First Electron-Scale Measurements of Magnetic Reconnection in Space

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*James L Burch[1]、Torbert Roy[1,2]、Phan Tai[3]、Chen Li-Jen[4]、Moore Thomas[5]、Ergun Robert[6]、Eastwood Jonathan[7]、Gershman Daniel[5]、Argall Matthew[2]、Wang Shan[4]、Hesse Michael[5]、Pollock Craig[15]、Giles Barbara[5]、Nakamura Rumi[8]、Mauk Barry[9]、Fuselier Stephen[1]、Russell Christopher[10]、Strangeway Robert[10]、Cassak Paul[11]、Drake James[4]、Shay Michael[12]、Khotyaintsev Yuri[13]、Lindqvist Per-Arne[14]、Wilder Frederick[6]、Oka Mitsuo[3]、Dorelli John[5]、Goldstein Jerry[1]、Baker Daniel[6]
*James L Burch[1], Roy B. Torbert[1,2], Tai D. Phan[3], Li-Jen Chen[4], Thomas E Moore[5], Robert E Ergun[6], Jonathan P Eastwood[7], Daniel J Gershman[5], Matthew R Argall[2], Shan Wang[4], Michael Hesse[5], Craig J Pollock[15], Barbara L Giles[5], Rumi Nakamura[8], Barry H Mauk[9], Stephen A Fuselier[1], Christopher T Russell[10], Robert J Strangeway[10], Paul A Cassak[11], James F Drake[4], Michael A Shay[12], Yuri Khotyaintsev[13], Per-Arne Lindqvist[14], Frederick D Wilder[6], Mitsuo Oka[3], John C Dorelli[5], Jerry Goldstein[1], Daniel N Baker[6]

1.Southwest Research Institute、2.University of New Hampshire、3.University of California, Berkeley、4.University of Maryland、5.NASA, Goddard Space Flight Center、6.University of Colorado LASP、7.Imperial College London、8.Space Research Institute, Austrian Academy of Sciences、9.Johns Hopkins University Applied Physics Laboratory、10.University of California, Los Angeles、11.West Virginia University、12.University of Delaware、13.Swedish Institute of Space Physics、14.Swedish Royal Institute of Technology、15.Denali Scientific
1.Southwest Research Institute, 2.University of New Hampshire, 3.University of California, Berkeley, 4.University of Maryland, 5.NASA, Goddard Space Flight Center, 6.University of Colorado LASP, 7.Imperial College London, 8.Space Research Institute, Austrian Academy of Sciences, 9.Johns Hopkins University Applied Physics Laboratory, 10.University of California, Los Angeles, 11.West Virginia University, 12.University of Delaware, 13.Swedish Institute of Space Physics, 14.Swedish Royal Institute of Technology, 15.Denali Scientific

Magnetic reconnection is a fundamental plasma physical process in which stored magnetic energy is explosively converted through the reconfiguration of a magnetic field into heat and kinetic energy of charged particles. Reconnection occurs in many astrophysical plasma environments as well as in laboratory plasma experiments and is responsible for solar flares and coronal mass ejections, x-ray flares in magnetars, magnetospheric storms and substorms, and sawtooth collapses in fusion devices. Although the effects of reconnection are easily observed, the electron-scale kinetic physics that allows plasmas to become demagnetized, with the resulting change in the topology of the magnetic field and the release of particle energy, has up to now eluded observation in both space and the laboratory. However, recent observations by NASA’s Magnetospheric Multiscale Mission (MMS), made with unprecedently high time resolution (100 times faster than previous missions for electrons and 30 times faster for ions), have provided the first detailed look at electron demagnetization and acceleration at sites along the sunward boundary of Earth’s magnetosphere where the interplanetary magnetic field encounters and reconnects with the terrestrial magnetic field. With these new measurements we have (1) observed the reduction of magnetic-field energy to near zero, (2) measured the reconnection electric field and the current that flows along it causing the dissipation of magnetic energy, and (3) identified the electron population that carries the current as a result of demagnetization and acceleration during their penetration of the reconnection dissipation region. The persistence of a characteristic crescent shape in the velocity-space distributions of these electrons suggests that the kinetic processes causing magnetic field line reconnection in this event were dominated by laminar electron physics rather than turbulence-induced dissipation.

キーワード：Magnetic Reconnection、Solar-Wind Magnetosphere Interactions、Charged Particle Acceleration
Keywords: Magnetic Reconnection, Solar-Wind Magnetosphere Interactions, Charged Particle Acceleration

MMSへの日本からの参加：現状とこれから
Japanese Participation to MMS: Current Status and Future Plan

*斎藤 義文[1]、横田 勝一郎[1]、北村 成寿[1]、長谷川 洋[1]
*Yoshifumi Saito[1], Shoichiro Yokota[1], Naritoshi Kitamura[1], Hiroshi Hasegawa[1]

1.宇宙航空研究開発機構・宇宙科学研究所・太陽系科学研究系
1.Solar System Science Division, Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency

MMS was successfully launched on12 March 2015 and is continuing to produce highest quality data ever we had. Based on the results obtained by Geotail observations, Japanese researchers have been interested in the main target of MMS that is to understand the micro process of the magnetic reconnection. The same group that developed the low energy particle experiment (LEP) on Geotail has been participating to the development of one of the instruments on MMS that is FPI-DIS (Fast Plasma Investigation - Dual Ion Sensor). Design, fabrication, assembly, and the initial tests of the 16 Flight Model DIS sensors were made in Japan collaborating with U.S. and French colleagues. Currently, Japanese scientists are also participating to the initial analysis of the obtained data and evaluation of the performance of the 16 DIS sensors.
Since the time resolution of the FPI is high, the amount of the data is quite large. FPI data are delivered to Japan periodically using hard drives since it takes too long time to transfer all the data from the data center over the internet. ISAS is operating a data server for FPI data, that can be accessed by Japanese FPI team members.
The collaborative observation between MMS and Geotail is also making progress. After July 2015, the operation time of Geotail in Japan is increased in order to make collaborative observation with MMS. Since Geotail has unique orbit with apogee of 30Re and perigee of 9Re, Geotail - MMS pairs will realize multiple scale measurements of the key regions of the magnetic reconnection region. In some of the period, Geotail can be used as a solar wind monitor, that is closer to the magnetosphere than solar wind monitor at L1 point.
Since many Japanese researchers have great interest in the night side phenomena in the Earth's magnetotail, we are placing high expectations on the MMS Phase2 data that will be obtained in the near future. The time resolution of the Geotail low energy particle observation was 12 seconds. Therefore it was difficult to see the detailed structure of the the Earth's magnetotail. Although the sensitivity of the FPI sensors are not enough high for tenuous plasma measurements in the magnetotail, they can make observation much faster than 12sec. FPI- DIS will be able to measure low energy ions with more than an order higher time resolution than Geotail-LEP even taking into account the sensitivity. Many new discoveries are expected to be made also in the Earth's magnetotail in the near future.

