Masters Project Title: Application of the apparent impedance approach to identify the physical nature of cusp transients and waves

Overall Research Project: INTPART project: Magnetic Pulsations and transients: the Sun-Earth connection and impact on the high latitude ionosphere (Research Council of Norway) (Work Package 4)

Timeline: 1 year (60 ECTS)

Main UNIS Supervisor: Assoc. Prof. Lisa Baddeley (UNIS)

Co-supervisor: Prof. Slava Pilipenko (Institute of Physics of the Earth, Moscow)

Funding: Funding assistance for travel and accommodation on Svalbard is available for the duration of the project

Project Description: Ultra Low Frequency (ULF) waves (with timescales of a few seconds to minutes), manifest themselves as periodic fluctuations in the Earth's magnetic field (see Menk 2011 for a review). These signatures can be observed both in the Earth's magnetosphere and ionosphere. The energy source for the waves can be either external or internal to the Earth's magnetosphere. The ionosphere acts as a sink for the wave energy. There are several forms ULF waves can take, which relate to the ratio of the magnetic and electric field polarizations as well as their effect on ionospheric conductance. One way to discriminate between the different ULF wave modes is the measurements of their apparent impedance, i.e., the E/B ratio. The impedance technique is widely used in satellite observations to identify the nature of electromagnetic structures in space and has been developed by Pilipenko et al. (2012) for applications to ionospheric observations.

This project will use ground magnetometer data from Longyearbyen to build up a database of Pc5-6 pulsations (waves with periods of between 150 – 600seconds) associated with the dayside aurora. This data base will be cross referenced with:

- EISCAT radar data to provide measurements of the ionospheric conductivities
- SuperDARN radar data to provide measurements of the ionospheric velocities
- The apparent impedance technique will then be applied to all of the events and compared to theoretical predictions for the various wave modes.

The results from the project will be incorporated into a larger international research project (the INTPART research project, work package 4) and hopefully provide input parameters to ionospheric models of ULF waves.

Scientific Conference Attendance

There is also the possibility to travel to a scientific conference to present the work, as part of the INTPART project, at the completion of the Masters thesis (also funded through the project).

Methods: The student will familiarize themselves with the different categories of ULF waves and their energy source (through the reading of several scientific papers) and the impedance technique of Pilipenko et al. 2012. The research work will then entail:

- the downloading, analyzing and processing of data from online databases (for instrumentation listed above).
- A visit to the EISCAT Svalbard radar where the student will be in charge of an experiment to monitor the ionosphere for ULF wave signatures.
- Preparation and writing of thesis manuscript.
- Preparation and presentation of results at a science conference (subject to availability of conference and progression in the project)

Fieldwork: The student will be instructed how to use the EISCAT Svalbard Radar before running their own experiment to hopefully increase the database of events (NB: The ionosphere cannot be controlled so there is no guarantee of increasing the dataset!)

Experience: Programming experience essential – preferably with matlab (python and IDL are also acceptable). Background knowledge of ionospheric / magnetospheric physics is also required.

References:

- Belakhovsky, V., V. Pilipenko, D. Murr, E. Fedorov, and A. Kozlovsky (2016) Modulation of the ionosphere by Pc5 waves observed simultaneously by GPS/TEC and EISCAT, Earth Planets Space, 68:102, doi: 10.1186/s40623-016-0480-7.
- Menk, F., (2011), The Dynamic Magnetosphere, Springer, ISBN : 94-007-0501-8, Chapter 13 – Magnetospheric ULF Waves: A review
- Pilipenko V., V. Belakhovsky, A. Kozlovsky, E. Fedorov, and K. Kauristie, Determination of the wave mode contribution into the ULF pulsations from combined radar and magnetometer data: Method of apparent impedance, J. Atmospheric and Solar-Terrestrial Physics, 77, 85-95, doi:10.1016/j.jastp.2011.11.013, 2012.
- Pilipenko, V., V. Belakhovsky, M.J. Engebretson, A. Kozlovsky, and T. Yeoman, Are dayside long-period pulsations related to the cusp? Annales Geophysicae, 33, 395-404, doi:10.5194/angeo-33-1-2015, 2015.
- Pilipenko, V., V. Belakhovsky, A. Kozlovsky, E. Fedorov, and K. Kauristie, ULF wave modulation of the ionospheric parameters: Radar and magnetometer observations, J. Atmosph. Solar-Terr. Physics, 108, 68-76, 10.1016/j.jastp.2013.12.015, 2014.