Contribution of pickup ions to the radial profile of the heliosheath

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The heliosheath (HS) is the two-layered region beyond the solar wind termination shock (TS). The inner heliosheath (IHS) is filled with solar wind plasmas, heated and decelerated at the TS, whereas the outer heliosheath (OHS) consists of interstellar medium (both plasmas and neutral atoms). The heliopause is the interface between the IHS and the OHS. The presence of a large amount of pickup ions (PUIs) gives distinct properties to the HS environment. Recent in-situ observations by Voyager 1/2 and measurements of ENA emission from the heliospheric boundary by IBEX have indeed suggested the significance of the PUI dynamics, e.g., its predominance of energy density in the HS. In this study, we have demonstrated numerical simulations using a hybrid code to investigate the consequence of interaction between the solar wind and interstellar plasmas, where PUIs are initially present only in the solar wind. We have confirmed the formation and growth of the TS and HP simultaneously, and identified that the inclusion of PUIs enlarges the radial depth of the IHS. We will further examine the dependence of the HS properties on the density ratio of PUI, the type of the initial PUI velocity distribution, and the magnetic field direction with respect to the TS/HP surfaces.

2018-19 年のひさき-NICER-X 線望遠鏡協調観測で発見された近接連星系における恒星フレア

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Stellar flare of a close binary system monitored by the Hisaki satellite during the NICER-Hisaki Observing Campaign 2018-2019

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Dynamics of stellar flare is still not well understood compared to that of the sun because of lack of continuous monitoring of distant stars at multiple wavelengths. Here we present a flare event at a close binary system, UX Arietis, monitored with the planetary extreme ultraviolet (EUV) space telescope Hisaki during the coordinated observing campaign with the NICER X-ray Telescope from late 2018 to early 2019. Time variability in the EUV spectrum of the binary was successfully monitored from the begging to the end of flare. Emission power at the EUV wavelengths peaked at 6e+24 W, which is comparable with that measured in the previous X-ray observations by e.g., the Advanced Satellite for Cosmology and Astrophysics (ASCA) (Gudel et al., 1999). The EUV spectrum showed emission lines of carbon, nitrogen, oxygen, and silicon ions. Electron temperature and density, emission measure, and ion balance were reduced from the emission lines by EUV spectral diagnostics. The spectral diagnostic indicates that EUV emission region with density and temperature comparable to the solar chromosphere expanded to spatial scale of a stellar radius (1-4e+6 km) during the flare. We interpret the EUV emission region is a flare ribbon expanding in the chromosphere. The flare's spatial scale of a stellar radius clearly contradicts the previous implication that the flare loop bridges between the two stars of binary system separated by 1.6 AU (2.4e+8 km) (Simon et al., 1980).

表面ピッチ角の扱いが異なるトーラス型フラックスロープモデルフィッティングの比較

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Comparison of toroidal flux rope model fitting with different boundary pitch angle treatments

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Interplanetary flux rope (IFR) is a characteristic magnetic field structure expelled from the Sun. The magnetic field structure of IFR consists of helical field lines whose pitch angles change with the distance from the axis. Correct estimation of axis direction and magnetic flux of IFR is important for understanding the formation of IFR at the Sun and the rotation of axis direction during propagation. These properties of IFR have been estimated by model fitting methods. Constant-alpha force-free toroidal model is used by Marubashi et al. (2007) to consider curvature effect which arises when spacecraft passes through IFR flank. In this model fitting, pitch angle of magnetic field at IFR surface is fixed to 90 degree (hereinafter we call conventional method). However, Nishimura et al. (2019) found that approximately 30% of IFR events have pitch angle significantly different from 90 degree using the cylindrical model fitting in which pitch angle is a free parameter (hereinafter we call generalized method). Nishimura et al. (2019) also found that estimated axis direction and magnetic flux of IFR were different between the conventional and generalized methods for the cylindrical model fitting. In this presentation, we introduce the generalized method for the toroidal model fitting. We show the difference between the results of the conventional and generalized methods, and the statistical distribution of pitch angle obtained from the generalized method for the toroidal model fitting. The toroidal model is fitted to in situ observations of magnetic obstacles (MOs) by Wind, STEREO-A or STEREO-B between 1995 and 2016 using the conventional and generalized methods. We compare the results of the conventional method and those of the generalized method. The difference of the results between the conventional and generalized methods is found to be small for poloidal magnetic flux (flux perpendicular to IFR axis), direction normal to torus plane, and tilt angle of axis direction at IFR apex. However, for toroidal magnetic flux (flux parallel to IFR axis) large difference (larger than the factor of $10^{0.25}$) is shown for approximately 35% of the events. This result shows that it is better to use the generalized method than the conventional method for the estimation of toroidal magnetic flux. The statistical distribution of pitch angle, which was estimated using the generalized method, shows a spread of 30 degree centered at 90 degree and that 65% of events are between 60 degree and 120 degree. This distribution is similar to that obtained from the cylindrical model fitting, in which the generalized method was used, by Nishimura et al. 2019. These results suggest that pitch angle at the surface of IFR is constant from the apex to the flank of IFR and for most of the events magnetic field direction at the surface of IFR is perpendicular to IFR axis.