キーワード：磁気リコネクション、衛星観測、プラズマ計測
Keywords: magnetic reconnection, satellite observation, plasma measurement

ジオスペース探査ERGプロジェクトと国際連携

Geospace Exploration Project ERG: Contribution to Heliosphere/Geospace (H/GSO) system observatory

*三好 由純[1]、篠原 育[2]、高島 健[2]、浅村 和史[2]、松本 晴久[2]、東尾 奈々[2]、三谷 烈史[2]、横田 勝一郎[2]、笠原 慧[2]、風間 洋一[3]、Wang Shaing-Yu[3]、平原 聖文[1]、笠原 禎也[4]、笠羽 康正[4]、八木谷 聡[4]、松岡 彩子[2]、小嶋 浩嗣[6]、藤本 正樹[2]、塩川 和夫[1]、関 華奈子[7]、加藤 雄人[5]、小野 高幸[5]
*Yoshizumi Miyoshi[1], Iku Shinohara[2], Takeshi Takashima[2], Kazushi Asamura[2], haruhisa matsumoto[2], Nana Higashio[2], Takefumi Mitani[2], Shoichiro Yokota[2], Satoshi Kasahara[2], Yoichi Kazama[3], Shaing-Yu Wang[3], Masafumi Hirahara[1], Yoshiya Kasahara[4], Yasumasa Kasaba[4], Satoshi Yagitani[4], Ayako Matsuoka[2], Hirotsugu Kojima[6], Masaki Fujimoto[2], Kazuo Shiokawa[1], Kanako Seki[7], Yuto Katoh[5], Takayuki Ono[5]

1.名古屋大学宇宙地球環境研究所、2.宇宙航空研究開発機構、3.Academia Sinica、4.金沢大学、5.東北大学、6.京都大学、7.東京大学
1.Institute for Space-Earth Environmental Research, Nagoya University, 2.JAXA, 3.Academia Sinica, Taiwan, 4.Kanazawa University, 5.Tohoku University, 6.Kyoto University, 7.The University of Tokyo

The ERG (Exploration of energization and Radiation in Geospace) isJapanese geospace exploration project. The project focuses on thegeospace dynamics and accelerations of radiation belt electrons in the context of the cross-energy coupling viawave-particle interactions. The project consists of the satelliteobservation team, the ground-based network observation team, andintegrated-data analysis/simulation team. The ERG satellite will belaunched in FY2016. Comprehensive instruments for plasma/particles, and eld/waves are installed in the ERG satellite to understand thecross-energy coupling system. In the ERG project, severalground-network teams join; magnetometer networks, radar networks,optical imager networks, etc, which provide a gloval view of geospace and complementary observation with the ERG satellite observation. Moreover, the modeling/simulations playan important role for the quantitative understanding. Besides research teams in the project, the science center has been operated. The science data from the project have been archived. Moreover, the science center has developed an integrated data analysis software that are a plug-in for SPEDAS in cooperation with the THEMIS mission. These data and softwares are available via the ERG-Science Webpage
(http://ergsc.stelab.nagoya-u.ac.jp). In thispresentation, we will talk about an overview of the ERG project and discuss the international collaborations with Van Allen Probes, MMS, THEMIS, Cluster, etc and ground network observations under the flame work of Heliosphere/Geospace (H/GSO) system observatory.

キーワード：ジオスペース探査、国際協力
Keywords: Geospace Exploration, International Collaboration

MMS High time resolution measurements of kinetic plasma turbulence in Earth's magnetosheath and upstream solar wind

MMS High time resolution measurements of kinetic plasma turbulence in Earth's magnetosheath and upstream solar wind

*Pollock Craig[1]、Giles Barbara[1]、斎藤 義文[2]、Matthaeus William [3]、Torbert Roy[4,5]
*Craig J. Pollock[1], Barbara L. Giles[1], Yoshifumi Saito[2], William Matthaeus [3], Roy Torbert[4,5]

1.NASA Goddard Space Center、2.宇宙航空研究開発機構・宇宙科学研究所・太陽系科学研究系、3.University of Delaware、4.University of New Hampshire、5.Southwest Research Institute
1.NASA Goddard Space Center, 2.Solar System Science Division, Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 3.University of Delaware, 4.University of New Hampshire, 5.Southwest Research Institute

Kinetic plasma turbulence is known to be widespread in both solar wind and magnetosheath plasmas. The relationships between kinetic plasma turbulence and collisionless magnetic reconnection are likely myriad and complex. Plasma and magnetic field measurements are provided by MMS at unprecedented cadences, up to 133 Hz for sparsely sampled 3D electron distribution functions. Such fast measurements enable use of new windows into the kinetics of plasma turbulence in Earth's magnetosheath and the nearby solar wind. We will present examples of the turbulence signatures observed in the plasma and magnetic field observations on board MMS during the first Phase (1A) of the mission.

プラズマシートにおける磁気リコネクションと低域混成ドリフト不安定のもとでの磁気エネルギー散逸
Magnetic energy dissipation of plasma sheet under coupling of magnetic reconnection and lower hybrid drift instability

*星野 真弘[1]
*Masahiro Hoshino[1]

1.東京大学大学院理学系研究科
1.Graduate School of Science, The University of Tokyo

Understanding of the magnetic energy dissipation process in a current sheet is an important problem in space plasma as well as in MMS science. So far the inertia resistivity by reconnection and the current driven instability such as the lower hybrid drift instability (LHDI) have been discussed as possible candidates for the origin of microscopic process of magnetic energy dissipation. It is well known that while the LHDI is mainly excited in the plasma sheet boundary, the inertia resistivity effectively works at the neutral sheet. Therefore, the role of the LHDI to the magnetic field dissipation is less important than the inertia resistivity involved in the magnetic reconnection. However, the activity of lower hybrid drift waves together with the electron heating is commonly observed in the plasma sheet boundary by modern satellite observations, and their impact on the magnetic field dissipation at the neutral sheet is not necessarily neglected. In addition, the nonlinear coupling between them is not theoretically understood yet. In this talk, we study the coupling of the collisionless reconnection and the LHDI by using a three-dimensional PIC simulation by paying a special attention to electron heating and the magnetic energy dissipation, and discuss the importance of the current driven instability during magnetic reconnection.

