Japan Geoscience Union Meeting 2014
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PEM37-01 会場:414 時間:4 月 30 日 11:00-11:15

Pc5 が関与した脈動オーロラの変調
A coherent modulation of pulsating aurora at Pc5 frequency

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Ground and satellite magnetometer observations and all-sky video images revealed that the Pc5 pulsations that occurred in 17 January 1994 showed a wide distribution in longitude from Alaska, USA (0 MLT) to the Hudson bay, Canada (11 MLT) and in latitudes from 62N (L=4.5) to 70N (L=8.5).

Auroras in all-sky image were composed of field line resonance (FLR) in higher latitudes in 67-70N and pulsating aurora (PsA) in lower latitudes in 62-67N.
It is found that the PsA, FLR, and field magnitude at the geosynchronous altitudes were all oscillated coherently at Pc5 periodicities.

We conclude that the coherent modulation of FLR and PsA are attributable to toroidally and poloidally polarized Pc5 pulsations, respectively, generated by the polarization splitting of the Alfven spectrum by the finite plasma pressures.(1), (2).

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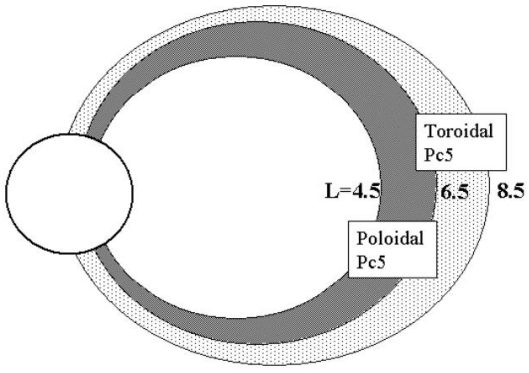
キーワード: Pc5 脈動, 脈動オーロラ, ポロイダルモード
Keywords: Pc5 pulsations, pulsating aurora, poloidal mode



Japan Geoscience Union Meeting 2014
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PEM37-02 会場:414 時間:4 月 30 日 11:15-11:30

脈動オーロラの発生条件：低温電子と電場の役割
Generation of pulsating aurora: Role of cold electron and electric field

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脈動オーロラはオーロラサブストームの回復期に必ず出現する普遍的な現象である。この脈動オーロラの基本的特性である 10 秒前後の準周期的変調、パッチ状やバンド状などの形状、定在型や伝播などの動き、などの発生機構は未だに解明されていない。これらの特性を解明する上で、衛星-地上同時観測は重要である。これまでの THEMIS 衛星と地上全天カメラ網で同時に観測された脈動オーロラの粒子・電磁場・波動などの特性比較から、次の事が明らかになってきた。
1) 全ての脈動オーロライベントは 5 keV 以上の高エネルギー電子フラックスが増加する時に起こっている、2) 20eV 以下の低温電子フラックスと電場の準周期的変動が脈動オーロラの準周期的な変調に対応している、3）これらの低温電子フラックスと電場の準周期的変動が低周波電磁コーラス波動（lower-band electromagnetic chorus wave）と静電的な電子サイクロトロンハーモニック波動 (electrostatic Electron Cyclotron Harmonic wave: ECH wave) の準周期的な変動と一対一の良い対応を示す場合がある、 4) 全ての脈動オーロラがコーラス波動や ECH 波動の出現に対応しているわけではない。
本講演では、強い脈動オーロラが起こっている領域と起こっていない領域の境界が極めてはっきりした現象の領域を THEMIS 衛星が通過したイベントに注目した。これら領域内外でどのような特性の変化を THEMIS 衛星が観測したかを調べた。その結果、強い脈動オーロラが発生している領域内では数 mV/m の強い静電場が存在し、それが 20 秒前後の周期で変調していた。300Hz 以下の低周波数 ULF-ELF 帯静電波動も観測され、その強度変調が静電場の準周期的変調と良い一致を示した。さらに、20eV 以下の低温電子フラックスも同様な準周期的変調を示していた。なお、ULF-ELF 帯波動の磁場成分は極めて弱く、かつ、lower-band コーラス波動も観測されなかった。そして、衛星が脈動オーロラ領域から抜けて出て暗い領域に入ると、それまで活発であった静電場、ULF-ELF 帯の静電波動、低温電子フラックス、などの準周期的変調はピタリ止まった。興味深いことに、10keV 以上の高エネルギー電子フラックスは脈動オーロラが起こっていない領域に入ってもその量は減少していなかった。一方、顕著な低温電子フラックス量の減少と電子温度の上昇が観測された。このイベント例から、低温電子フラックスや電場などが脈動オーロラの発生にどのように寄与しているかを考察する。

