

PEM027-01

会場:103

時間:5月25日 16:30-16:45

2010-2011年冬期ポーカークラットにおけるEMCCDカメラを用いたオーロラ観測初期結果

Initial results of auroral observations using an EMCCD camera in 2010/2011 winter campaign at Poker Flat Research Range

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Pulsating aurora is a phenomenon which shows periodic changes of emission intensity in the diffuse aurora. The emission is characterized by not sinusoidal change but pulsation, and its typical period is from a few seconds to a few tens of seconds [e.g., *Oguti et al.*, 1981; *Yamamoto*, 1988]. Precipitating electrons which generate pulsating aurora were observed with 3 Hz modulations by rockets and low-altitude satellites, and the energy ranges from a few keV to a few tens keV [e.g., *Sandahl et al.*, 1980]. Since pulsating aurora appears in diffuse aurora, electrons are thought to undergo cyclotron resonance with whistler mode waves in the equatorial region of the magnetosphere and to precipitate into the Earth's upper atmosphere by pitch angle scattering. Some simultaneous optical and VLF whistler mode wave observations have been carried out to demonstrate this idea [*Hansen and Scourfield*, 1990; *Tagirov et al.*, 1998]. These studies suggested that appearance of auroral pulsations were related to VLF emission activity, however, one-to-one correspondence of order of a few hundred ms between auroral fine-scale structures with high temporal fluctuations and each element of VLF emission were not shown yet. In addition, recent simultaneous ground-satellite observations of pulsating auroras suggests not only mechanism associated with whistler mode waves but also one associated with Electron Cyclotron Harmonics (ECH), especially in high latitude regions ($L > 6$) [*Liang et al.*, 2010]. Therefore, continuous ground-based observations including optical and ELF-VLF measurements are still needed to reveal what drives pulsating auroras.

The purpose of this study is to investigate the characteristic of temporal variations in pulsating auroras using a high-speed camera equipped with an Electron Multiplying CCD (EMCCD). We are planning a new observation that addresses especially pulsating auroras. The plan is to carry out simultaneous observations with three cameras (two EMCCD cameras and another camera for guiding), a photometer, a VLF receive system (100 kHz sampling) for short term campaign and an ELF magnetometer (1 kHz sampling). EMCCD camera takes an image at mainly 670.0 nm (N_2 1st Positive Band) wavelength at intervals of 10 ms. The field of view is 48.9 x 48.9 degrees and the spatial resolutions equals to 1.6 km at an altitude of 110 km (8 x 8 binning). The photometer consists of a Schmidt-Cassegrain telescope (F10.0, f2000mm), an interference filter at 670.0 nm, a photo counting head and a photo counting unit. Its field of view is 0.22 x 0.22 degrees and corresponding to 840 x 840 m at an altitude of 110 km. It is designed to detect 10% fluctuations of intensity of pulsating auroras with a few kR by 1 kHz sampling.

The observation began to be operated at Poker Flat Research Range (MLAT 66.77 deg. MLON 262.97 deg.) in Alaska on November, 2010. Our instruments are working without fatal errors and many data of pulsating auroras have been acquired. Initial results of our observations will be reported in this presentation.

キーワード: オーロラ, パルセーティングオーロラ, 地上光学観測, 波動粒子相互作用, サブストーム

Keywords: aurora, pulsating aurora, optical observations, wave-particle interaction, substorm

PEM027-02

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電離層駆動の磁気圏交換型不安定に伴う磁気圏から中性大気に至る磁力線形状 Structure of field lines associated with ionosphere-driven interchange instability from the magnetosphere to atmosphere