キーワード：磁気リコネクション、プラズマシート、プラズマ加熱、低域混成ドリフト不安定
Keywords: magnetic reconnection, plasma sheet, palsma heating, lower hybrid drift instability

The Electron Diffusion Region in Asymmetric Magnetic Reconnection with Guide Fields

*Michael Hesse[1], Yi-Hsin Liu[1], Li-Jen Chen[1], Naoki Bessho[1], James L. Burch[3], Joachim Birn[2]

1.NASA Goddard Space Flight Center, 2.Space Science Institute and Los Alamos National Lab, 3.Southwest Research Institute

The launch of the Magnetospheric Multiscale mission is leading to a revolution in our understanding of the way magnetic reconnection works. During the first orbit phases, MMS science focuses on asymmetric reconnection, as is commonly found at the Earth’s magnetopause. MMS observations have begun to support the view that reconnection operates primarily as a quasi-laminar process, supporting one class of theoretical predictions and a number of concurrent simulations. In this presentation, we present a detailed look at model predictions pertaining to asymmetric magnetic reconnection with a guide magnetic field, and we present a comparison to recent MMS observations.

Keywords: Magnetospheric Multiscale, Magnetic reconnection, Magnetopause

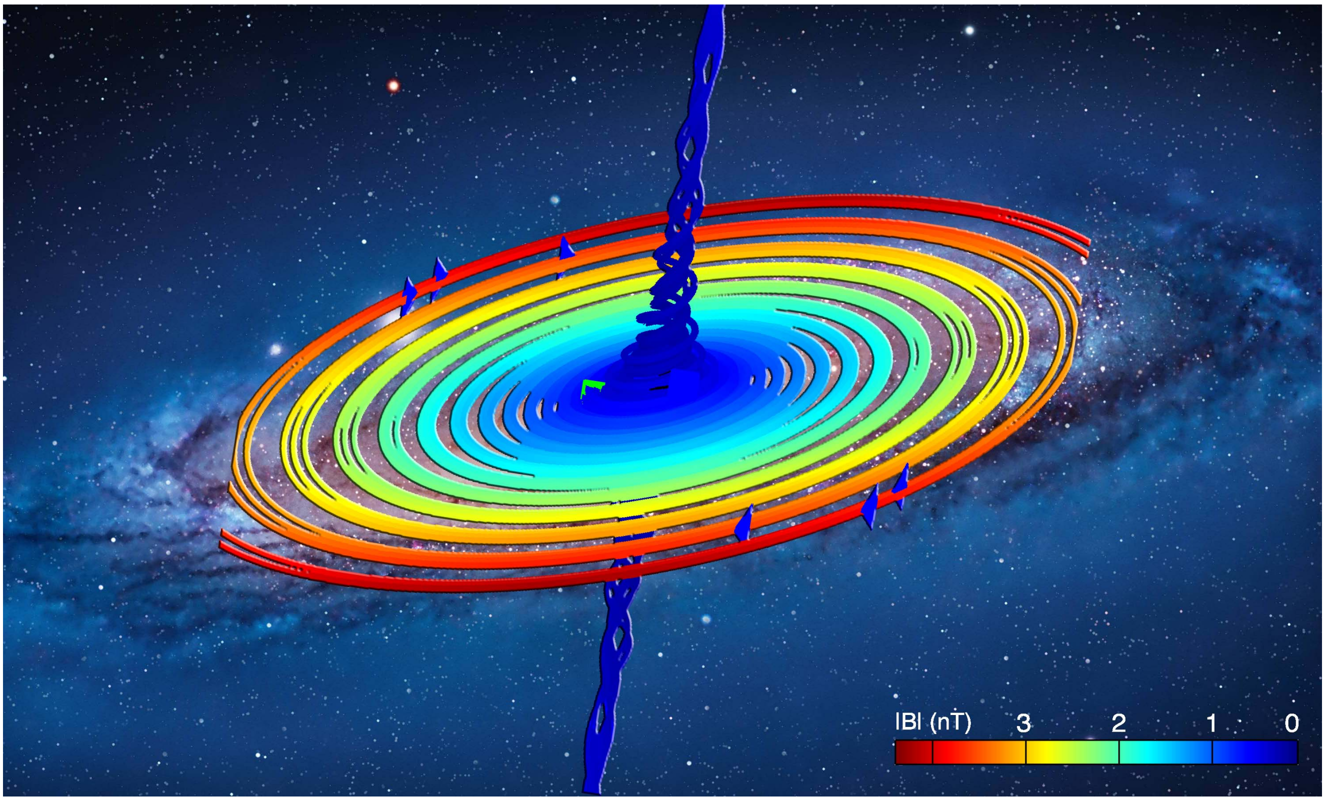
How to find magnetic nulls and reconstruct field topology with MMS data?

*Huishan Fu[1], Andris Vaivads[2], Yuri Khotyaintsev[2], Vyacheslav Olshevsky[3], Mats André[2], Jinbin Cao[1], Shiyong Huang[4], Alessandro Retino[5]

1.Beihang University, 2.Swedish Institute of Space Physics, 3.KU Leuven, 4.Wuhan University, 5.Laboratoire de Physique des Plasmas, CNRS

In this study, we apply a new method—the first-order Taylor expansion (FOTE)—to find magnetic nulls and reconstruct magnetic field topology, in order to use it with the data from the forth-coming MMS mission. We compare this method with the previously used Poincare index (PI), and find that they are generally consistent, except that the PI method can only find a null inside the spacecraft (SC) tetrahedron, while the FOTE method can find a null both inside and outside the tetrahedron and also deduce its drift velocity. In addition, the FOTE method can (1) avoid limitations of the PI method such as data resolution, instrument uncertainty (Bz offset), and SC separation; (2) identify 3D null types (A, B, As, and Bs) and determine whether these types can degenerate into 2D (X and O); (3) reconstruct the magnetic field topology. We quantitively test the accuracy of FOTE in positioning magnetic nulls and reconstructing field topology, by using the data from 3D kinetic simulations. The influences of SC separation (0.05~1 d_i) and null-SC distance (0~1 d_i) on the accuracy are both considered. We find that: (1) for an isolated null, the method is accurate when the SC separation is smaller than 1 d_i, and the null-SC distance is smaller than 0.25~0.5 d_i; (2) for a null pair, the accuracy is same as in the isolated-null situation, except at the separator line, where the field is nonlinear. We define a parameter in terms of the eigenvalues of the null to quantify the quality of our method—the smaller this parameter the better the results. Comparing to the previously used one, this parameter is more relevant for null identification. Using the new method, we reconstruct the magnetic field topology around a radial-type null and a spiral-type null, and find that the topologies are well consistent with those predicted in theory. We therefore suggest using this method to find magnetic nulls and reconstruct field topology with four-point measurements, particularly from Cluster and the forth-coming MMS mission. For the MMS mission, this null-finding algorithm can be used to trigger its burst-mode measurements.

