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AURORAL PHENOMENA AS SEEN BY CO-ORDINATED MEASUREMENTS OF SKA-3, UVSIPS AND IMAP-3 EXPERIMENTS ON BOARD THE INTERBALL-2 SATELLITE

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ABSTRACT

The Interball project investigates the system solar wind-magnetosphere- ionosphere by Auroral and Tail probes. On board the Auroral satellite, SKA-3 (a set of particle detectors) and the magnetometer IMAP-3 provide in-situ characteristics of the energetic particles and the magnetic field, respectively. The UV Spectrometer UVSIPS maps the ionospheric auroral characteristics in 3 lines: of the atomic oxygen (1304Å, 1356Å) and nitrogen (1493Å). The co-ordination of the satellite and the ground-based measurements allows to clarify the solar wind-magnetosphere-ionosphere interactions and to contribute in understanding the magnetospheric models.The purpose is to present examples of the observations demonstrating the quality of the data recorded by the instruments.

INTRODUCTION

Simultaneous measurements of the magnetospheric substorms, the dissipated energetic particles and the auroral phenomena contribute essentially to the research of a coupled solar wind-magnetosphere-ionosphere system. The experiments of the Interball project coordinated with the ground-based measurements provide valuable information for the time/space development of the auroral processes in the Earth, frame which is necessary for the proper assessment of the strongly variable local magnetospheric features, observed by the Interball satellites (A.A.Galeev et al., 1995 a,1996 b).

INSTRUMENTATION

The instruments SKA-3, UVSIPS and IMAP-3 work aboard the Auroral probe (AP), which was launched on August 29, 1996 (R.S.Kremnev et al.,1996). The altitude of the AP orbit apogee is approximately 20,000 km with 62.8 degrees inclination of the orbit plane. The spin period of AP is 120 sec, the spin axis is directed to the Sun. The instrumentation set SKA-3 consists of 4 instruments, EA-2, EA-3, EM-1-1, EM-1-2 (F.K.Shuiskaya et al,1995). EA-2 and EA-3 are aimed to measure electrons and ions from 30 to 15,000 eV; EM-1-1 and EM-1-2 to measure higher energies particles. EA-2 and EA-3 are energy/angle spectrometers with parallel particles registration in the angle range from 0 to 360 degrees and they perform energy scanning. EA-2 and EA-3 measure electrons and ions from 30 to 15,000 eV, respectively. EA-2 and EA-3 include a type of electrostatic toroidal analyzer, which originally is aimed to search narrow field-aligned particle beams when equipped with a set of special multiwindow collimators with differential electrical shutters. The

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instruments EM-1-1 and EM-1-2 are completely identical. They are time-of-flight (TOF) energy/mass spectrometers of charged particles to measure electrons and ions simultaneously with masses 1, 4, 16 in 7 energy intervals that are within 20 to 500 KeV. Their fields of view are directed to opposite directions aboard the satellite. The field of view of these spectrometers is a cone of 8 degrees. The calculated geometrical factor of both instruments is 3.0*10-3 cm2.sr. The UVSIPS UV-spectrometer is built according to the classical scheme of slit-less spectrograph with a plane diffraction grating (A.K.Kuzmin et al.,1995). The radiation from the glow regions is observed at a certain time interval of the satellite spin period. The image size is determined both by the field of view of 0.3 degrees approximately and by the satellite altitude. The radiation is directed to the instrument by a plane input scanning mirror. The spectrometer has 3 channels to measure only in 3 spectral intervals, centered to wavelengths 1304, 1356 Å (oxygen) and 1493 Å (nitrogen), respectively, each of them equal to the half-width of the spectrometer apparatus function. The details for the characteristics of these UV emissions of the upper atmosphere can be seen in the monograph and in its references (R.E.Hofman,1994). The characteristics of the slit collimator, the dimension of the field diaphragms and the optical characteristics of the slit-less spectrograph determine the effective spectral half-width of the apparatus function, corresponding to an instantaneous image and equal to nearly 32 A°. The instrumental characteristics of the IMAP-3 magnetometer are described in (Arshinkov et al.,1995).

RESULTS

In this paper we present co-related results from the SKA-3, UVSIPS and IMAP-3 instruments data. By means of special synchronizing cyclograms, joint measurements were carried out during the magnetic storm on 19.10.1996. The co-ordination of the Interball project experiments with the ground-based measurements provides information for the time/space development of the auroral phenomena that are necessary for analyses of the local magnetospheric-ionospheric features, observed by the Interball instruments. A magnetogram obtained in Kiruna (geogr. lat. 67,8 degrees; geogr. long. 20,4 degrees) by the ground-based magnetometer is presented.