Isolated Enhancement of >10MeV protons at or near interplanetary shock

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Solar Energetic Particles (SEPs) are often produced and detected at 1AU in association with solar eruptive events. While SEP events are generally classified into gradual and impulsive events depending on the observed time profiles, detailed SEP properties vary significantly from event to event. Here we report >10 MeV proton events at 1AU that do not immediately fall into either category of gradual or impulsive event. The primary feature of these events is a spiky, but relatively small, enhancement of >10 MeV proton flux with typical durations of a few hours. The events we have found so far were clearly associated with a passage of an interplanetary shock. Therefore, the events may be regarded as the so-called Energetic Storm Particle (ESP) events but with no (or very small) background SEP. Because all events were preceded by a passage of another shock and an enhancement of mildly energetic (0.1 - 2 MeV) particles, we conjecture that such isolated ESP events occurred due to local acceleration of particles facilitated by pre-conditioning or pre-acceleration.

電波掩蔽観測による太陽コロナの準周期変動と太陽活動度依存性の研究

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Quasi-periodic density fluctuation of the solar corona and its solar activity dependence studied by radio occultation

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For solar wind generation, the pressure gradient caused by the high temperature of the corona reaching 1 million K is important. Coronal heating is one of the unresolved problems of space plasma physics. Though various heating mechanisms such as wave heating and nano-flares have been proposed, confirmation by observational data is insufficient. We can divide this corona heating problem into two problems. One is the mechanism that heats plasma rapidly to a high temperature within several thousand km from the photosphere to the bottom of the corona, and the other is the mechanism that maintains the high temperature upto a distance of 10 to 20 solar radii. In recent years, information on the physical processes in the lower corona is being obtained by optical remote sensing by solar observation satellites. On the other hand, for the solar wind to be accelerated up to several hundred km/s as observed, the plasma needs to be continuously heated to somewhat far distances from several to tens solar radii. This region is too dark to investigate by optical observation, and the temperature is too high for in-situ measurements, and thus the observational data is limited. Radio occultation observation is one of the limited means that can approach this region.

The previous research using the Japanese Venus explorer Akatsuki in 2011 detected quasi-periodic density fluctuations that are considered to be acoustic waves using radio waves transmitted from the spacecraft and received at the ground station during the superior conjunction period, and derived the radial dependence of the energy flux. The quasi-periodic density fluctuations were considered to have been generated from the nonlinearity of Alfven waves that originate from the photosphere. At the same time, from the comparison with the solar wind velocity obtained by radio occultation, it was estimated that the dissipation of the acoustic waves heated the corona and accelerated the solar wind. However, the result was limited to a certain period of the 11-year solar activity cycle.

In this research, observations were carried out using radio waves transmitted from the spacecraft and received at the ground station during the superior conjunction period from 30 May 2016 to 15 June 2016 and the period from 29 December 2017 to 20 January 2018. Solar offset distances of about 2 to 10 solar radii were probed intermittently 11 times in the former period and 10 times in the latter period. We used data set of the frequency fluctuation of radio waves received from Akatsuki, which is derived from waveform data recorded at the ground station. We applied wavelet analysis to these data set, and then we aim to detect quasi-periodic density fluctuations (acoustic waves) and clarify the predominant period, amplitude, and the radial dependence of the energy flux. We also aim to clarify the dependence on the solar activity by analyzing all observational data from 2011 to 2018. In this presentation, we will report the current results of these analyses.

