SPACE WEATHER INVESTIGATIONS USING IN-SITU AND GROUND MEASUREMENTS – IAGA DIVISION 3. MAGNETOSPHERIC PHENOMENA

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1 Theoretical results on monochromatic and UWB propagation in wave guides and in moving inhomogeneous media

In the field of the theoretical model development of the full wave solutions of the Mawell's equations, beside the applications of the models developed earlier, several new results were achieved:

1) The general solution of the electromagnetic wave propagation in inhomogeneus moving media inside the validity of the special relativity was published in Radio Science (Ferencz 2011)
2) The general solution of the electromagnetic wave propagation in general relativistic situations was published in Radio Science (Cs. Ferencz, Radio Science, Vol.47, RS1014).
3) The application of this method for finding non-radiating, but propagating solutions which can affect the space-time structure is under way.
4) The application of the earlier UWB solutions is successful in the POPDAT and PLASMON EU FP7 projects and in the Chibis-M satellite mission.
5) Application of the new, fully analytical inhomogeneous model of transient propagation in the ionosphere for simultaneous terrestrial and onboard recordings, more exact determination of the profile of the inhomogeneity of the traversed medium.
6) Application of the Methods of Inhomogeneous Basic Modes solving method of the Maxwell's equations for elastic problems (generalization of the transient solution for seismic problems) is also under way.
7) Development of a new approach for numerical Laplace transformation for more complicated propagation problems (i.e. curved wave guides, curved geomagnetic field lines, etc.) continued.

2 Space Weather investigations using in-situ measurements by DEMETER, CHIBIS-M and RELEK satellites

Systematic investigation in archived DEMETER wave recordings were continued. Compartive study of one-hop whistlers, occurred simultaneously in ground stations, detected automatically by the AWDANet, and identified in on-board LEO satellite recordings, during nearby passes was performed. Preliminary results draw the probable extent whistler wavefront in the topside ionosphere, and confirm the picture of local guided propagation. New detection algorithm, optimized for lightning generated fractional-hop whistlers, recorded on-board was developed, and applied in 6.5 years of burst wave data.

The Russian-Hungarian-Ukrainian Chibis-M microsatellite, with SAS3 ULF-VLF experiment on board has been properly operated since its successful launch to circular LEO orbit in February 2012. Detailed analysis of wave recordings is in progress, including time domain waveforms and VLF monitoring spectra, as well as in data sets of on board event-counting routine. Recordings of the Chibis-M satellite, being the sole ionospheric spacecraft currently performing regular wave recordings in the topside ionosphere, represent unique database in space weather research.

Systematic investigation of the recordings, obtained by the SAS3 ULF-VLF wave experiment on board of the Russian-Hungarian-Ukrainian Chibis-M LEO micro satellite (2012-2014) has been

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performed. Occurrence rates and intensities, temporal and spatial distribution of natural wave emission in the recorded 0-40kHz monitoring data were compared to space weather indices. TLE events and intense storms were analyzed by UWB prop code using source lightning data and waveform (burst) records.

After the successful launch in July 2014 of the Russian RELEK (Relativistic Electrons) micro satellite with our SAS3 on board, autonomous signal detection software module (ISDM), detection and first order analysis of pre-defined wave classes has been started to operate. ISDM has been designed according to much limited on-board CPU and TM resources, emulating and testing the conditions of the near future BepiColombo Mercury magnetosphere orbiter plasma wave experiment. RELEC polar orbit allows to follow and monitor wave activity globally, RELEK LEO recordings in 0-40kHz band fills a gap in current ionospheric wave data base.

3 Monitoring the plasmasphere by Automatic Whistler Detector and Analyzer Network (AWDANet) for space weather purposes - the PLASMON FP7-Space project

In the PLASMON EU FP7-Space project – a new, ground based data-assimilative model of the Earth's Plasmasphere – a critical contribution to Radiation Belt modeling for Space Weather purposes (2011-2014), we have installed 15 stations in the Automatic Whistler Detector and Analyzer Network. These stations have been enhanced with Automatic Whistler Analyzer (AWA) units and these nodes are now capable not only for detecting but analyzing the whistler events in quasi real-time since mid-2014. Parallel to the real time analysis, the processing of the archive whistlers collected by AWDANet since 2002 has also been started. The calibration of equatorial electron densities obtained from whistler inversion with in-situ cold plasma measurements has been done, the electron densities derived from upper hybrid measurements on RBSP satellites were used to calibrate with densities from whistlers recorded at Rothera. The results show excellent agreement between the data from two sources, confirming the validity of the physical models (wave propagation, field-aligned density distribution, equatorial electron density distribution and magnetic field) used in the inversion procedure.

The equatorial electron densities obtained by AWDANet - together with plasma mass densities inferred from the European Magnetic Meridian Array, also extended and enhanced in PALSMON project – are fed to the data assimiliative model of the plasmasphere developed in the project (http://plasmon.elte.hu).

4 Ionospheric Wave Catalogue for Space Weather investigations in the POPDAT FP7-Space

In the POPDAT – Problem-oriented Processing and Database Creation for Ionosphere Exploration project we have created a ionospheric wave catalogue. This catalog is based on systematic processing of typical wave-like phenomena of historic and active wave data of ten ionospheric satellites to create a thematic database. The wave-like phenomena include atmospheric gravity waves, moving plasma inhomogeneities, natural ELF-VLF emissions (chorus, hiss, whistler). The thematic database is integrated into the Ionospheric Wave Service developed in the project (http://popdat.org). The searchable database contains ~24 million whistler event processed, including date and time, satellite position, event type and primary wavform characteristics.

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