Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)


PEM31-01 Room:304 Time:May 23 15:30-15:45

# Heater-induced artificial ionospheric ion upflow

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We have investigated force balance associated with ion upflow, by using the EISCAT UHF radar and heating facility in Tromsoe, northern Norway (69.6 deg N, 19.2 deg E). The heating facility enables us to induce not only enhanced electron temperature but also upward flowing ions in the F-region/topside ionosphere. The heater-induced artificial ion upflow is one of the most suitable events to estimate force balance of ionospheric ions quantitatively and also understand generation mechanisms of ion upflow. Furthermore, the heater-induced ionospheric data are potentially usable to estimate height profiles of ion-neutral collision frequency, neutral density, and horizontal neutral wind in the F-region/topside ionosphere.

We conducted the heater and radar observations as an EISCAT special program by UK and Japan between 17 and 20 November, 2011, and successfully obtained data including artificial ionospheric ion upflow. The UHF radar and heater beams were both pointed into the magnetic zenith, and pump cycle of the heater was 16 min on, and 12 min off. During heater on period electron temperature sometimes increased up to about 4000 K and upward ion velocity reached about 500 m/s at an altitude of 500 km.

In this paper, we show the detailed results of the heating experiment, and discuss quantitative force balance associated with ion upflow.

Keywords: polar ionosphere, ion upflow, ion outflow, EISCAT

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PEM31-02 Room:304 Time:May 23 15:45-16:00

# Reimei observations on correlation of field-alinged current to precipitating electrons and accelerated ionospheric ions

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High-time and -spatial resolution data obtained by the low-altitude polar-orbiting micro satellite, Reimei, provide us with remarkable opportunities for revealing the characteristics of electrons and auroras based on the perfectly simultaneous and conjunction measurements of auroral emissions and particles.

The Reimei satellite has been making numerous notable observations in the nightside southern polar ionosphere during the winter seasons during 2005-2008. The first case shown in this paper is a comprehensive set of various fine-scale auroral activities, which shows four types of auroral forms and their variations taken by the multispectral auroral imaging camera (MAC): faint bands, streaming multiple arcs, shearing pair of arcs, and vortices/curls. The electron energy spectrum analyzer (ESA) covering a full pitch angle range observed various properties of electron energy-pitch angle distributions and their time variations, each of which is distinctive of the correspondent auroral activity. It is evident that the main energy fluxes responsible for the arc-type emissions are carried by the inverted-V electrons accelerated by (quasi-)electrostatic parallel potential structures above the satellite orbit. On the other hand, the rapidly rotating vortices are associated with the significant fluxes of spiky electron components with energy-time dispersions produced by dispersive Alfven waves. The field-aligned current signatures are also affected by these relations between auroras and precipitating electrons, which are controlled by difference of the upward and downward electron fluxes.

Another case presents unique correlative features between streaming fireball-type auroral globs at the poleward edge of the auroral bands and sharply field-aligned sporadic electron precipitations with clear energy-time dispersions embedded in the inverted-V electrons. The peak energies of the dispersive electron signatures at the start are almost equal to the characteristic energies of the inverted-V components. This correlation obviously designate the fine modification of the auroral forms/emissions in the larger structure driven by the strong dispersive Alfven waves at the similar altitudes with the parallel potential drop.

Keywords: auroral electron, ionospheric ion acceleration, field-aligned current, satellite observation, field-aligned potential, auroral dynamics

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PEM31-03 Room:304 Time:May 23 16:00-16:15

# Spatial Variations of O+ Rexonance Scattering Emission Estimated by the UPI-TEX on KAGUYA

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In 1980s, terrestrial Oxygen ion (O+) outflow was observed much more than expected amount in the polar region where the magnetic field connects to interplanetary space. However, it is not yet obvious when and how much O+ outflow are produced. In order to observe terrestrial O+ outflow, we use the Upper Atmosphere and Plasma Imager-Telescope of Extreme ultraviolet (UPI-TEX) on board the lunar orbiter, KAGUYA(SELENE). TEX imaging observations can detect both temporal and spatial variations of O+ resonance scattering emissions, which reflects to the O+ column density. However, O+ scattering light is too weak to see the spatial variations obviously. Therefore, this analysis is to estimate spatial variations of O+ scattering light that is removing filter support effects and spatial integrated it. In this study, we discussed about validity of its estimate and changing O+ scattering light associated with geomagnetic activity (AE).