太陽風の生成には 100 万 K を超える太陽コロナの高温がもたらす圧力勾配が重要である。コロナ加熱問題は宇宙プラズマ物理の未解決問題の一つであり、波動加熱説やナノフレア説などの様々な加熱機構が提案されているが、観測データによる検証が不十分である。このコロナの加熱問題は 2 つの問題に分けて考えることができる。一つは太陽表面 (光球) からコロナ底部に至る数千 km の間に急激に高温に加熱するメカニズムであり、もう一つは 10〜20 太陽半径という遠方まで高温を維持するメカニズムである。近年、太陽観測衛星などによる光学リモートセンシングによってコロナ底部の加熱機構についての情報は得られつつある。しかし観測されているような数百〜1000km/s という太陽速度を達成するには 10〜20 太陽半径という遠方まで持続的な加熱が必要である。この空間領域は光学観測で調べるには暗く、探査機が近づいて観測するには温度が高すぎるため、観測データが乏しい。ここにアプローチできる限られた手段の一つとして電波掩蔽観測がある。

金星探査機「あかつき」を用いた先行研究では、2011 年に「あかつき」が地球から見て太陽の反対側を通過する機会に探査機と地上局を結ぶ電波を用いて音波と考えられる準周期的な密度変動を検出し、エネルギー流束の距離依存性を導出して、この波が Alfven 波の非線形性から生じたと推定した。また同時に電波掩蔽で得た太陽風速度との比較から、音波の散逸がコロナを加熱し太陽風を加速していると推定した。しかし 11 年周期で変動する太陽活動度のある一時期の結果しか得られていない。

今回は 2016 年 5 月 30 日から 6 月 15 日、および 2017 年 12 月 29 日から 2018 年 1 月 20 日にかけて「あかつき」が地球から見て太陽の反対側を通過する機会をとらえて電波掩蔽観測を行った。前者の期間には 11 回、後者の期間には 10 回にわたって、太陽中心からおよそ 2-10 太陽半径の範囲を断続的に観測した。地上局で記録した波形データから導出した「あかつき」からの電波の受信周波数の変動について wavelet 解析を行い、準周期密度変動 (音波) を検出し、卓越周期と振幅、エネルギー流束の距離依存性を明らかにすることを目指している。また、2011 年〜2018 年の全ての観測データについて解析を行うことにより太陽活動度への依存性を明らかにすることも目指している。本発表ではこれらの解析についての現段階での結果を報告する。

次世代太陽圏観測装置の検討と試作機の設計

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Next generation heliospheric observation instrument: plan and pathfinder design

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There are still many important issues in the heliospheric physics, such as the acceleration and propagation of the solar wind, the global structure of the heliosphere, and its variations associated with the solar activity. In addition, the propagation of coronal mass emissions (CMEs) in the inner heliosphere is important for the space weather forecasting. Interplanetary scintillation (IPS) is a radio scattering phenomenon caused by the disturbances in the solar wind. The IPS observation using ground-based radio telescopes has been an important technique to investigate the global structure of the heliosphere. We have observed the solar wind velocity and density irregularities for several decades using our own large radio telescopes. Recently, the unusual solar actively makes complex solar wind distributions, which requires more detailed IPS observations. In this study, we investigated the design of next generation IPS observation instruments, and developed their pathfinders.

Multi-point IPS observations throughout the year are required for more detailed reconstructions of the solar wind velocity distributions. In order to realize the IPS observation even in the snowfall season, we considered a flat two-dimensional dipole array with a wide field of view. This structure is also resistant to natural disasters such as typhoons by eliminating the drive unit. The real time digital signal processing of the receiver system is required for the digital multi beam forming that observes multiple directions simultaneously. This system will enable us to take several all-sky IPS maps within a day to track fast CMEs. One of the important development parts in this project will be the digital signal processing part that requires about 1000 units of digital boards. We designed a low-cost digital board dedicated to the IPS observation using ADCs and FPGAs, and found that the digital board has enough performance.