キーワード: オーロラ, 脈度オーロラ, コーラス波動, 磁気圏, 電離圏, 極域
Keywords: aurora, pulsating aurora, chorus wave, magnetosphere, ionosphere, polar region

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PEM37-03 会場:414 時間:4 月 30 日 11:30-11:45

カナダ・アサバスカで同時に観測されたVLF/ELF波動とパルセィティングオーロラの高時間分解能相関解析
High-resolution correlation analysis between VLF/ELF chorus waves and pulsating aurora observed at Athabasca, Canada

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私たちは、カナダ・アサバスカ観測点（磁気緯度 61.2 度、L=4.4）で、ループアンテナを用いて 100kHz サンプルの VLF/ELF 波動観測を 2012 年 9 月 25 日から行っている。2013 年 10 月からの冬期には狭視野の EMCCD カメラを設置して同時定常観測を行い、オーロラと VLF/ELF 波動の関係を調べている。本研究では、2013 年 2 月 7 日に観測されたパルセーティングオーロラとコーラス波動の間に見られた相関関係について調べた。このパルセーティングオーロラの強度変化と 1.5-2.5 kHz のコーラス波動の強度変化のパワースペクトルを比較し、両者は 0.1-0.15 Hz の同じ脈動周期があることが分かった。これらの間の相互相関解析から、オーロラ粒子とコーラス波動の磁気圏赤道面から地上までの到達時間差を見積もった結果、2 つのパターンの時間差が数十秒スケールで切り替わっていることを見出した。1 つ目のパターンは、波動よりも電子の方が 2 秒遅く電離圏に到達していることを示しており、これは南向きに伝搬した電子が南側半球で反射した場合の理論値と一致する。2 つ目のパターンは、波動よりも電子の方が 4.5 秒早く電離圏に到達していることを示しており、これは南向きに伝搬した波動が南側半球で反射した場合の理論値と一致する。これらの結果は、高エネルギー電子とコーラス波動の相互作用が数十秒スケールで切り替わっていたことを初めて示すものである。

キーワード: パルセィティングオーロラ, コーラス波動, 波動粒子相互作用, 地上観測
Keywords: pulsating aurora, chorus waves, Wave-particle interactions, ground-based observation

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PEM37-04 会場:414 時間:4 月 30 日 11:45-12:00

ディフューズオーロラに伴う相対論的電子降り込み
Relativistic electron precipitations in association with diffuse aurora

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It has been widely thought that diffuse auroras are generated by electron precipitations in the energy range from a few keV to tens keV. Recent simulation results based on the quasi-linear theory showed that the scattering by whistler-mode waves plays an important role in the production of precipitating electrons responsible for diffuse auroras. A test particle simulation on electron-whistler interactions shows that relativistic electrons can be scattered into the loss cone simultaneously with the electrons in the energy range from a few keV to tens keV. Thus, it is expected that relativistic electrons precipitate into the atmosphere in association with diffuse auroras if whistler-mode waves contribute to generation of diffuse auroras. To examine this hypothesis, we investigated conjugate observations of SAMPEX and the all sky camera at Syowa Station on the dawn side, where diffuse auroras are frequently observed. In this study, we show a case study that relativistic electron (>1 MeV) precipitations observed by SAMPEX are associated with the diffuse aurora observed at Syowa Station. The SAMPEX observation shows that the enhancement of precipitating relativistic electrons are well correlated with that of precipitating >150 keV electrons, indicating that electrons in the energy range from a few keV to 1 MeV precipitate into the atmosphere simultaneously. It is observational evidence that whistler mode waves contribute to generation of diffuse auroras.