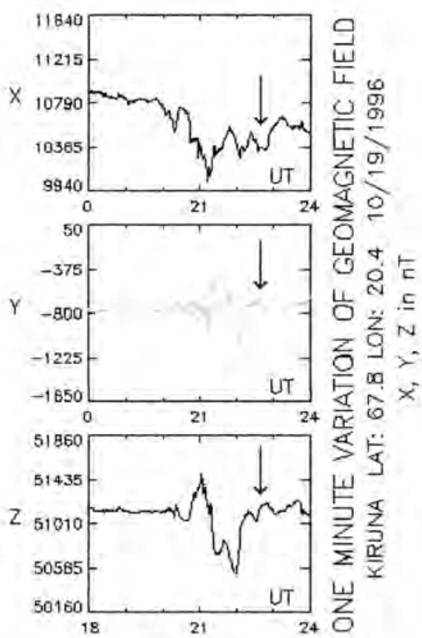

Fig. 1.Magnetogram from the ground-based magnetometer in Kiruna-Sweden.

This picture (see Figure 1) presents the geomagnetic conditions at 18-24 hr on 19.10.1996. The planetary index Kp in the 21-24 UT interval is 5+.

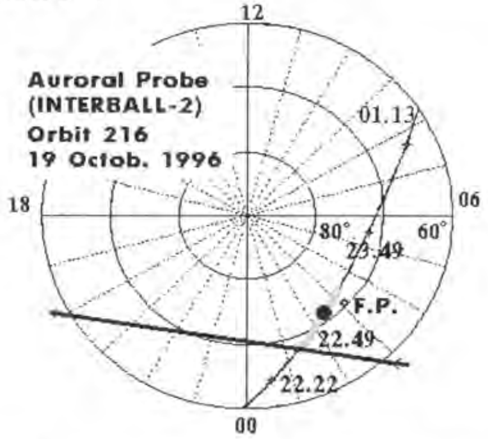

Fig. 2. Polar co-ordinates during the measurements.

The satellite projection in interval orbit and the projection of the UV-spectrometer F.P..scan (see Figure 2) determine the altitude of the UV auroral emissions at 150 km in ILAT-MLT co-ordinates .

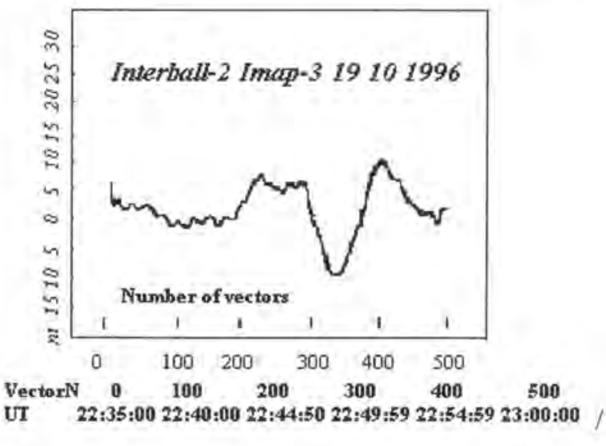

Fig. 3. Magnetogram of IMAP-3.

The magnetogram of IMAP-3 (see Figure 3) begins with a quiet interval that continues until 22.45 UT. The magnetic disturbances observed after that may be connected with current layers crossed by the satellite. From 22.45 UT until 22.50 UT field gradients, reaching 10 nT can be seen. Probably, these changes in the magnetic field are the result of small-scale field-aligned current layers. The minimum width of such a structure may be of the order of dozen km. At higher latitudes, in some of the observations from 22.50 UT until 22.56 UT, the magnetic field change is two times larger, which is connected with a large-scale current structure crossed by the satellite. This current layer width is about 130 km reduced to atmospheric altitudes. UVSIPS performs scanning of the Earth atmosphere in 3 scanning series every 120 sec during the satellite spin. Due to the precession of the satellite spin axis and its declination from the direction to the Sun only in the 2nd scanning of the 3rd series the UVSIPS field of view crosses the polar region of the Earth atmosphere within the interval 22.49.00-22.49.06 UT. Rather high intensities of the oxygen emissions that reach more than 10 kR (for 1304 Å oxygen line) at the nightsight of the auroral oval are registered in this scan. The real declination of the satellite axis is a few degrees apart from the nominal; that is why the foot print (for 150 km altitude) turned out a scan (see Figure 2). The emission intensities profiles of 1304, 1356 Å (see Figure 4) are shown.