太陽風の加速・伝搬過程や太陽圏のグローバルな構造、およびその太陽活動に伴う変動など、太陽圏物理学には未だ重要な問題が多く残されている。加えて、コロナ質量放出（CME）の太陽圏内の伝搬は宇宙天気予報の観点でも重要な研究対象である。太陽風中の擾乱が伝搬を散乱することで惑星間空間シンチレーション（IPS）が発生する。名古屋大学では独自の IPS 観測装置を開発し国内 3 カ所に設置することで、地上電波観測から太陽風の速度と密度を測定し、太陽圏の物理過程の解明に取り組んできた。一方、近年の特異な太陽活動に伴う複雑かつ低密度な太陽風構造の導出のためには、より詳細で稠密な観測データが必要となってきた。本研究では、次世代の太陽圏研究に向けた IPS 観測装置の検討を行うとともに、実証実験機の設計を行った。

太陽風速度分布をより詳細に導出するためには、通年での多地点 IPS 観測が有効である。そこで、降雪時にも装置を運用できるよう、アンテナ部は 2 次元の広視野平面ダイポールアレイを採用し、駆動部を無くすことで台風などの自然災害にも強い構造を検討した。受信機では信号をリアルタイムにデジタル処理することで、複数の方向を同時に指向するデジタルマルチビームフォーミングを採用し、1 日に複数回全天をスキャンすることで、より高速な CME の追跡を可能にした。本計画における最大の開発要素は約 1000 台必要となるデジタル信号処理部である。そこで、本観測専用のデジタルボードを、AD 変換機と FPGA 等を用いて設計した結果、十分に低コストで目標の性能を実現できることが分かった。

かにパルサーの太陽掩蔽による 5-14 Rs におけるコロナプラズマ密度測定

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Coronal plasma density measurements at 5-14 Rs from solar occultation of Crab pulsar

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Dispersion measures (DMs) derived from pulsar observations provide information of line-of-sight (LOS) integrated density of the intervening plasma. We made DM measurements of Crab pulsar in 2018 during solar occultation in 2018 using the 327-MHz radio-telescope at Toyokawa (called SWIFT, Tokumaru et al., 2011). The aim of these measurements is to investigate the coronal plasma density near the Sun in the current cycle; SC24; which is the weakest in the past 100 years. The LOS of Crab pulsar approaches the Sun as close as ˜5 Rs, passing over the South pole in mid-June every year. We determined the DM by maximizing a peak height for each giant pulse (GP) detected from Crab observations, and then taking a mean of the values obtained for a given day. The observed DMs during the period around the closest approach; i.e. June 13-19, 2018, showed excesses over the interpolated level from two adjacent DMs which were taken at $>$50 Rs. This excesses were considered as the effect of the solar corona. We fit a spherically symmetric model of the coronal density, which was given as a power law function of the radial distance, to the observed DM data. The best fit model were found to be generally consistent with past studies which reported Crab pulsar observations in 1969-1973. This may suggest that no significant change occurred in the coronal plasma density despite marked decline of the solar activity in SC24. However, data obtained here are associated with large estimation errors, and the number of the data is limited. Therefore, we need to collect the data further to deduce a conclusion about the difference between the current and past cycles. We compared the DM data with LASCO coronagraph observations and also with solar wind speed data derived from ISEE IPS observations. As result, a high level of the DM excess observed on June 19 was found to likely represent the high density plasma associated with the streamer and the slow solar wind near the equator. No significant increase in the scattering timescales of giant pulses was observed during the solar occultation. Since the variation of giant pulse occurrence rates correlated with that of scattering timescales, it was ascribed to the scattering effect by the interstellar medium.

高速太陽風の三次元磁気流体シミュレーション

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Three-dimensional magnetohydrodynamic simulation of the fast solar wind

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Using a three-dimensional compressible magnetohydrodynamic (MHD) simulation, we have reproduced the fast solar wind in a direct and self-consistent manner, based on the wave/turbulence-driven scenario. As a natural consequence of Alfvenic perturbations at the coronal base, highly compressional and turbulent fluctuations are generated, leading to heating and acceleration of the solar wind. The analysis of power spectra and structure functions reveals that the turbulence is characterized by its imbalanced (in the sense of outward Alfvenic fluctuations) and anisotropic nature. The density fluctuation originates from the parametric decay instability (PDI) of outwardly propagating Alfven waves and plays a significant role in the Alfven-wave reflection that triggers turbulence. Our conclusion is that the fast solar wind is heated and accelerated by compressible MHD turbulence driven by PDI and resultant Alfven-wave reflection.