Keywords: KAGUYA Satellite, UPI-TEX, Oxygen ion outflow, Solar wind, Geomagnetic activity

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PEM31-04 Room:304 Time:May 24 09:00-09:15

# Ionospheric current patterns during the undershielding and overshielding deduced by a global ionospheric potential solve

NAKAMIZO, Aoi[1*], HIRAKI, Yasutaka[2], HORI, Tomoaki[1], SEKI, Kanako[1], IEDA, Akimasa[1], TSUJI, Yuji[1], MIYOSHI, Yoshizumi[1], SHINBORI, Atsuki[3], EBIHARA, Yusuke[3], KIKUCHI, Takashi[1]

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Toward the understanding of the magnetosphere-inner magnetosphere-ionosphere coupled system, we have developed a two-dimensional ionospheric global potential solver (GEMSIS-POT). Our model basically follows a methodology of the so-called "thin shell model." The important extension from previous studies is that our model covers the pole-to-pole ionosphere without placing any boundary at the equator. By using the solver, we investigated how the ionosphere changes from under-shielding condition to over-shielding condition as the FAC distribution changes. Calculations are performed by changing j0, R2 / j0, R1 (the ratio of peak current density of R2 and R1-FAC) and moving R2-FAC toward the nightside with dLTR2-R1 (the local time deference between the R1 and R2-FAC peaks) relative to the fixed R1-FAC. In the previous talk, we reported the calculation results focusing on the electric field structure. In the present study, we analyze the ionospheric current and equivalent magnetic field perturbation of the calculation examples representing the undershielding and overshielding.

We separate the ionospheric current into the diagonal and non-diagonal components in terms of the thin shell approximation. In the polar region, where the dip angle of the geomagnetic field is close to zero, the diagonal and non-diagonal components are nearly equivalent to Pederson and Hall currents, respectively. However, in the low latitude region with the finite dip angle, they cannot be simply reduced to Pederson and Hall currents because of the mixture of Pederson, Hall and parallel conductivities in the conductivity tensor arising from the thin shell approximation of Jz=0 (vertical ionospheric current is assumed to be zero).

The calculation results show that the non-diagonal part is the major part of the ionospheric current in the polar region, whereas, in the equatorial region, the diagonal component becomes the major part. In this talk, we discuss how the current circuit from the polar to equatorial region is described by the pair of diagonal and non-diagonal components and also discuss the derived current circuit in relation to the pair of Pederson and Hall currents.

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PEM31-05 Room:304 Time:May 24 09:15-09:30

# Detection of the ionospheric day/night terminator effect by SuperDARN radars

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It is well known that the non-uniform ionospheric conductivity has an effect to deform the ionospheric convection pattern. For example, it is deduced that the dawn-dusk asymmetry of the ionospheric convection pattern in the polar region is caused by the electric charges and the secondary electric field arisen from the nun-uniform ionospheric conductivity around the day/night terminator.

We have tried to detect the sharp deformation of the ionospheric convection around the day/night terminator by using data from the SENSU Syowa East SuperDARN radar. We found a remarkable convection pattern during the intervals from February to March and from September to October when the day/night terminator crossed the field of view (FOV) of the radar. However, the direction of the convection was opposite to that expected from the day/night terminator effect and is rather explained by the line of sight (LOS) velocity expected when the ionospheric plasma flows anti-sunward across the FOV of the radar. In addition, it was difficult to interpret the obtained results, because the place where the day/night terminator crosses the FOV of the radar corresponds to the auroral zone around the midnight. In this study, therefore, we attempt to detect the day/night terminator effect by using data from the SuperDARN radars that observe the polar cap ionosphere.