Keywords: Magnetic null, MMS mission, Magnetic reconnection, Topology , Reconstruction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広範囲にわたって持続する磁気リコネクション時の磁気圏界面の構造：GeotailとMMSの共同観測
Structure of the magnetopause during quasi-continuous spatially-extended magnetic reconnection: Geotail and MMS conjunction on 2015-10-02

*長谷川 洋[1]、北村 成寿[1]、斎藤 義文[1]、篠原 育[1]、横田 勝一郎[1]、長井 嗣信[2]、銭谷 誠司[3]、The MMS team
*Hiroshi Hasegawa[1], Naritoshi Kitamura[1], Yoshifumi Saito[1], Iku Shinohara[1], Shoichiro Yokota[1], Tsugunobu Nagai[2], Seiji Zenitani[3], The MMS team

1.宇宙航空研究開発機構宇宙科学研究所、2.東京工業大学、3.国立天文台
1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.Tokyo Institute of Technology, 3.National Astronomical Observatory of Japan

We present observations on 2 October 2015 when Geotail, near the Earth’s equatorial plane, and Magnetospheric Multiscale (MMS), at mid-southern latitudes, simultaneously traversed the Earth’s postnoon magnetopause and detected southward magnetic reconnection jets under southward interplanetary magnetic field (IMF) conditions. Such fortuitous observations allow us to estimate the length of the reconnection site, and to reveal spatial evolution of the jets along the magnetopause. Our observations show that the primary reconnection X-line under modest solar wind Alfven Mach number condition can be extended over a wide range of local time and remain active for hours. During a due southward IMF interval when anti-parallel reconnection was occurring, MMS encountered a localized ion-scale current sheet within the jet far downstream (>300 ion inertial lengths) of the primary reconnection site. The current sheet contained super-Alfvenic perpendicular electron flow, perpendicular electric current of order 500 nA/m^2, electron flow reversal, and both Hall current and Hall magnetic field signatures. The observations are consistent with the occurrence of secondary reconnection within the jets of quasi-continuous spatially-extended reconnection. It appears that the primary site of magnetopause reconnection under favorable conditions is two-dimensional, but the resulting reconnection jets and secondary reconnection are three-dimensional.

キーワード：磁気リコネクション、磁気圏界面、イオン拡散領域
Keywords: magnetic reconnection, magnetopause, ion diffusion region

Shift of the magnetopause reconnection line to the winter hemisphere under southward IMF conditions: Geotail and MMS observations

Shift of the magnetopause reconnection line to the winter hemisphere under southward IMF conditions: Geotail and MMS observations

*北村 成寿[1]、長谷川 洋[1]、斎藤 義文[1]、篠原 育[1]、横田 勝一郎[1]、長井 嗣信[2]、Pollock Craig[3,4]、Giles Barbara[3]、Moore Thomas[3]、Torbert Roy[5]、Russell Christopher[6]、Strangeway Robert[6]、Burch James[7]
*Naritoshi Kitamura[1], Hiroshi Hasegawa[1], Yoshifumi Saito[1], Iku Shinohara[1], Shoichiro Yokota[1], Tsugunobu Nagai[2], Craig J Pollock[3,4], Barbara L Giles[3], Thomas E Moore[3], Roy B Torbert[5], Christopher T Russell[6], Robert J Strangeway[6], James L Burch[7]

1.宇宙航空研究開発機構 宇宙科学研究所、2.東京工業大学、3.NASA ゴダード宇宙センター、4.Denali Scientific、5.ニューハンプシャー大学、6.カリフォルニア大学ロサンゼルス校、7.サウスウエスト研究所
1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.Tokyo Institute of Technology, 3.NASA Goddard Space Flight Center, 4.Denali Scientific, 5.University of New Hampshire, 6.University of California, Los Angeles, 7.Southwest Research Institute

Recent global modeling studies and remote observations have indicated that the location of the dayside magnetopause reconnection line under southward interplanetary magnetic field (IMF) conditions tend to shift toward the winter hemisphere from the subsolar point owing to the effect of geomagnetic dipole tilt. We examined this idea using the data obtained by the Geotail and MMS (Magnetospheric Multi Scale mission) spacecraft near the GSM Z = 0 plane under southward IMF conditions. Around 0213 UT on 18 November 2015, the MMS spacecraft observed southward reconnection jets at the subsolar magnetopause (GSM Z = -0.33 R_E) under southward and dawnward IMF conditions. We estimated the plane of the magnetopause current sheet using the minimum variance analysis of current densities that were derived by the curlometer technique. The N axis of the LMN coordinates was defined as the normal to this plane. The L axis was defined as the nearest direction in this plane from the maximum variance direction of magnetic fields. Using the ratio between the N and L components of the magnetic field, the reconnection rate was estimated to be 0.03. The distance between the ion edge and the center of the current sheet (weakest magnitude of the magnetic field) was estimated as ~540 km, using the N component of the deHoffmann-Teller velocity and the time period between the two. On the basis of the estimated distance and reconnection rate, the reconnection line was ~2.8 R_E northward from the MMS. This corresponds to GSM Z ~ 2.5 R_E. About 30 minutes later, the Geotail spacecraft also observed southward reconnection jets at the dawnside magnetopause even though Geotail was in the northern hemisphere (GSM Z = 1.3 R_E). The effect of IMF B_y was very small around this time, since the MMS spacecraft observed purely southward directed magnetic fields in the magnetosheath. These observations are consistent with the idea that the dayside magnetopause reconnection line shifts toward the winter hemisphere under southward IMF conditions.