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磁気圏のエネルギー原理に基づいて電離層駆動の交換型不安定が存在することが示されてきた。電離層駆動の交換型不安定は磁気圏に於いて、全く新しい形の交換型不安定の駆動の方法を示唆しており、その成否の検証は磁気圏の電磁流体不安定を統一的に議論し得る磁気圏のエネルギー原理の有効性と有用性を確かめる上で重要である。またこのような電離層駆動の交換型不安定の存在は圧力勾配が小さく圧力駆動の交換型不安定が期待できない内部磁気圏に於ける放射線帯の力学やオーロラの物理を議論する上で重要である。磁気圏のエネルギー原理では電離層下の中性大気存在を無視しており、磁気圏から大気に至る電離層駆動の交換型不安定に伴う擾乱の形状を明らかにできなかった。しかし磁気圏のエネルギー原理は大気を含む形に拡張され磁気圏から大気に至る擾乱の構造を明らかにすることができるようになった。そこで磁気圏力学に於ける拡張された磁気圏のエネルギー原理の有効性と有用性は磁気圏中のみならず、中性大気中における擾乱の構造を調べるにより検証が可能となった。そこで今回は観測の点からは容易だと思われる電離層駆動の交換型不安定から予想される磁力線形状と磁場擾乱の構造について明らかにする。理想電磁流体の元では磁場凍結の原理が成り立ち、磁気圏プラズマ中では磁力線の概念は非常に役に立ち磁力線はプラズマと共に動くとして解釈される。一方、中性大気中では電流は存在し得ず磁場はポテンシャル磁場で表される。プラズマは存在しないため、磁力線の動きという概念は使われないが、磁場ベクトルの接する曲線という磁力線の概念は中性大気中でも有効である。磁気圏プラズマと中性大気にはさまれた境界領域である電離層中では磁場が存在し、磁力線も定義できる。しかし散逸があるため磁力線がプラズマと一緒に動くという概念は成り立たない。磁気圏のエネルギー原理によれば球面の電離層に0次の磁力線が垂直に入射する場合、もし磁力線が擾乱電場で移流されれば電離層で磁場の水平擾乱が誘起される。一方交換型不安定では磁気圏内で磁力線の変形はなく磁場の水平方向の擾乱も生じない。従って電離層では磁力線のキンク(曲がり)ができることが予想される。一方、電離層の上下で電場の接線成分の連続の式から電離層の直下にも磁場の水平方向の擾乱が生ずる。しかし中性大気中では磁場はポテンシャル磁場であり、磁場擾乱は地面に向かって急激に単調に減少していく。従って電離層駆動の交換型不安定では磁力線は磁気圏では水平擾乱がなく、電離層で曲がり、中性大気中では単調に地面に向かって減少していく形状が予想される。このような磁力線形状あるいは磁場擾乱の構造が確認できれば、磁気圏のエネルギー原理から予想される電離層駆動の交換型不安定の存在を示すことができ、磁気圏力学における磁気圏のエネルギー原理の有効性及び有用性を検証することが可能となる。

キーワード: 磁気圏, 電離層駆動の交換型不安定, 電磁流体不安定, 中性大気, 磁力線, エネルギー原理

Keywords: magnetosphere, ionosphere-driven interchange instability, MHD instability, neutral atmosphere, magnetic field lines, energy principle

PEM027-03

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放射線帯粒子の動径方向拡散に関連する Pc5 波動モード時空間発展の理解 Spatiotemporal characteristics of Toroidal Pc 5 ULF during high-speed solar wind intervals

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ULF waves in frequency band between 1.67 and 6.67 mHz, especially Pc 5 magnetic pulsations, are believed to contribute to Relativistic Electron Enhancement (REE) in the outer radiation belt during magnetic storms. Many researchers suggested that high solar wind velocity and high long-duration Pc 5 power observed on the ground in the storm recovery phase are closely associated with the production of relativistic electrons (Baker et al., 1998; Rostoker et al., 1998; Mathie and Mann, 2000; O'Brien et al., 2001, 2003). Theoretically, the polarization (toroidal, poloidal or compressional modes) of the Pc 5 pulsations is discussed for the effectiveness of transporting radially energetic particles in terms of radial diffusion. Most of ground-based works focused on the activities of Pc 5 pulsations (e.g., amplitude or power), and they have rarely considered the polarization of Pc 5 pulsations because of difficulty to identify it by using only ground-based observations.

The purpose of this paper is to directly demonstrate the polarization characteristics and its spatiotemporal distribution of Pc 5 waves in the inner magnetosphere by the in-situ observations. We analyzed the magnetic and electric field data obtained by Time History of Events and Macroscale Interactions During Substorms (THEMIS) for the REE (14) / Non-REE (10) events under the high-speed solar wind conditions during 2008, and identified the polarization of these Pc 5 waves. It is clear that the Pc 5 polarization characteristics are strongly local time dependent. We found that the dayside toroidal Pc 5 wave at the outer radiation belt ($L > 8$) is the important role of the radial diffusion mechanism.