Keywords: SuperDARN radars, ionosphere, conductivity, day/night terminator, convection

PEM31-06 Room:304 Time:May 24 09:30-09:45

# Walen Separation in the ionosphere

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Global ionospheric current and convection system couples to the magnetospheric dynamics. Transmission of electromagnetic energy, momentum and current from the magnetosphere to the ionosphere for driving and maintaining the ionosoheric current system against to the Joule dissipation should be mediated via shear Alfven wave. Fundamentally, the above fact won't be changed even for quasi-static state. This means that the ionospheric current and convection system is formed as a result of incident and reflection process of shear Alfven wave at the ionosphere.

Applying the concept of Walen relation of incompressible MHD disturbances to the ionospheric current and convection system, we develop the methodology that describes the ionospheric current and convection system as a superposition of incident and reflected components of shear Alfven wave. Extracted incident component corresponds to the driving force of ionospheric current system, while reflected component corresponds to the feed back component to the magnetosphere that is excited as a result of magnetosphere ionosphere coupling process. The Walen separation also enables to extract the Cowling channel from the ionospheric current and convection system.

In this presentation we will discuss about how the Walen-separation technique can be applied to the realistic ionospheric data and show a specific result of separation analysis.

Keywords: magnetosphere-ionosphere coupling, Walen relation, Alfven wave, ionospheric current, ionospheric convection

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PEM31-07 Room:304 Time:May 24 09:45-10:00

# Ion-neutral collision frequency from EISCAT observations in the polar lower ionosphere during geomagnetic disturbances

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One of the fundamental processes in the thermosphere-ionosphere coupled system is collision between ions and neutral particles. The collisional process contributes to, for example, ion drag and Joule heating. Ion drag transfers momentum of ions to neutral particles, and may temporally modulate thermospheric dynamics, in particular, at F-region heights. The ion-drag process can also be defined as increasing flow velocity of a bulk motion of neutral gas along the mean ion velocity. Collisions also result in increases of thermal energy of both ions and neutral species. These processes are called frictional heating and Joule heating, which elevate the ion temperature first then the thermospheric temperature. The ion-neutral collision frequency is an essential parameter to represent equations related to the ion drag and frictional/Joule heating. Then the ion-neutral collision frequency was estimated using data from the European Incoherent Scatter (EISCAT) radar at Tromsoe, Norway during the Dynamics and Energetics of the Lower Thermosphere in Aurora 2 (DELTA-2) campaign in 2009. Vertical component of the ion velocity in the lower ionosphere (106-135 km) and the ion momentum equation were applied to the calculation. The calculated ion-neutral collision frequency was approximately equivalent to that predicted using modeled density data. However, notable increases were found above 126.8 km during natural ionospheric heating events. An obvious depression in calculated values was also found between 114.6 km and 126.8 km just after cessation of another heating event. This paper discusses contributions of the vertical thermospheric motion to variations of the ion-neutral collision frequency.

Keywords: Ionosphere, Thermosphere, High latitude, ion-neutral collision frequency, EISCAT radar

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PEM31-08 Room:304 Time:May 24 10:00-10:15

# The occurrence rate of THR emissions observed by the Akebono satellite

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This is a report on the occurrence rate of Terrestrial Hectometric Radiation (THR), auroral radio emissions emanating from the topside ionosphere in the MF and HF ranges. Data shown in this paper were obtained by the Plasma waves and sounder experiment (PWS) mounted on the Akebono satellite. The Akebono/PWS measurements show that THR emissions are sometimes observed in two frequency bands near 1.5-2.0 MHz and 3.0-4.0 MHz when the satellite passes over the auroral latitudes; however, their occurence rate has not yet been invesigated. Statisitical studies using the Akebono/PWS data show the spatial distribution of THR occurence; THR is detected at all magnetic local times and most often during premidnight hours (2100-2400 MLT) in a wide magnetic latitude range ($|MLAT| > 30$deg). During daytime hours (0600-1500 MLT), the distribution of its occurence is confined in higher latitude ranges ($|MLAT| > 70$deg). The explanation of this spatial distribution is that THR is favorably generated in the night-side auroral latitudes near 1000-km altitude.