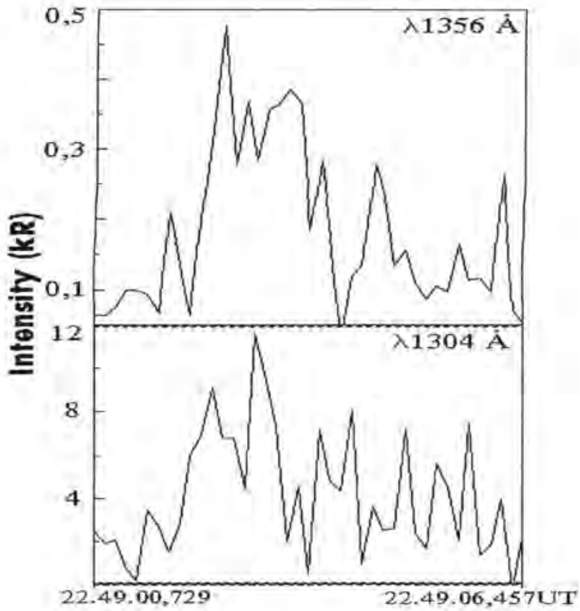

Fig. 4. Intensity of 1304 Å and 1356 Å lines.

This high aurora brightness in accordance with the III [rd] aurora ball is along part of the crossing chord that can be seen in the region of the modeled (for Kp=5) auroral oval (D.A.Hardy et al., 1985), (see Figure 2.). Arrows on the magnetogram obtained in Kiruna (see Figure 1.) mark the measurement moment of IMAP-3, UVSIPS and SKA-3 aboard the Auroral Probe satellite. It is evident that the measurements are performed at the end of the maximum phase - the initial phase of the recovery. Pay attention (see Figure 3.) that in the interval 22.45-22.46 UT the magnetic field (IMAP-3) increase is observed of the order of several nT corresponding to a restricted currents structure and to the intensive emission gradients taking into consideration the direction of the magnetic-conjugated region of the auroral oval. Panels 2,3,4 from the upper part (see Figure 5.) show the spectrogram (time-space-energy-intensity) of protons, oxygen and electrons obtained by means of the semiconducting time-of-flight energy/mass spectrometer EM-1-1 of the SKA-3 instruments complex.

The sinusoidal evolvent of the pitch angle for the EM-1-1 instrument is shown above of spectrogram panels. For a better graphic presentation, the electron fluxes (pulse/sec) profiles with energy 30 keV are shown below the spectrogram. At the scan moment, rather intensive isotropic electron fluxes and especially 15 keV electron fluxes are seen (A.K.Kuzmin et al.,1996). This intensity profile can be seen in the lowest panel (see Figure 5), which shows profiles electron and ions measured by means of EA-2 and EA-3 electrostatic analyzers of the SKA-3 instrumental complex. These analyzers operate in this period with fixed 15 keV energy mode. The intensive maximum of the characteristic energy of 0,4-0,7 keV with energy flux of more than 7 electron/sm^2.sec.sr.keV is observed in the electron spectra, obtained by the ION instrument (J.A.Sauvaud et al.,1995) data for interval 22.46.00-22.46.32 UT presented for analysis to R.A.Kovrazhkin and J.A.Sauvaud. The altitude of AP orbit when the satellite crosses this zone, is 14000 km approximately, and L~9.4. In accordance with the results of the model calculations (D.J.Strickland and D.E.Anderson,1983) , the electron characteristics energy of ~0.5 keV corresponds to 0.5-0.6 kR 1356 Å emission intensity and 0.05-0.2 kR/erg.sm^2 yields 1304 Å emission (see Figure 10.6 in

(R.E.Huffman, 1994)). As it can be seen, the 1304 Å emission intensity (see Figure 4) reaches more than 10 kR. In accordance with (R.E.Huffman, 1994) this is possible when 50-100 erg/sm^2.s energy fluxes are observed in the IIIrd ball aurora.