Identification of coarse-graining scales of solar wind Alfvenic turbulence via time series of a single point measurement

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Energy cascade and scale-coupling processes in solar wind turbulence have widely been investigated by many authors. Since broadening spectra of the solar wind turbulence usually contain both MHD and ion kinetic scales, adequate coarse-graining scales for MHD approximation is not trivial in the solar wind plasmas. In this presentation, we discuss the identification of coarse-graining scale of Alfvenic turbulence with sub-grid scale modeling (filtering). By using the Taylor hypothesis, time series obtained by a single point measurement is applied to identify the coarse-graining scales. Dependence of the coarse-graining scales on filtering methods and spectra of the turbulence will be demonstrated by using both numerical and observational data.

月ウェイク中タイプ II エントリープロトンに伴う ELF 波の振動方向について

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Direction of oscillation of the ELF waves associated with the type-II entry protons in the deepest lunar wake

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The solar wind particles that hit the moon are mostly absorbed by the lunar surface, leaving a plasma void region called the lunar wake downstream. Differently from the solar side of the moon where reflected solar wind particles give rise to various wave activities, the lunar wake is essentially quiet in magnetic fluctuations.

An exception is the ELF waves associated with the type-II entry ions, a kind of reflected ions that can access the central wake due to their large gyro radius. In order to study the generation mechanism of the waves, the directions of k vectors and the magnetic oscillation were examined using magnetic field and plasma observations by MAP/LMAG magnetometer onboard Kaguya. It is difficult to find the exact direction of k vector because the variation of the magnetic field is not always two-dimensional but often one-dimensional. They were rather on the perpendicular side to the background magnetic field. The direction of the oscillation shows preference to be parallel to the background magnetic field.

太陽風中の月の裏側は、太陽風粒子が入り込むことができないため通常は磁場変動が少なく静穏であるが、稀に月の真裏の深ウェイクに周波数 0.1-5Hz 程度の ELF 波動が観測されることがある。この波はタイプ II エントリープロトン（月面でいったん反射したのちジャイロ運動でウェイクに侵入するプロトン）とともにみられ、さらに沿磁力線電子流も同時に観測されることがわかっている。しかしこの波の励起機構はわかっていなかった。

これを考えるうえで、波の k ベクトルの向きが重要となるため、かぐや衛星搭載 MAP/LMAP データに基づいて周波数別の minimum variance analysis(MVA) を行い k ベクトルの方向を調べた。その結果、k の方向は背景磁場に垂直に近くなる傾向がみられた。一方、変化最大の方向は背景磁場に平行に近くなっており、磁場を横切るプロトンが音波のような波を立てる描像と合っている。

候補となる変形 2 流体不安定性 (MTSI)、低域混成ドリフト不安定性の妥当性を考えるには、k ベクトルの方向とイオン速度の方向、電流の方向との関係が重要である。2008 年 9 月 24 日 10:10 の例では、磁場 y 成分卓越時に、タイプ II エントリーイオンと沿磁力線電子流に加え、電子の速度に z 方向成分が観測され、また z 成分のみにイオンと電子に速度差が見られた。しかしながら k ベクトルの方向が周波数ごとにばらついており、未だ発生機構の決定には至っていない。

地球バウショックにおけるコヒーレントなホイッスラーモード波動の解析：MMS衛星による複数衛星観測

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Analysis of coherent whistler mode waves at Earth's bow shock: MMS spacecraft observation

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The generation mechanism of nonthermal particles is one of the most important unresolved problems in space physics. The Fermi acceleration at a shock wave is one of the leading mechanisms for the nonthermal particle acceleration. In this mechanism, pitch angle scattering due to wave-particle interaction is important to confine charged particles in the vicinity of the shock wave while charged particles are being accelerated. In particular, whistler mode waves are considered as the scattering agent for electrons. The whistler mode waves are high frequency electromagnetic waves which propagate parallel to the background magnetic field with right-hand circular polarization. Whistler mode waves are observed in the shock transition layer [Hull et al., 2012], and are thought to scatter electrons efficiently by cyclotron resonance. In fact, observation of wave-particle interaction between electrons and whistler mode waves in the shock wave transition layer has been reported [Oka et al., 2017]. However, it has been known that the acceleration of electrons at the shock is rare, and the relation between whistler mode waves and electron scattering efficiency has not yet been clarified.