PEM027-04

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静止軌道で高エネルギーイオンの増加を伴って現れる高緯度 Pc5 脈動 Activities of Pc5 pulsations in high-latitudes associated with energetic ion enhancement at geosynchronous altitudes

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オーロラ帯で観測される朝方と夕方の Pc5 脈動の主たる違いは経度方向への伝播の逆転であるため Pc5 は太陽風の流れの影響を受けていると考えられる (Saka et al., JGR, 1983)。また Pc5 脈動はサブストームに関連した粒子活動との関連が報告されている (Saka et al., JGR, 1992)。

本講演で報告する高緯度帯 Pc5 脈動は静止軌道で高エネルギーイオンの増加を伴って観測された。この高エネルギーイオンの増加は Pi2 開始から 10 分程度遅れて始まる Inner magnetosphere の Inflation に関連している (Saka et al., JASTP, 2010)。

Inflation によって磁気圏が双極子に回帰したため太陽風の流れが磁力線振動を起こし易くしたと考えれば、Pc5 - 太陽風 - 粒子の関係が理解できる。

キーワード: Pc5 脈動, 高エネルギー粒子, 内部磁気圏, 静止軌道, オーロラ帯

Keywords: Pc5 pulsation, energetic particles, inner magnetosphere, geosynchronous altitudes, auroral region

PEM027-05

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内部磁気圏におけるイオンピッチ角分布の統計解析 Statistical analysis of the ion pitch angle distribution in the inner magnetosphere

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内部磁気圏ではさまざまなエネルギー粒子が地球周辺をドリフトしていることが知られており、その軌道上で起こりうる物理現象を調べるために粒子のピッチ角分布 (Pitch Angle Distribution, PAD) が研究されてきた。これまで様々な形 (normal 型、isotropic 型、head-and-shoulder 型、butterfly 型) のピッチ角分布が発見されており、特に、butterfly 型分布の生成理論については、“Particle injection and drift effect” [Konradi, 1973]、“Drift shell splitting + magnetopause shadowing” [West et al., 1973]、“Drift shell splitting + negative radial flux gradient” [Sibeck et al., 1987]、“Ring current effect” [Ebihara et al., 2008]、“Multiple pitch angle scattering effect” [Shibahara et al., 2010] 等が提唱されている。

本研究では、高エネルギーイオン粒子 (10keV~200keV) に注目し、磁気擾乱度合い、粒子エネルギーで分類した PAD の統計解析及び、これまで提唱されている Butterfly 型 PAD 生成理論の再検討を行った。使用するデータは、極軌道衛星 Polar に搭載されている CAMMICE/MICS で得られた粒子フラックス (1.0keV/q~193.4keV/q) で、1996~2002 年の間に衛星が磁気赤道付近を通過するイベントを対象とした。

その結果、50keV 以上の粒子においては、Normal 型は昼側全域、Butterfly 型は midnight 側、Isotropic 型は Normal 域と Butterfly 域の間で見られ、他方で 10keV 程度の低エネルギー粒子の PAD は高エネルギー粒子と異なる様相を示した。また、Butterfly 型をその形状で“ M-type ”と“ U-type ”に分類して調べたところ、基本的には M-type が支配的だが、10keV 前後の粒子においては夜側で U-type が見られた。また、Pre-noon 域で Butterfly 型があまり見られないことから、Magnetopause shadowing 以外の効果も十分に効いていることがわかった。本発表では、内部磁気圏におけるイオンピッチ角分布を包括的に述べていくなかで、その他の Butterfly 生成理論についても詳しく検討していく予定である。

キーワード: 内部磁気圏, ピッチ角分布

Keywords: inner magnetosphere, pitch angle distribution

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PEM027-06

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地球磁気圏近尾部領域におけるプラズモイド周りの磁場構造 Magnetic Configurations around a Plasmoid in the Near-Earth Magnetotail

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Magnetic configurations around plasmoids propagating in the directions of earthward and tailward in the near-Earth plasma sheet were studied using MHD simulations and statistical analyses of Geotail observations. MHD simulations were done giving a single X-line. These results are appeared in the statistics of events. This fact making it possible to conclude that magnetic configurations around plasmoids in the near-Earth plasma sheet are the NFTE-like structure, not the flux rope-like structure.