Keywords: auroral phenomena, auroral radio emissions, radio propagation, auroral ionosphere

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PEM31-09 Room:304 Time:May 24 10:15-10:30

# Spatial distribution of the magnetic perturbation in the magnetosphere at the times of low-latitude round Pi 2's

IMAJO, Shun[1*], YUMOTO, Kiyohumi[2], UOZUMI, Teiji[2], KOGA, Kiyokazu[3], OBARA, Takahiro[4], KAWANO, Hideaki[1], YOSHIKAWA, Akimasa[1], ABE, Shuji[2], IKEDA, Akihiro[2], Vassilis Angelopoulos[5]

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Pi 2 magnetic pulsations are damped magnetic oscillations having periods between 40 and 150 seconds; they are observed by ground-based magnetometers and satellites at the onset times of the expansion phase of substorms.

In this study, we use magnetometer data from the ETS-VIII geosynchronous satellite (M.Lat = -7.88deg, M.Lon = 218.56deg) [Koga and Obara, 2008], the THEMIS satellites [Angelopoulos, 2008], and a MAGDAS ground station YAP (M.Lat = 1.49, M.Lon = 209.09) [Yumoto et al., 2006]. We identified 100 isolated Pi 2 pulsations in the ground H (northward) component data from YAP in the period from 1 January 2009 to 31 May 2009; in this period, the apogees of the THEMIS satellites were located in the nighttime region at $5Re < r < 30Re$ (r : geocentric distance). We statistically investigated the maximum amplitude of the compressional magnetic field component observed by THEMIS in the interval of 5 min before and after the Pi 2 onset time observed at YAP. We found that large magnetic perturbations (>10nT) were most frequently observed in the region of r = 8-10Re and LT = 22-24hr. This location is the same as that of the Pi 2 source region deduced by Uozumi et al. [2007] from ground-based observations. Taking into account the decay of the fast-mode wave with distance from a source, the above result strongy suggests that the epicenter of the Pi 2-related compressional pulse is located in the region of r = 8-10Re and LT = 22-24hr.

Keywords: Pi 2 magnetic pulsation, Pi 2 source, multi point observation, propagation

PEM31-10 Room:304 Time:May 24 10:45-11:00

# Magnetic conjugacy of northern and southern auroral beads

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Auroral beads, i.e. azimuthally arrayed small-scale bright spots resembling a pearl necklace, have recently drawn the attention of researchers as a possible precursor of explosive activation of the aurora. Here we used simultaneous, ground-based, all-sky camera observations from a geomagnetically conjugate Iceland-Syowa Station pair to demonstrate that small-scale auroral beads evolve synchronously in the northern and southern hemispheres and have good magnetic conjugacy for ˜7 min before an auroral breakup. The synchronous conjugate auroral beads undergo a two-step evolution: in the first ˜4 minutes, well-organized bead structures move eastward with an almost constant speed of 1 km/s or less, and subsequently they develop dramatically into brighter and larger auroral forms with faster propagation speed of 2-6 km/s. Our observations strongly suggest that, for the auroral beads, the magnetosphere plays a fundamental role in the determining their temporal evolution, while the ionospheric contribution that can induce asymmetric auroral behavior in the two hemispheres is minor or not significant.

Keywords: auroral beads, magnetic conjugacy, substorm

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PEM31-11 Room:304 Time:May 24 11:00-11:15

# Stability analysis of auroral arc with magnetic shear effects

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The dynamics of auroral arcs in the magnetosphere-ionosphere coupling system has been vigorously studied on the basis of magnetohydrodynamic instabilities and their nonlinear evolution. The feedback instability was proposed for a mechanism [Sato, 1978; Lysak, 1991], where destabilization of shear Alfven waves is induced through a resonant coupling with density waves propagating in the ionospheric convection electric field. Recently, two-dimensional simulations (along a field line and crossing arcs) with dipole magnetic fields demonstrated formation of small-scale arcs and ionospheric cavity modes [Streltsov and Lotko, 2004; Lu et al., 2008]. Treating nonlinear terms appropriately, a three-dimensional simulation in slab geometry showed that Kelvin-Helmholtz type vortex structures are spontaneously excited in the magnetosphere [Watanabe, 2010]. A linear analysis with non-uniformity of the Alfven velocity clarified growth properties of the field-line resonances and cavity modes [Hiraki and Watanabe, 2011]. Furthermore, their relationship to the occurrence of auroral vortices has been investigated with nonlinear simulations.