キーワード: ディフューズオーロラ, ホイッスラーモード波動, 波動粒子相互作用, 相対論的電子, 放射線帯
Keywords: diffuse aurora, whistler mode wave, relativistic electron, radiation belts, wave-particle interaction

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PEM37-05 会場:414 時間:4 月 30 日 12:00-12:15

プラズマ圏の生成
Refilling of Plasmasphere

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Satellite observations have revealed that ions are heated in the ionospheric polar region and are flowing to the magnetosphere. The fluxes of H+, He+, and O+ are ˜1011 ions m-2 s-1, ˜1011 ions m-2 s-1, ˜1010 ions m-2 s-1, ˜1010 ions m-2 s-1 during the solar maximum and ˜1010 ions m-2 s-1, ˜109 ions m-2 s-1, ˜109 ions m-2 s-1 near the solar minimum condition, respectively. The large amount of ions, including heavy ions such as O+, contributes the refilling of plasmasphere and inner magnetosphere. The ions are formed often as conics / transversely accelerated ion in the topside polar ionosphere. To understand the refilling process, the refilling time scale and the effects to the structure and dynamics of plasmasphere and inner magnetosphere, we have developed a three dimensional model of Atmosphere ? Plasmasphere including Electrodynamics (APE model). The model calculates densities, velocities and temperatures for electron, O2+, N2+, NO+, O+, He+ and H+ at altitudes from 90 km to 10 Re and for N2, O2, O, He and H in the thermosphere, and electric fields in the ionosphere, plasmasphere and inner magnetosphere. We calculate also parallel and perpendicular components of ion and electron temperatures to include the effect of perpendicular heating of ion in the polar ionosphere. The results show clearly the importance of ion heating in the polar region for the structure of plasmasphere, the refilling and the response to the magnetic disturbance.

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PEM37-06 会場:414 時間:4 月 30 日 12:15-12:30

あけぼので観測された M/Q=2 イオンサイクロトロンホイスラの解析
M/Q=2 Ion Cyclotron Whistlers Observed by Akebono

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雷放電ホイスラは地上付近で発生する雷放電に伴って励起される VLF 波動であり，電離層を突き抜けて地球磁気圏内を伝搬するものがあけぼの衛星などの観測によって報告されている．多くの衛星観測による結果から，雷放電ホイスラは数十 kHz 以下のホイスラモード (右回り偏波) の波動であることが知られている．一方で，複数のイオンが存在するプラズマ中では，H^+ のサイクロトロン周波数以下でイオンモード (左回り偏波) のプラズマ波動が伝搬可能である．雷放電ホイスラの低周波成分は，ときに H^+ のサイクロトロン周波数をも下回って伝搬するが，その際にイオンモードのクロスオーバー周波数付近で波動の一部がモード遷移を伴い，左回り偏波のイオンサイクロトロンホイスラが励起されることがある [1]．イオンモードのクロスオーバー周波数は，プラズマ中のイオン組成によって変動することが知られており，イオンサイクロトロンホイスラの伝搬の様子を解析することで，伝搬経路上のイオン組成を推定することが可能であると考えられる．

Watanabe et al.[2] は ISIS-2 による観測から，高度 1,360 km 付近にM/Q=2 イオンの存在を示唆するイオンサイクロトロンホイスラを発見した．彼らはそのイオンを，電離層から供給された D^+ と推測し，deuteron whistler と名付けた．

本研究では，あけぼの衛星の VLF 波動観測装置によって観測された ELF 帯の電磁界波形を詳細解析し，観測史上最も高い，高度 4,500km 付近で観測された”M/Q=2 イオンサイクロトロンホイスラ”を報告する．これらは観測点付近に He^{++} や D^+ といったM/Q=2 イオンが存在することで，H^+ モードと He^+ モードの二つのイオンモードの間に，新たに M/Q=2 イオンモードが生じたことを示唆するものである．

ELF/VLF 帯のプラズマ波動とプラズマ粒子との相互作用の解明は，2015 年冬に打ち上げが予定されている次期地球内部磁気圏観測衛星 ERG[3] でもサイエンス目標に掲げられており，近年非常に注目されている．また，プラズマ圏内のイオン組成を知ることは，ray tracing などの高度なシミュレーションを行うための事前情報としても非常に重要である．本講演では，M/Q=2 イオンサイクロトロンホイスラを含む多くの観測例から，あけぼの衛星の軌道がカバーする広域のイオン組成比を導く取り組みについても紹介する．

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キーワード: イオンサイクロトロンホイスラ, M/Q=2 イオン, EMIC 波動, あけぼの衛星
Keywords: ion cyclotron whistler, M/Q=2 ion, EMIC wave, Akebono satellite