キーワード: リコネクション, プラズモイド, 磁場構造, MHD シミュレーション, 衛星観測
Keywords: Reconnection, Plasmoid, Magnetic Configuration, MHD simulation, Satellite observations

PEM027-07

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時間:5月25日 18:00-18:15

近地球プラズマシート高速流の統計解析 Characteristics of fast plasma flows in the near-earth plasma sheet

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The Bubble model or the interchange motion of the plasma depleted flux tube, which is originally proposed to solve the so-called 'Pressure Balance Inconsistency', is one of the accepted candidates of the mechanism for high-speed flows observed in the near-earth plasma sheet. However it is not clear yet that it is quite so, and eventually how they are associated with (play a role in) the magnetospheric convection and substorm dynamics.

This study addresses the above problem by investigating the characteristics of fast flows in the central plasma sheet observed by Geotail. We use plasma moments and magnetic field data acquired respectively with LEP and MGF instruments during January 1993 to November 2005. We also include EPIC/STICS data for the derivation of plasma moments. By classifying the fast flow events according to the flow direction (earthward or tailward), flow speed, and distance from the earth, we examined the variations of physical quantities that will show the systematic change if the fast flow was a passage of 'Bubble.' The quantities include the ion pressure (P), north-south component of the magnetic field (B_z), and value equivalent to the specific entropy (PV^γ , where V is the volume of the flux tube, but here we use B_z as an alternative).

As for the earthward flows, summing up the analysis results, we can conclude that the earthward flows can be basically interpreted as the passage of Bubbles. In addition, it is found for the first time that the speed range in which the Bubble-like features prominently appear shifts to the relatively lower-speed ($<400\text{km/s}$) range in the region closer to the earth ($|x| < 15R_E$). This result not only indicates the flow breaking but also suggests that we should reconsider the categorical criteria for the selection of fast flows used in statistical studies. As for the tailward flows, we will discuss their characteristics in association with possibilities, such as bounces of bubbles, vortex-like flows, and the ballooning instability.

PEM027-08

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IMFの南北反転に伴う磁気圏ダイナミクス Magnetospheric Dynamics on Southward/Northward Turning of IMF

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One of important problems in space plasma physics is to understand relationships among magnetic reconnection and initiation of substorm processes and magnetospheric dynamics when the IMF turns from northward to southward or vice versa. When the IMF is northward, a dipole-like magnetic field configuration is formed in a steady state and magnetic reconnection occurs in high latitude tail region. On the other hand, when it is southward, a tail-like configuration is formed and reconnection occurs at the dayside magnetopause and plasma sheet. The reconnection site shifts to subsolar region in the dayside magnetosphere when the IMF turns southward from northward. Then, reconnected magnetic flux transfers from the subsolar region to lobes through polar regions and is accumulated in lobe regions of magnetotail. As the result, plasma sheet thinning is happened and successively tail reconnection as formation of near-earth neutral line (NENL) begins and fast jet flows appear in both directions in the plasma sheet.

How do the processes of magnetic reconnection proceed at the dayside magnetopause and in the magnetotail? What are causal relationships satisfied in processes such as the initiation reconnection, formation of NENL, full spread of neutral line up to flank magnetopause, start of lobe reconnection? What do the plasma, momentum and energy carry toward the earth and how do the plasma sheet configuration change? We have studied the detail processes on magnetic reconnection in the plasma sheet and successive magnetospheric dynamics from a high-resolution and 3-dimensional global MHD simulation of interaction between the solar wind and earth's magnetosphere when the IMF turns from northward to southward and vice versa. As the results, the first reconnection occurs in closed field lines in the magnetotail and proceeds to full spread of reconnection line up to flank magnetopause and lobe reconnection in a few minutes, and then fast plasma flows appear in the plasma sheet. We will discuss what are important to carry the plasma, momentum and energy in the plasma sheet and to change the configuration of near-earth plasma pressure and magnetospheric convection.

キーワード: MHD シミュレーション, 惑星間磁場, 磁気リコネクション, 磁気圏ダイナミクス, サブストーム, エネルギー輸送

Keywords: MHD Simulation, Interplanetary Magnetic Field, Magnetic Reconnection, Magnetospheric Dynamics, Substorms, Energy Transport