In this study, we revisit linear stability of auroral arcs and shear Alfven waves. Recent imaging observations revealed that, before substorm onset, arcs appear at high latitudes, propagate slowly, and suddenly destabilize to breakup at a low latitude region [Mende et al., 2009]. We examine this fact to be understood as a switching phenomenon where stability of arcs changes through changes of its direction relative to the convection electric field. Global two-cell convection fields at midnight point to the east-west direction, whereas strong north-south components are locally formed by the Harang discontinuities at low latitudes [e.g., Zou et al., 2009]. From analyses of feedback instability, it is found that the growth rates are mainly controlled by the amplitude of convection fields and are at the maximum for modes with wave numbers parallel to the ionospheric currents. However, we can analytically suggest that magnetic shear produced by the field-aligned current of arcs has a stabilizing effect on modes perpendicular to the shear; it can produce a strong directivity for growing modes. In this talk, we introduce results of this stability analysis with arc-induced magnetic shears as well as the dependences on convection field and conductivity.

Keywords: auroral arc, feedback instability, magnetic shear

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PEM31-12 Room:304 Time:May 24 11:15-11:30

# Crater red aurora in the cusp

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A new high-resolution all-sky imager (Longyearbyen, Svalbard) detected the formation of ”crater red aurora” in the cusp and the immediate ejection of the narrow auroral form from the crater during an interval of southward IMF on 29 December 2011. The crater red aurora can be defined as a circular-shaped region in which 630-nm dayside auroral emissions weaken. The emission data obtained continuously with an exposure time of 4 s show that the circular shape whose diameter was approximately 150 km at F region heights was formed for 2 min after the initial weakening at a smaller region. Immediately after the circular-shape was formed, a latitudinally-narrow (˜40 km) auroral form was ejected from the inside wall of the crater in the azimuthal direction. The speed of the leading edge is estimated to be approximately 1.5 km/s. These observations strongly suggest that the crater red aurora is the ionospheric signature of a crater flux transfer event, which has been studied recently with data from spacecraft near the dayside magnetopause. Considering that the scale of a crater flux transfer event reflects the size of a flux transfer event itself, the present observation shows that the ionospheric signature of a flux transfer event is much larger than the ejected narrow auroral form. Such an auroral form, which has been regarded as a so-called poleward moving auroral form, would represent the structure inside a flux transfer event, not the whole structure of a flux transfer event.

Keywords: red aurora, F region, cusp, plasma flow

PEM31-13 Room:304 Time:May 24 11:30-11:45

# Simultaneous observation of polar cap patches with all-sky imager and EISCAT radars

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The airglow intensity of polar cap patches is related to the local electron density profile of the polar cap ionosphere as well as the profiles of neutral gases that contribute to optical emission. Concurrent operation of an all-sky imager and incoherent scatter radars enables simultaneous observations of optical intensity of polar cap airglow and ionosphere parameters. An all-sky airglow imager equipped with a high sensitivity EMCCD detector has been deployed in Longyearbyen, Svalbard (78.1 N, 16.0 E) since October 2011. The imager's fine time and 2D resolution and its proximity to the EISCAT Svalbard radar (ESR) provide opportunities to study the relationship between the optical intensity and electron density of polar cap patches. By virtue of the spatial resolution of approximately 2 km per pixel, it is possible to identify a fine structure of the electron density in the region where the ESR beam crosses at a particular altitude. A 4-second exposure time of the imager combined with its high spatial resolution allows us to detect rapid changes in patch structures which have not been possible to identify with radar-alone observations.