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PEM37-07 会場:414 時間:4 月 30 日 12:30-12:45

THEMIS 衛星で観測された EMIC トリガード放射におけるサブパケット構造
Sub-packet structures in the EMIC triggered emission observed by the THEMIS probes

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We analyse Electromagnetic Ion Cyclotron (EMIC) triggered emission by the data from the THEMIS probes. These phenomena have recently received much attention because of the possibility of their strong interaction with energetic particles in the inner magnetosphere in spite of their scarceness in observations[1,2,3]. For 1400-1445 UT on 9 September 2010, THEMIS A, D and E observed strong EMIC waves with rising tone emissions. The probes were located near the dayside magnetopause at 8 R_E of the radial distance from the Earth, 13 MLT, and a few degrees of the geomagnetic latitude. During this time interval, the geomagnetic field was very distorted by the variation in the solar wind. We assume these emissions were excited around minimum-B pockets in accordance with the magnetospheric compression. It is found the rising tone emissions comprise of some smaller rising tones, which are called ”sub-packet structures”[4]. We compare these observed sub-packet structures with the nonlinear wave growth theory developed by Omura et al. [5]. The observed relationship between the amplitudes and frequencies of the emissions are well explained by the theory, and it is also found that the threshold and optimum amplitudes for the nonlinear growth agree well with the observed dynamic spectra.

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PEM37-08 会場:414 時間:4 月 30 日 14:15-14:30

Statistical analysis of ionospheric Pi2 pulsations observed at mid and low latitude by the SuperDARN Hokkaido radar

Statistical analysis of ionospheric Pi2 pulsations observed at mid and low latitude by the SuperDARN Hokkaido radar

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Ultra-low-frequency waves with the periods of 40-150 s are categorized as Pi2 pulsations, which occur over a wide rage of latitude in the night side at substorm onsets. To identify the generation mechanism of Pi2 pulsations, a number of studies using different devices such as ground-based magnetometers and satellites have been carried out. These study provide spatial properties of Pi2 pulsations on the ground and in the inner magnetosphere and suggested that high- and mid-latitude Pi2 pulsations are associated with Alfven waves in the auroral region, while the cavity mode resonance established in the plasmasphere by the fast mode waves has been proposed as a possible Pi2 source at mid and low latitudes.

The interaction of Pi2 pulsations with the ionosphere creates current systems that modify the amplitude and spatial scale size of the waves. In order to construct a coherent view of Pi2 signals measured by ground-based magnetometers, radars and satellites, the effect of the ionosphere needs to be understood.

In present study, statistical studies of Pi2 pulsations in the ionosphere were performed with the SuperDARN Hokkaido radar at Rikubetsu (AACGM magnetic coordinates: 36.5○, 214.7○). The radar can observe the Doppler velocity of ionospheric plasma due to the electric field of Pi2 pulsations in the mid- and low-latitude ionosphere. We investigated the spatial characteristics of the similarity, amplitude ratio, and cross phase between Pi2 pulsations observed by the radar and a ground magnetometer Memanbetsu (MMB) which is located close to the radar site. We will present the results and discuss the interaction of Pi2 pulsations with the ionosphere.

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サブストーム発生時における磁気圏近尾部Ｐｉ型磁気波動
Pi pulsations in the near-earth magnetotail at substorm onset

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The THEMIS satellite observations showed that Pi 1 and Pi 2 period range oscillations of the magnetic and electric fields play an important role at a substorm onset in the near-Earth magnetotail. They associated energetic particle accelerations toward the inner magnetosphere. The energetic particle accelerations were observed with very similar oscillation signatures to the Pi 1 and Pi 2 period range oscillations observed in the magnetic and electric fields.. This observation suggests that the Pi 1 and Pi 2 period range oscillations might play an important role for contribution to the auroral particle accelerations at substorm onset in the near-Earth magnetotail . The examination has been done on a substorm event observed on 28 February, 2009 at a THEMIS GBO station, Kuujjuaq (KUUJ) (Mag. Lat.=66.89 N, Mag. Lon.=13.23 E, Mag. Midnight =4.15 UT, L-value = 6.4) in the west coast at the high latitude of the North America Continent. This substorm event was simultaneously observed in the near-Earth magnetotail by the three THEMIS satellites, THEMIS-A, -E, and ?D located in the midnight region at ˜8 Re, ˜8 Re and ˜11 Re, respectively. The data examined in this study are the magnetic field, all-sky images (ASI) and keograms (ASK) obtained at KUUJ and the satellite observations of the magnetic field, electric field, and the electron and ion energy spectra in the ESA peir, and peer data. The results show very interesting facts of the Pi 1 and Pi 2 period range oscillations in the magnetic field and auroral activities observed on the ground and their conjunctions of the magnetic, electric fields, and the associated accelerated particles in the near-Earth magnetotail. The implication of this work provides the importance of the Pi 1 and Pi 2 period range oscillations for controlling the substorm onset plasma processes in the near-Earth magnetotail.