キーワード：MMS衛星群、磁気リコネクション、磁気圏界面、Geotail衛星
Keywords: MMS spacecraft, magnetic reconnection, magnetopause, Geotail spacecraft

Locations of Magnetopause Magnetic Reconnection: The Role of Magnetosheath Plasma Pressure

*Hui Zhang[1], Zuyin Pu[2], Jianyong Lu[3], Suiyan Fu[2], Changbo Zhu[1], Chongjing Yuan[1], Zhaodi Zhou[1], Weixing Wan[1], Libo Liu[1], Yiding Chen[1], Huijun Le[1]

1.Institute of Geology and Geophysics, Chinese Academy of Sciences, 2.School of Earth and Space Sciences, Peking University, 3.College of Math & Statistics, Institute of Space Weather, Nanjing University of Information Science and Technology

Question of where magnetic reconnection (MR) occurs or equivalently what mechanisms control the initiation of MR on the dayside magnetopause is intensively studied but not fully understood. Here, a novel statistic study reveals that magnetosheath thermal pressure maximizes near the subsolar point, its location, however, is modified by the dipole tilt angle in a manner the same as MR locations are. The maximum sheath thermal pressure, cooccurring with the enhanced magnetic pressure immediately inside the magnetopause, is though to be linked to a maximum magnetopause current density, where tearing mode instabilities tend to develop and MR initiates. The high pressure region shifts from the subsolar region due to magnetopause reshaping when the dipole tilt angle varies. The sheath flow stagnation point, however, remains unchanged at the subsolar point, and Xlines thus are embedded within sub Alfvenic sheath flows and are convected toward high latitudes. The successive Xlines may thus generate flux ropes.

Keywords: Magnetopuse, Magnetic Reconnection, Pressure

MMS衛星観測に基づく磁気圏界面構造とケルビン-ヘルムホルツ不安定性に与える影響の研究
Structure of the magnetopause observed by MMS and its effects on the Kelvin-Helmholtz instability

*関 華奈子[1]、松本 洋介[2]、北村 成寿[3]、斎藤 義文[3]、横田 勝一郎[3]、星野 真弘[1]、Pollock Craig J.[4,5]、Giles Barbara L.[5]、Moore Thomas E.[5]、Torbert Roy B.[6]、Russell Christopher T.[7]、Burch James L.[8]
*Kanako Seki[1], Yosuke Matsumoto[2], Naritoshi Kitamura[3], Yoshifumi Saito[3], Shoichiro Yokota[3], Masahiro Hoshino[1], Craig J. Pollock[4,5], Barbara L. Giles[5], Thomas E. Moore[5], Roy B. Torbert[6], Christopher T. Russell[7], James L. Burch[8]

1.東京大学大学院理学系研究科、2.千葉大学大学院理学研究科、3.JAXA宇宙科学研究所、4.Denali Scientific、5.NASA Goddard Space Flight Center、6.University of New Hampshire、7.University of California, Los Angeles、8.Southwest Research Institute
1.Graduate School of Science, University of Tokyo, 2.Graduate School of Science, Chiba University, 3.ISAS, JAXA, 4.Denali Scientific, 5.NASA Goddard Space Flight Center, 6.University of New Hampshire, 7.University of California, Los Angeles, 8.Southwest Research Institute

How to cause plasma mixing across different plasma regimes has been one of the fundamental problems in the collisionless plasma physics. At a plasma boundary where different plasma regimes are in contact, there often exists a velocity shear and a density gradient. The Kelvin-Helmholtz instability (KHI) has been studied as a promising mechanism to cause the plasma mixing. Although the importance of the density gradient in the plasma transport acress the Earth’s magnetopause has previously been pointed out, the detailed structure of the boundary remains unknown due to lack of high-cadence observations across the magnetopause. Based on high time-resolution observations of ions and electrons as well as simultaneous magnetic field by MMS, we investigated the relations between the density gradient and velocity shear at the magnetopause. Based on the observed structure, we implemented a new initial condition for KHI simulations, and effects of the boundary structure on KHI excitation and subsequent plasma mixing is discussed.

キーワード：磁気圏界面、境界層、ケルビン-ヘルムホルツ不安定性、プラズマ混合、密度勾配、MMS
Keywords: magnetopause, boundary layer, Kelvin-Helmholtz Instability, plasma mixing, density gradient, MMS

MMS衛星とEISCATレイダーによる昼側高速流の観測
MMS satellites and EISCAT radar observations of dayside flow bursts.

*家田 章正[1]、小川 泰信[2]、大山 伸一郎[1]、北村 成寿[3]、斎藤 義文[3]、横田 勝一郎[3]、長谷川 洋[3]、田口 聡[4]、細川 敬祐[5]、町田 忍[1]、内野 宏俊[4]、堀 智昭[1]、Pollock C.[6]、Giles B.[6]、Moore T.[6]、Russell C.[7]、Strangeway R.[7]、中村 るみ[8]、Burch J.[9]
*Akimasa Ieda[1], Yasunobu Ogawa[2], Shin-ichiro Oyama[1], Naritoshi Kitamura[3], Yoshifumi Saito[3], Shoichiro Yokota[3], Hiroshi Hasegawa[3], Satoshi Taguchi[4], Keisuke Hosokawa[5], Shinobu Machida[1], Hirotoshi Uchino[4], Tomoaki Hori[1], C. J. Pollock[6], B. L. Giles[6], T. E. Moore[6], C. T. Russell[7], R. J. Strangeway[7], Rumi Nakamura[8], J. L. Burch[9]

1.名古屋大学 宇宙地球環境研究所、2.国立極地研究所、3.宇宙科学研究所、4.京都大学、5.電気通信大学、6.NASA Goddard Space Flight Center、7.University of California, Los Angeles、8.Space Research Institute, Austrian Academy of Sciences、9.Southwest Research Institute
1.Institute for Space-Earth Environmental Research, Nagoya University, 2.National Institute of Polar Research, 3.Institute of Space and Astronautical Science, 4.Kyoto University, 5.University of Electro-Communication, 6.NASA Goddard Space Flight Center, 7.University of California, Los Angeles, 8.Space Research Institute, Austrian Academy of Sciences, 9.Southwest Research Institute

A magnetic flux transfer event (FTE) was compared with ground radar observations of ionospheric ion flow bursts. Magnetospheric multiscale (MMS) satellites were located near the subsolar magnetopause at approximately 1049 UT on 15 December 2015. MMS satellites observed a southward turning of the interplanetary magnetic field (IMF), followed by a FTE 20 minutes later, and MMS entered the magnetosphere a further 10 minutes later. The European incoherent scatter (EISCAT) VHF radar at Tromso (Norway) was pointed to geographic north, with an elevation angle of 30 degrees, and was monitoring the ionospheric F region between 68 and 72 MLAT at 13 MLT. The Tromso radar did not observe an ionospheric flow burst at the time of the IMF southward turning but instead at the time of the FTE. A 630 nm all-sky imager at Longyearbean (74 MLAT, Norway) observed several poleward moving auroral forms (PMAFs) originating near 74 MLAT but none below 73 MLAT. The most significant PMAF accelerated and became enhanced approximately 3 minutes before the observation of the FTE. FTEs are usually associated with ionospheric flow bursts near the cusp and higher latitudes. In this particular case, it is suggested that the FTE is also associated with an ionospheric flow burst in subauroral latitudes. Such a subauroral flow burst may indicate a rarefaction inflow into the cusp and may occur when significant magnetic flux is removed by a FTE.

