our results demonstrate that the main power of these pulsations is in the frequency range below 1 mHz, which is less than previously suggested. These oscillating frequencies can hardly be explained with traditional mechanisms based on the internal magnetospheric parameters; the two most probable mechanisms explaining them are ionospheric feedback instability and oscillations in the solar wind. We performed an analysis on data from the ACE satellite and found several cases of correlations between oscillations detected on ACE and on the ground, although there were also cases when such correlations are absent.