キーワード: 磁気圏物理, サブストーム, Ｐｉ型波動
Keywords: Magnetospheric Physics, Substorm, Pi pulsations

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PEM37-10 会場:414 時間:4 月 30 日 14:45-15:00

サブストームオンセット過程
Substorm onset process: Ignition of auroral acceleration and related substorm phases

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The substorm onset process was studied on the basis of the vertical evolution of auroral acceleration regions derived from auroral kilometric radiation (AKR) spectra and Pi pulsations on the ground. The field-aligned auroral acceleration at substorm onset demonstrated two distinct phases. Low-altitude acceleration (h~3000-5000 km), which accompanied auroral initial brightening, pre-breakup Pi2, and direct current of ultra-low frequency (DC-ULF) pulsation, was first activated and played an important role (pre-condition) in the subsequent substorm expansion-phase onset. Pre-breakup Pi 2 is suggestive of the ballooning-mode wave generation, and negative decrease in DC-ULF suggests increasing field-aligned current (FAC). We called this stage the substorm initial phase. A few minutes after this initial phase onset, high-altitude acceleration, which accompanied auroral breakup and poleward expansion with breakup Pi 1 and Pi 2 pulsations, suddenly broke out in an altitude range from 8000-16000 km. Thus, substorm expansion onset originated in the magnetosphere-ionosphere (M-I) coupling region, i.e., substorm ignition in the M-I coupling region. It is suggested that current disruption and subsequent violent energy release from the tail region take place after this ignition. Statistical investigations revealed that about 65% of earthward flow bursts observed in the plasma sheet were accompanied by enhanced low-altitude AKR, suggesting that flow braking of bursts causes FAC and resulting low-altitude field-aligned acceleration in the M-I coupling region. On the basis of these observations, we propose a substorm onset scenario in which FAC that originated from the braking of plasma flow bursts first enhances low-altitude acceleration (substorm initial phase onset), and then the increasing FAC induces current-driven instability in the M-I coupling region, which leads to high-altitude acceleration and resulting substorm expansion-phase onset.

キーワード: サブストーム, オーロラ, 加速域, サブストーム開始
Keywords: substorm, aurora, acceleration region, substorm onset

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PEM37-11 会場:414 時間:4 月 30 日 15:00-15:15

磁気圏対流駆動機構-バルクフローの役割
drivers of the magnetospheric convection

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We present here the role of the plasma bulk flow in generation of the magnetosphere-ionosphere convection. Traditionally, the magnetospheric convection is studied with the perpendicular flow because this flow is equivalent with the speed of migration of the magnetic field. For example, the perpendicular force balance equations are utilized in discussion of the dynamo generation ($E*J<0$) in the cusp-mantle region [Tanaka, 1995]. However, since the plasma kinetic energy flux and the internal energy flux are transported along the plasma bulk flow, it is evident that the plasma bulk flow should be considered in generation of the magnetospheric convection. In
addition, the global MHD simulation reveals that the plasmas are accelerated into the cusp from the magnetosheath along the magnetic field. Thus, the plasma bulk flow transports energy into the magnetosphere.

At first, we discuss the dynamo in the cusp-mantle region based on the full set of physical principles (mass conservation, momentum conservation, and energy conservation). As a result, the load in the lower-latitude side of the cusp is invoked by plasma compression due to sudden deceleration of the field-aligned flow from the magnetosheath. The adiabatic assumption invokes pressure enhancement associated with plasma compression. Thus, energy should be supplied to compensate increase in the plasma pressure. As the kinetic energy is much smaller than the electromagnetic energy in the magnetosphere, the electromagnetic energy is converted to the thermal energy. Therefore, the load appears in the lower-latitude side of the cusp. On the other hand, in the cusp-mantle region, plasmas are squeezed with the field-aligned flow toward the lobe region. This yields plasma rarefaction, which eventually invokes energy conversion from the thermal energy to the electromagnetic energy. Thus, the dynamo appears. This process is also explained in terms of the slow mode expansion fan in the cusp-mantle region.