キーワード：リコネクション、MMS、EISCAT
Keywords: reconnection, MMS, EISCAT

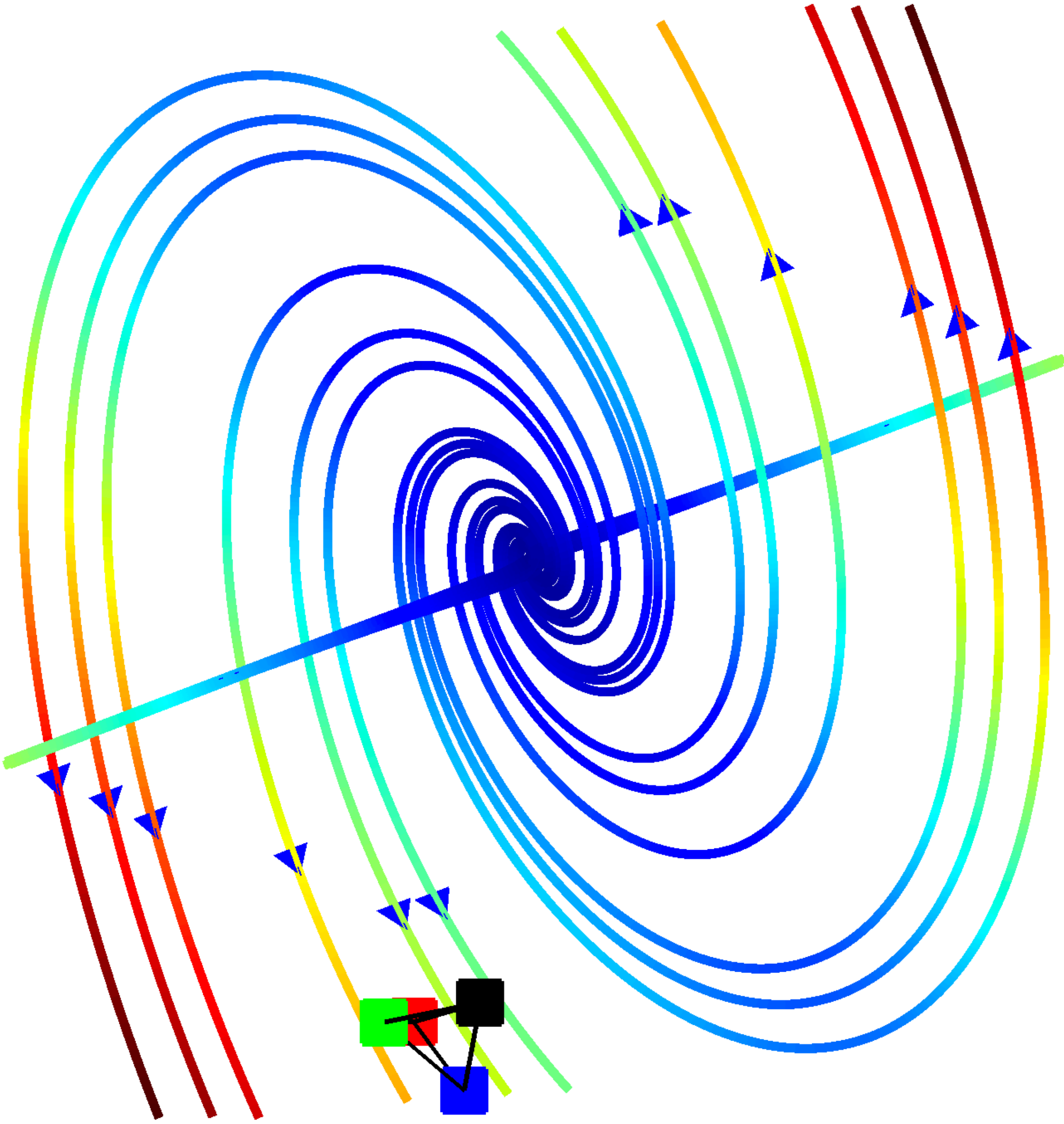
Identifying magnetic reconnection events using the FOTE method

*Huishan Fu[1], Jinbin Cao[1], Andris Vaivads [2], Yuri Khotyaintsev[2], Mats Andre[2], Malcolm Dunlop[1]

1.Beihang University, 2.Swedish Institute of Space Physics

A magnetic reconnection event detected by Cluster is analyzed using three methods: Single-spacecraft Inference based on Flow-reversal Sequence (SIFS), Multi-spacecraft Inference based on Timing a Structure (MITS), and the First-Order Taylor Expansion (FOTE). Using the SIFS method, we find that the reconnection structure is an X-line; while using the MITS and FOTE methods, we find it is a magnetic island (O-line). We compare the efficiency and accuracy of these three methods, and find that the most efficient and accurate approach to identify a reconnection event is FOTE. In both the guide- and non-guide-field reconnection regimes, the FOTE method is equally applicable. This study for the first time demonstrates the capability of FOTE in identifying magnetic reconnection events; it would be useful to the forth-coming MMS mission.