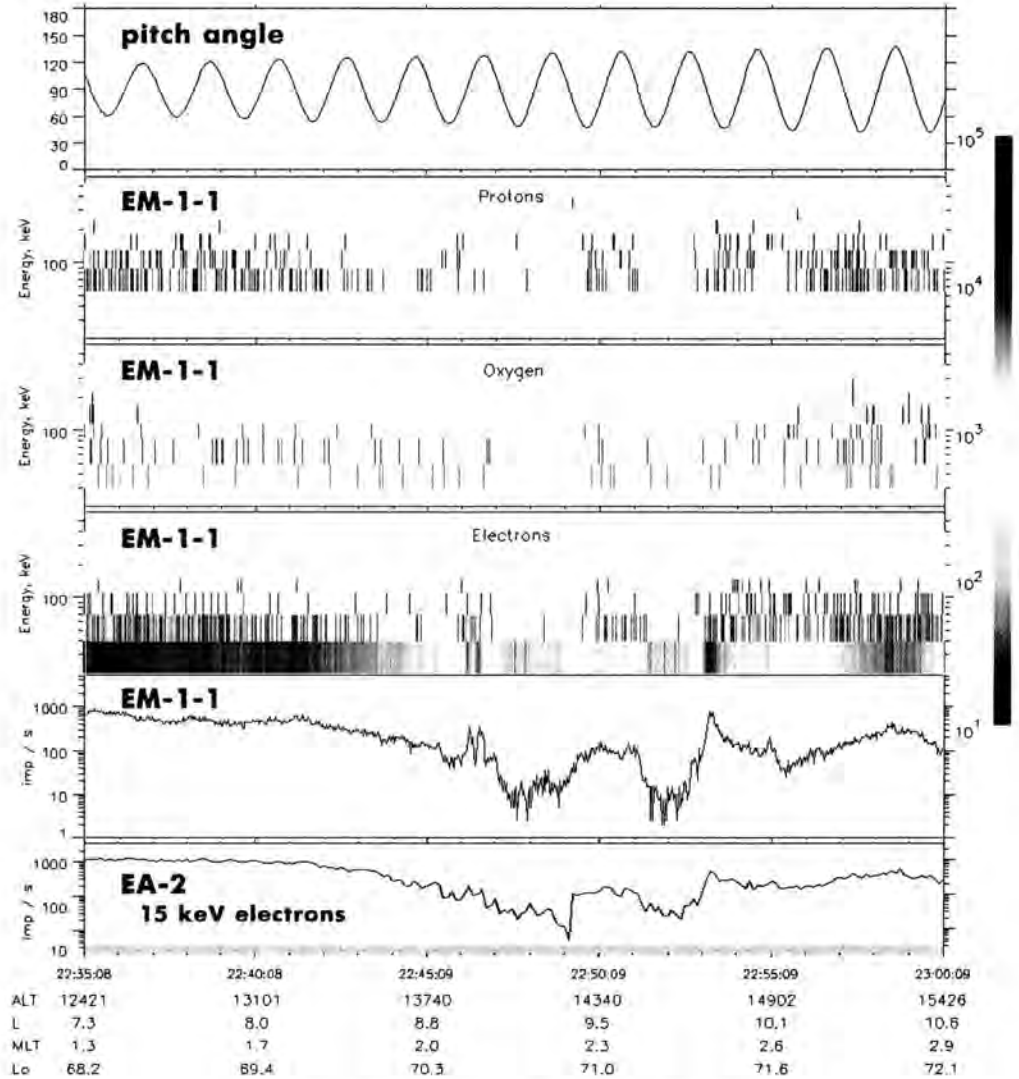

Fig. 5. Spectrograms provided by SKA-3.

Other good observations are available from the instruments, especially from IMAP-3 (7, 11, 13 March 1996; 27 Oct.,1996 – for the cusp), UVSIPS and SKA –3 (October, November 1996, March 1997 – substorm events), UVSIPS and UVAI (UV Imager) on 5 March 1997, etc.

CONCLUSION

The results demonstrated by this substorm case show the utility of the SKA-3 ,IMAP-3,UVSIPS observations and allow to detect and localize the places of active processes in the auroral oval, connected with intensive electrons and ions dissipation , contribute essentially to the study of the space/time characteristics and the cause-and-effects relationships, for important progress in the theory and modeling of the substorms and auroral phenomena, for precise time/space evolution in the auroral activation and substorms in the existing theoretical models. They also provide considerable progress in the understanding of the plasma processes in the near-Earth's space.

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