Next, we define an unique magnetospheric energy convection in the dayside magnetosphere. It is noted that the Poynting flux activated in the cusp-mantle region is transported across the dayside magnetosphere to the dayside magnetopause. The electromagnetic energy is totally deposited here. The deposited electromagnetic energy is converted into the thermal energy in the magnetopause. Then we need a mechanism of transporting this thermal energy elsewhere. The MHD simulation shows the thermal energy and the high-speed solar-wind kinetic energy are transported into the cusp from the magnetosheath. This flow goes to the mantle region. Then, the thermal energy transported from the magnetosheath via the cusp is partially converted into the electromagnetic energy in the cusp-mantle region. Finally, the loop of energy convection is completed.

The magnetospheric energy convection is unique because the energy convection and the mass convection show quite different behavior. On the other hand, in the normal fluid like the atmosphere, the energy convection is related to the mass convection in the atmospheric global circulation (convection).

キーワード: 磁気圏対流, MHD シミュレーション, バルクフロー, エネルギー変換, 磁気圏エネルギー対流, カスプダイナモ
Keywords: magnetospheric convection, MHD simulation, bulk flow, energy conversion, magnetospheric energy convection, cusp dynamo

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PEM37-12 会場:414 時間:4 月 30 日 15:15-15:30

THEMIS 観測と MHD シミュレーションを用いた近地球プラズマシートにおけるプラズマ圧力の急激な増加に関する研究
Sudden pressure enhancement and tailward retreat in the near-Earth plasma sheet: THEMIS observation and MHD simulation

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Plasma pressure enhancement is one of the drastic substorm-associated phenomena in the inner magnetosphere. In a substorm occurred on 1 March 2008, four of THEMIS (Time History of Events and Macroscale Interactions during Substorms) probes were almost aligned along the sun-Earth line, which was suitable for investigating spatial-temporal evolution of the near-Earth plasma sheet in a substorm. They observed a sudden increase in the plasma pressure at the inner probe (at ∼7.2 Re), followed by the outer probes (at ∼7.5, ∼8.3, and ∼10.4 Re), that is the high pressure region propagates tailward. Hereinafter, we call this sudden pressure enhancement (SPE). We compared the observations with simulation results of a global magnetohydrodynamics (MHD) simulation, and found a fairly good agreement between them in terms of the followings. (1) Tailward propagation of the SPE can be seen only at off-equator after the substorm onset. In the equatorial plane, an earthward propagation of the SPE precedes the tailward propagation. (2) Observations from the three inner probes show that the SPE consists of two enhancements. The first one is attributed to the convergence of bulk flow energy flux, namely flow braking. The latter one is due to the convergence of the thermal energy flux and subsequent inflation of the plasma sheet. (3) Plasma flow turned from the tailward-and-toward-the-equatorial-plane to earthward-and-away-from-the-equatorial plane near the onset from the simulation results. We discuss the spatial-temporal evolution of the plasma flow and the magnetic field during the substorm.

キーワード: サブストーム, THEMIS 衛星観測, グローバル MHD シミュレーション, プラズマ圧力の急激な増加
Keywords: substorm, THEMIS observation, Global MHD simulation, Sudden pressure enhancement

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PEM37-13 会場:414 時間:4 月 30 日 15:30-15:45

強い北向き IMF 時, 変化する IMF By によって発生するシータオーロラ
Evolution of theta aurora during strong positive IMF Bz and varying IMF By condition

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Formation of the theta aurora, which appears under the condition of northward IMF and greater IMF magnitude, is investigated from the analysis of the numerical MHD simulation. The theta aurora is caused by the transient convection after a sign change of IMF By. This transient convection must include a replacement of lobe field lines from old IMF orienting fields, a rotation of plasma sheet to opposite inclination, and a reformation of ionospheric convection cells. In the midst of these reconfigurations, old and new convection system must coexist in the magnetosphere-ionosphere system. In this stage, the polar cap and tail lobes are continuously encroached by the new open field lines connected to the new IMF. Whereas magnetic field lines accumulated in new lobes tend to rotate the outer plasma sheet in the opposite direction, the old merging cell convection still continues to generate closed field lines that must return to dayside against the new lobe formation. As time progresses, the growth of new lobes results in the blocking of the return path toward dayside of closed field lines generated in the old merging cell to form the kink structure in the plasma sheet. Losing their return path, these closed field lines generated from old lobes accumulated on the night side. The theta aurora appears at the foot point of these accumulated closed field lines. In the presentation, we will demonstrate some observational results brought by satellites and ground based instruments, which support above mentioned hypothesis for theta aurora foramation.