Keywords: Magnetic reconnection , MMS mission, FOTE , Magnetic null , X-line , O-line



Electron acceleration at the Earth's quasi-perpendicular bow shock: MMS observation

*Mitsuo Oka[1], Tai Phan[1], Arthur Hull[1], Jim Burch[2], Roy Torbert[3], Craig Pollock[4], Daniel Gershman[5], Barbara Giles[5]

1.UC Berkeley, 2.SwRI, 3.Univ. New Hampshire, 4.Denali Scientific, 5.NASA GSFC

Electrons can be accelerated to non-thermal energies (> 1 keV) at interplanetary shocks and the Earth's bow shock. While simulation studies have proposed various mechanisms, the precise mechanism of electron acceleration remains unclear. Here we show, based on the ultra high-time resolution measurements by MMS, that electrons form a power-law energy spectrum at and around the shock ramp region. The signatures of non-thermal electrons are modulated by the periodic variations of the shock internal structure at the time scale of roughly ion gyro period. In an event of high Mach number (~11) quasi-perpendicular shock crossing (shock angle ~ 80 degrees), we found that there exists an upper energy-limit (cutoff) in the power-law spectrum at ~10 keV and that the electron gyro-radius of this energy is roughly equal to the local ion inertial length, consistent with the idea of acceleration within the narrow shock ramp region. In this presentation, we will further discuss possible mechanisms of electron acceleration by, for example, gradient B drift and stochastic processes via waves.

Keywords: particle acceleration, shock, non-thermal, MMS, electron

昼側磁気圏界面リコネクション起源の電子スケール開放境界層におけるホイッスラーモード波動の励起
Excitation of whistler-mode waves in the electron scale open boundary layer generated by the dayside magnetopause reconnection

*内野 宏俊[1]、栗田 怜[2]、原田 裕己[3]、町田 忍[2]
*Hirotoshi Uchino[1], Satoshi Kurita[2], Yuki Harada[3], Shinobu Machida[2]

1.京都大学大学院理学研究科地球惑星科学専攻 地球物理学教室 太陽惑星系電磁気学講座、2.名古屋大学宇宙地球環境研究所、3.Space Sciences Laboratory, University of California, Berkeley
1.Solar-Planetary Electromagnetism Laboratory,Department of Geophysics,Faculty of Science,Kyoto University, 2.Institute for Space-Earth Environmental Research, Nagoya University, 3.Space Sciences Laboratory, University of California, Berkeley

The magnetic reconnection at the dayside magnetopause is generally because upstream physical quantities between magnetosheath and magnetosphere are quite different. Kinetic simulations of asymmetric magnetic reconnection produce an electron outflow layer mainly composed of magnetosheath electrons at the magnetosphere side of the separatrix. The simulation results suggest that this electron outflow layer corresponds to the reconnected open magnetic field closest to the magnetosphere. Based on the simulation result and data from the THEMIS probes, we show an observation of whistler mode waves in the electron outflow layer caused by asymmetric magnetic reconnection at the magnetopause. The waves propagated toward the reconnection region, and the linear growth rate of the wave was positive at the resonant velocity due to the electron temperature anisotropy. We suggest that the anisotropy can be originated from lack of the magnetospheric electrons moving anti-reconnection direction at small pitch angles since the magnetic field as a channel of the electrons connects to the magnetosheath region by the reconnection. This study quantitatively clarifies the excitation of the whistler-mode waves in the electron scale open boundary layer at the magnetopause in association with the dayside magnetopause reconnection.

キーワード：昼側磁気圏界面リコネクション、電子スケール開放境界、ホイッスラーモード波動
Keywords: Dayside magnetopause magnetic reconnection, electron scale open boundary, Whister mode wave

THEMIS衛星による昼側磁気圏境界面におけるXライン及びOラインの移動方向の統計解析
Direction of motion of reconnection X-lines and O-lines at the dayside magnetopause observed by the THEMIS spacecraft

*星 康人[1]、長谷川 洋[2]、北村 成寿[2]、斎藤 義文[2]
*Yasuto Hoshi[1], Hiroshi Hasegawa[2], Naritoshi Kitamura[2], Yoshifumi Saito[2]

1.東大・理・地惑、2.JAXA・宇宙研
1.Earth and Planetary Sci., Univ. of Tokyo, 2.ISAS/JAXA

地球磁気圏の昼側境界面における磁気リコネクションは、太陽風プラズマの質量、運動量、エネルギーが地球磁気圏への流入において最も重要な過程である。惑星間空間磁場（IMF）と地球磁場は、磁気圏境界面の電流層内のXライン上においてつなぎ変わる。さらに、複数のXラインにおいて非定常な磁気リコネクションが起こると、2つのXラインの間で磁力線が閉じたOラインが形成される。XラインやOラインは、電子の反磁性ドリフトや磁気圏シースのフロー等によって移動する事が知られているが、この移動方向については完全には理解されておらず、磁気リコネクションの研究において重要な課題である。XラインやOラインの移動方向は、磁気リコネクションによって加速されたイオンジェットが存在するとき、ジェットの向きの反転の極性から知る事が出来る。Xラインからは外向きのジェットが吹き出し、Oラインへは、Oラインを挟む2つのXラインからのジェットが向かってくる。境界面内で北へ移動するXライン付近を考えると、衛星静止系で北向きから南向きのflow reversalが観測され、同じく北へ移動するOライン付近では、南向きから北向きのflow reversalが観測される。すなわち、flow reversalの極性が同じであっても、移動方向は構造の違いによって異なる。このため、flow reversalを観測した際、XラインとOラインを区別する必要があるが、Oラインを通過した場合、磁場圧、プラズマ圧の和である全圧の数nPaの上昇、境界面法線方向の磁場成分の逆転、シースにおける電子の磁力線平行及び反平行方向の双方向のピッチ角分布などの特徴から区別出来る。

今回、THEMIS衛星観測データに基づいて、Xライン、及びOラインの存在する位置と移動方向を調べた。THEMIS衛星は2007年2月の打ち上げ以来、2010年までA機からE機の5機で、2010年から2016年現在までA機、D機、E機の3機で地球磁気圏を編隊観測している。2007年から現在まで、THEMIS衛星によって観測された低エネルギーイオン及び磁場データのうち、磁気地方時刻が10時から14時の範囲の昼側磁気圏境界面付近で観測されたデータを用いた。境界面平行方向に、この領域のアルフベン速度である約150 km/s以上の流速を持ちリコネクションにより発生したと思われるイオンジェットの反転が見られたイベントについて、観測された位置や構造の移動方向について統計解析を行った。発表では、観測されたXライン、Oラインの移動方向に対する、IMFと地磁気のシア角であるクロックアングルや、地磁気双極子の傾きの影響について議論する。

キーワード：磁気リコネクション、磁気圏境界面、flow reversal
Keywords: magnetic reconnection, magnetopause, flow reversal

磁気リコネクション成長段階におけるスケール則
Scaling-law for early-stage development of magnetic reconnection