In this study we analyze a storm time polar cap patch event combining the data obtained by the all-sky imager and two radars, the ESR and mainland EISCAT UHF radar. An interval between 17 UT and 24 UT on 22 January 2012 is studied. The variations of optical intensity and electron density show a good agreement, which enables us to cross-calibrate the two parameters. Cross examination of optical intensity and electron density reveals steep gradients and sharp edges of patch structures as narrow as a few kilometers. Temporal variations obtained from the two EISCAT radars suggest that some patches were transported antisunward from the polar cap to lower latitudes, which is in good agreement with the all-sky imager observation. These facts suggest that electron density structures may travel across the polar cap from the cusp region to the night side auroral zone keeping their sharp density gradients.

Keywords: polar cap patches, high-latitude ionosphere, EISCAT, all-sky imager, ionospheric electron density structures, airglow

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PEM31-14 Room:304 Time:May 24 11:45-12:00

# A coordinate analysis of dayside diffuse aurora: GEOTAIL, FAST, and South Pole auroral observations

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It has been thought that the source of diffuse auroral emissions is scattered plasma sheet electrons into the loss cone by some wave-particle interactions. Both ECH waves and whistler-mode chorus have been thought to be the contributors to the production of diffuse auroral electrons since they can resonate with plasma sheet electrons. A question which wave mode dominantly contributes to the production of diffuse auroral electrons has been discussed for more than four decades and there is still controversy. A recent study done by Thorne et al. [2010] reveals that whistler-mode chorus is dominantly responsible for the production of diffuse auroral electrons. While, there are some observational suggestions that ECH waves cause diffuse auroral electron precipitations. [e.g., Nishimura et al., 2010; Liang et al., 2010]. Multi-point observations along a field line using low altitude satellites and spacecraft around the magnetic equator are important to investigate the contributor to the generation of diffuse aurora since the properties of diffuse auroral electrons depend on the wave mode that causes electron pitch angle scattering.

This study shows a coordinate analysis of dayside diffuse auroras using the data obtained from a reliable ground-spacecraft conjunction event. During the event, diffuse auroras were observed by the South Pole all sky imager. At that time, GEOTAIL located in the dayside magnetosphere at a radial distance of ˜ 10Re, at 1000 MLT and its ionospheric footprint was inside the diffuse aurora. Furthermore, the FAST spacecraft passed over the footprint of GEOTAIL. The FAST observations showed the precipitating electrons in the energy range of 0.1 to 10 keV and the pitch angle distributions revealed that electron scattering rates reached strong diffusion limit in the energy range of 0.1 to 5 keV. PWI/SFA onboard GEOTAIL observed both whistler-mode waves and ECH waves around the conjunction event. More likely wave mode contributing to the electron precipitations was investigated by estimating resonant energies for whistler-mode waves and ECH waves, respectively. Based on the observed frequency distributions, minimum resonant energy for whistler-mode waves were too high to scatter the electrons in the energy range below 10 keV, while ECH waves can resonate with the electrons in the energy range of 0.1 to 10 keV. This result suggests that generation mechanism of diffuse aurora in this event was pitch angle scattering driven by ECH waves rather than whistler-mode waves.

Keywords: Diffuse aurora, wave-particle interaction, whistler-mode waves, ECH waves

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PEM31-15 Room:304 Time:May 24 12:00-12:15

# Two satellite observations of precipitating electrons associated with auroral breakup

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We compare auroral electrons several minutes before and after an auroral breakup. The electrons were observed by the FAST and DMSP satellites near the breakup location. The breakup was identified in global images taken by the Polar satellite at 1957:50 UT on 10 November 1999. FAST passed the breakup location 6 min before the breakup and observed diffuse electrons with energy around 10 keV. The diffuse electrons were accompanied by broadband electrons below 1 keV, which are supposed to be associated with Alfven waves. Seven min after the breakup, a DMSP satellite crossed the onset arc. DMSP observed inverted-V type electrons at the surge horn, which was 15 deg west of the initial breakup location. In summary, the onset arc corresponded to diffuse electrons with broadband elections before breakup, and to inverted-V electrons after breakup. It is thus suggested that the evolution of diffuse electrons to inverted-V electrons is associated with waves.

Keywords: aurora, auroral breakup, substorm, field-aligned current