キーワード: 惑星間空間磁場, 北向き IMF, 変動する IMF By, シータオーロラ, シミュレーション, 観測
Keywords: IMF, Strong northward IMF, Varying IMF By, Theta aurora, Simulation, Observation

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PEM37-14 会場:414 時間:4 月 30 日 15:45-16:00

Substorm Onset: Correlation between Ground and Space Observations

Substorm Onset: Correlation between Ground and Space Observations

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The observations of substorm onset phenomena in the magnetosphere and ionosphere are examined to study their correlation and to understand the substorm onset mechanism. In particular, we examine the Pi2 wave structure, propagation, frequency and growth rate in the magnetosphere observed by the THEMIS satellites in the near-Earth plasma sheet and the structure and propagation of the substorm auroral onset arcs. We show the correlation between the substorm onset wave-like arcs and the Pi2 pulsations in terms of wave structure, propagation, and the exponential growth of arc intensity and Pi2 wave amplitude. In particular, the azimuthal mode numbers of the Pi2 waves and the wave-like arc structure are estimated to be ˜100-200. The correlation between the ground and space phenomena strongly supports the kinetic ballooning instability (KBI) as the cause of substorms. KBI is the most natural mechanism for explaining the unstable Pi2 waves in the strong cross-tail current region and the KBI parallel electric field can accelerate electrons along the magnetic field lines into the ionosphere to produce the substorm onset wave-like arcs.

キーワード: substorm, magnetospheric dynamics, THEMIS observation
Keywords: substorm, magnetospheric dynamics, THEMIS observation

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PEM37-15 会場:414 時間:4 月 30 日 16:15-16:30

THEMIS 観測データに基づくサブストームトリガー機構の解明
Investigation of substorm triggering mechanism based on THEMIS data

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本研究では、THEMIS 衛星の 2007 年 11 月から 2009 年 4 月の期間のデータに対して、THEMIS/ASI の地上オーロラ観測から（UCLA 西村幸敏博士が）求めたサブストームオンセットの発生時刻を時間原点として行った時間重畳法解析の結果を報告する。今回は、オーロラブレークアップの前後それぞれ 100 秒の限られた範囲に時間を限定して、サブストームに伴う-7.5 >X(Re) >-23 の範囲の磁気圏尾部の変化を詳細に調べた。本解析によって、オンセットの 60 秒前に X ~-14 Re で地球向きのプラズマ流が発生し、それが地球向きに移動して t = 0 で磁場双極子化が X = -10 Re 付近で開始し、それと同時に、X = -20Re 付近で磁気リコネクションが開始することを確認した。この変動は、われわれの提唱している Catapult Current Sheet Relaxation model の妥当性を裏付けている。

興味深いことに、朝夕向きのプラズマ流速の絶対値 |Vy| が-20 <t(sec) <20 の時間帯に、プラズマシートおよびプラズマシート境界層で減少する傾向が見られた。今回この現象について個々のイベントを調べたとろ、オンセットを挟んで主として夕方向き（Vy >0）であったコンベクションに伴う流れが、朝方向きの流れ（Vy <0）に変化する際に、短時間その値をゼロとすることに対応していることが判明した。これらは、地球向きの流れが、地球の双極子磁場の影響で偏向あるいは反射されることに関係しており、よく知られているオンセット以降に X = -10 Re の近傍において尾部向きのプラズマ流が生成されることと同一の原因をもつ現象であることがわかった。

キーワード: サブストーム, 磁気圏尾部, 磁気リコネクション, 磁場双極子化, テミス衛星
Keywords: substorm, magnetotail, magnetic reconnection, dipolarization, THEMIS probes

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PEM37-16 会場:414 時間:4 月 30 日 16:30-16:45