*清水 健矢[1]、藤本 正樹[2,1]、篠原 育[2]
*Kenya Shimizu[1], Masaki Fujimoto[2,1], Iku Shinohara[2]

1.東京大学大学院理学系研究科、2.宇宙航空研究開発機構/宇宙科学研究所
1.Graduate School of Science, Tokyo University, 2.Japan Aerospace Exploration Agency/Institute of Space and Astronautical Science

A scaling-law for early-stage development of magnetic reconnection has been found from comparing two-dimensional particle simulation results of anti-parallel magnetic reconnection (asymptotic field denoted by B_0) with different current sheet thicknesses (D) and different ion-to-electron mass ratios (M). In these runs, magnetic reconnection is initiated by adding non-zero magnetic field normal to the current sheet. When the reconnected flux (in the B_0 D unit) at various times is plotted versus re-scaled reconnection electric field $E_{rx} D^{1/2}$ (E_{rx} in the $V_A B_0$ unit, where V_A is the relevant Alfven speed) obtained simultaneously, by which procedure a curve is obtained from each run, the curves obtained from the early development phases (reconnected flux < 2) of various runs are found to overlap among themselves. The spatial structures of some quantities around the X-lines determine the reconnection rates. Sampling the spatial profiles obtained when the same amount of magnetic flux is reconnected from different runs, we confirm that the non-dependence on M and the $D^{1/2}$-scaling of the reconnection rate are consistent with how the spatial scales vary according to M and D.

キーワード：磁気リコネクション
Keywords: Magnetic Reconnection

磁気圏尾部で観測されるアクティブ／非アクティブなフロー反転について
Active and non-active flow reversals observed in the magnetotail

*篠原 育[1]、長井 嗣信[2]、藤本 正樹[1]、小嶋 浩嗣[3]、銭谷 誠司[4]
*Iku Shinohara[1], Tsugunobu Nagai[2], Masaki Fujimoto[1], Hirotsugu Kojima[3], Seiji Zenitani[4]

1.宇宙航空研究開発機構／宇宙科学研究所、2.東京工業大学、3.京都大学／生存圏研究所、4.国立天文台
1.Japan Aerospace Exploration Agency/Institute of Space and Astronautical Science, 2.Tokyo Institute of Technology, 3.Kyoto University/Research Institute for Sustainable Humanosphere, 4.National Astronomical Observatory of Japan

We have statistically examined low-frequency plasma wave activity observed in the near Earth magnetotail flow reversals. 2/3 of the flow reversals have enhanced cross-tail electron current layer and ion-electron decoupling region detected in association with the simultaneous plasma flow and magnetic field reversals (“active” X-line), while the rest events do not show visible ion-electron decoupling features (“non-active” flow reversal). The most important conclusion of the present study on the electric wave activity in the lower hybrid frequency range is that only the active X-line events are accompanied by strong wave activities. Since the region where the strong wave activities are observed overlaps well with the ion-electron decoupling region, the ion-electron decoupling process would be related to excitation mechanisms of the intense electric wave activity. It means that the electric wave power around the flow reversals is a possible indicator for the ion-electron decoupling region (possibly, the liveliness of reconnection). This new finding would be one of the clues leading to our understanding of large-scale evolution of the magnetotail reconnection site. It is hard to address the physical meaning of the differences between active and non-active flow reversals only with single spacecraft measurements. This would be a good topic to be explored using MMS.

キーワード：磁気圏尾部、フロー反転、磁気リコネクション
Keywords: magnetotail, flow reversal, magnetic reconnection

Three-dimensional magnetotail reconnection: Geotail and Cluster observations

*Kevin Genestreti[1,2], Stephen A Fuselier[2,1], Jerry Goldstein[2,1], Tsugunobu Nagai[3], Jonathan P Eastwood [4]

1.Department of Physics and Astronomy, University of Texas San Antonio, 2.Space Science and Engineering Division, Southwest Research Institute, 3.Department of Earth and Planetary Sciences, Tokyo Institute of Technology, 4.The Blackett Laboratory, Imperial College London

In this study, we investigate the conditions required for reconnection at the dawn and far-dusk sides, which is significantly more rare than reconnection near midnight. We analyze more than 2 decades of Geotail and Cluster encounters with the near-Earth magnetotail reconnection site. Previous studies have suggested that reconnection onset occurs on the duskside, near midnight, and that reconnection sites may subsequently expand in the dawn-dusk direction with the cross-tail current. We find that reconnection on the duskside, near midnight can occur for comparably low and short-duration solar wind energy input. Reconnection sites on the dawn and far-dusk sides require sustained high solar wind energy input, suggesting that longer-cross-tail-length x-lines require sustained magnetotail reconnection. We also investigate the properties of the current sheet during 16 Cluster encounters with the reconnection site. We find the current sheet to be thinnest on the duskside, near midnight. Approximately where previous studies have identified the duskward edge of the reconnection site, we find the current sheet thickness to be larger than the ion inertial length, consistent with predictions from theoretical models of 3D reconnection. We compare the geomagnetic activity levels (Kp, AL, Dst) for each of the reconnection site observations. Consistent with the above solar wind activity dependence, we find that reconnection can be observed on the duskside, near-midnight, during extremely quiet times, but is only observed on the dawn and far-dusk sides during periods of highly elevated activity. This suggests that reconnection at the dawn and far dusk sides form as a result of cross-tail expansion during intervals where the total reconnection rate in the magnetotail is abnormally high. Finally, we use our work to make predictions for the upcoming MMS tail season.

Keywords: Magnetic Reconnection, Magnetotail, Magnetospheric Multiscale

Flapping current sheet motions excited by non-adiabatic ions in near-Earth magnetotail

*xinhua wei[1]

1. State Key Laboratory of Space Weather, National Space Science Center, Chinese Academy of Sciences

The current sheet is a crucial region of the magnetotail, where energy reserve and release take place. The origin of the up-down motions of the current sheet, referred to as flapping motions, is among the most fundamental issues of magnetotail dynamics. Obervational evidences suggest that the flapping motion is a kind of internal excited kink-like waves, but its particular propagating featueres such as the low phase speeds and the propagating direction from the tail center toward flanks do not match any local generation mechnisms prevrioudly established so far. Here we report observations of the current sheet flapping motions induced by non-adiabatic ions in the magentic field configurations with a finite guiding component, whose population present periodic hemispherical aymmetries.

Keywords: current sheet , flapping, non-adiabatic ions