磁気圏のグローバル MHD シミュレーションと 3 次元可視化
Global MHD simulations of magnetosphere and 3-dimensional visualization

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最近の IT 技術の進歩から、高精度のグローバル MHD シミュレーションと大規模データ解析を行うことが可能になった。特に VRML(Virtual Reality Modeling Language) を用いたボリュームレンダリング法で、空間微分量を用いてシミュレーションの 3 次元可視化を行い磁気圏ダイナミクスを新しい視点から再構築できる様になった。MHD 方程式の基礎物理量に於いて、ベクトル量の回転と発散をとり、磁力線に対して平行成分と垂直成分に分解する。それらの各基礎物理量を 3 次元可視化し、地球磁気圏のどの領域で値が大きいのか、なぜ大きいのか、MHD モードの分離とその寄与は何かを具体的に明らかにすることができた。

MHD 方程式の基礎物理量の空間微分量に注目して平行渦度が平行電流を生成することを確認し、垂直渦度と圧縮性が垂直電流を生成していること、及び、垂直電流と圧縮性と垂直電流の比によって FMS(Fast magnetosonic mode) と SMS(Slow magnetosonic mode) が分離できることを新たに導き出した。空間微分量を 3 次元可視化・解析することで、電流生成に支配的な物理量とその領域を特定した。地球遠方のプラズマシートに流れる電流生成源は垂直渦度であり、その他の領域の電流生成源は垂直渦度 と圧縮性の双方である。また、FMS と SMS のモード分離に成功し、その寄与を明らかにした。地球近傍のプラズマシート内では FMS が支配的であり、地球から離れるにつれて SMS が支配的となってゆく。リコネクション領域では特に FMS が顕著に励起されている。

キーワード: MHD シミュレーション, 電流生成機構, 渦度と圧縮性, MHD モードの役割, 磁気リコネクション, 磁気圏ダイナミックス
Keywords: global MHD simulation, current generation mechanism, vorticity and compressibility, roles of MHD modes, magnetic reconnection, magnetospheric dynamics

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PEM37-17 会場:414 時間:4 月 30 日 16:45-17:00

二点観測を用いた地球磁気圏界面三次元フラックスロープ構造の再現
Two-spacecraft reconstruction of a three-dimensional magnetic flux rope at the Earth's magnetopause

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We present first results of a data analysis method, developed by Sonnerup and Hasegawa [2011], for reconstructing three-dimensional (3-D), magnetohydrostatic structures from data taken as two closely spaced satellites traverse the structures. The method is applied to a flux transfer event (FTE), which was encountered on 27 June 2007 by at least three (TH-C, TH-D, and TH-E) of the five THEMIS probes and was situated between two oppositely directed reconnection jets near the subsolar magnetopause under a southward interplanetary magnetic field condition. The recovered 3-D field indicates that a magnetic flux rope with a diameter of about 3000 km was embedded in the magnetopause. The FTE flux rope obviously had a significantly 3-D structure, because the 3-D field reconstructed from the data from TH-C and TH-D (separated by 390 km) better predicts magnetic field variations actually measured along the TH-E path than does the 2-D Grad-Shafranov reconstruction [Hau and Sonnerup, 1999] using the data from TH-C (which was closer to TH-E than TH-D and was at about 1000 km from TH-E). Such a 3-D nature suggests that reconnected field lines from the two reconnection sites may have been entangled in a complicated way through their interaction with each other. The generation process of the observed 3-D flux rope is discussed on the basis of the reconstruction results and anisotropy of observed electron pitch-angle distributions.

Reference:
Hau, L.-N., and B. U. O. Sonnerup (1999), Two-dimensional coherent structures in the magnetopause: Recovery of static equilibria from single-spacecraft data, J. Geophys. Res. Space Physics, 104, 6899-6917.
Sonnerup, B. U. O., and H. Hasegawa (2011), Reconstruction of steady, three-dimensional, magnetohydrostatic field and plasma structures in space: Theory and benchmarking, J. Geophys. Res. Space Physics, 116, A09230, doi:10.1029/2011JA016675.

キーワード: 磁気圏界面, 磁気フラックスロープ, 磁気リコネクション, 磁気静水圧平衡, 編隊観測
Keywords: magnetopause, magnetic flux rope, magnetic reconnection, magnetohydrostatic equilibrium, formation-flying observations