In this study, we investigate the propagation characteristics of whistler mode waves statistically for clarifying the electron scattering efficiency in the shock transition layer using data from the Magnetospheric Multiscale (MMS) spacecraft.

We focused on 25 seconds of 10:29:50-10:30:15 UT on Dec. 6, 2016, as a period during which the energetic electron flux was enhanced in the Earth's bow shock. At first, as a single spacecraft analysis, we applied band pass filters with a bandwidth of 20 Hz for the typical frequency band of whistler mode waves, 0.1 to 0.5 fce (30 - 150 Hz; fce ~300 Hz). We performed Minimum Variance Analysis (MVA) with a time window of 50 ms for each of the filtered frequency bands. At this time, the propagation direction was uniquely determined by considering the direction of the Poynting flux. Also, we determined the phase velocity from the electric-to-magnetic field ratio using Faraday's law for each time window. We conducted this analysis for the above period during which the MMS spacecraft passed through the shock transition layer. We investigated the time variation of wave propagation directions, wave amplitude, and dispersion relation. We analyze each spacecraft independently and report the result of statistical analysis of the propagation direction and wave amplitude of the whistler mode wave in the shock transition layer.

In the previous analysis, we found that different spacecraft observed completely different waveforms when the spacecraft separation was as large as 20 km which is smaller than the typical ion inertial length. This indicates that the coherent scale length of whistler mode wave packets are on the electron scale. By taking the advantage of an even smaller spacecraft separation distance of 7 km for the analyzed event, we will discuss the spatial scale of the wave packet of the whistler mode wave and the propagation characteristics parallel and perpendicular to the magnetic field by comparing the analysis results independently performed by each spacecraft.

非熱的な荷電粒子の生成機構の問題は宇宙物理における大きな未解決課題の 1 つである．その有力な候補の 1 つとして衝撃波近傍におけるフェルミ加速が考えられている．フェルミ加速では、衝撃波近傍に粒子を閉じ込めるために波動粒子相互作用によるピッチ角散乱が重要となる．特に衝撃波近傍で電子を散乱させる波動としてホイッスラーモード波動が示唆されている．ホイッスラーモード波動は背景磁場に対し右円偏波しながら平行伝播する高周波の電磁波である．ホイッスラーモード波動は衝撃波遷移層で観測されており [Hull et al., 2012]、電子とサイクロトロン共鳴することで散乱効率を高めていると考えられている．実際に衝撃波遷移層で波動粒子相互作用する電子とホイッスラーモード波動の観測例が存在する [Oka et al., 2017]．しかし、衝撃波における電子加速の例が少なく、実際に加速を引き起こすためのホイッスラーモード波動による電子散乱効率は未だ明らかになっていない.

本研究では、ホイッスラーモード波動の伝播特性を統計的に調べ、衝撃波遷移層における電子散乱効率を明らかにすることを目的とする．今回の解析を行うにあたり、我々はＮＡＳＡのＭＭＳ (Magnetospheric Multiscale) 衛星を用いた．

本研究では、地球バウショックにおいて電子のエネルギーが増大している期間として 2016 年 12 月 6 日 10 時 29 分 50 秒 - 30 分 15 秒の 25 秒間に着目した．まず単一衛星解析として、ホイッスラーモード波動の主な周波数帯である 0.1-0.5 fce(30-150 Hz；fce~300 Hz) について 20 Hz 毎に区切ってバンドパスフィルタをかけた．フィルタをかけた各周波数帯において 50 ms の時間幅で Minimum Variance Analysis(MVA) を行った．この時ポインティングフラックスの向きを考慮することにより、伝播方向を一意に決定した．また、各時間帯での電場と磁場の強度比からファラデーの法則を用いて位相速度を求めた．この解析を、ＭＭＳ衛星が衝撃波遷移層を通過する上記期間について行い、各周波数帯における波動の伝播方向や磁場強度の時間変動、および磁場に対して平行方向の伝播速度と周波数の関係を調べた．発表では、各衛星について独立にこれらの解析を行い、衝撃波遷移層内でのホイッスラーモード波動の伝播方向や磁場強度の特性を統

計的に解析した結果を報告する．

また、過去に我々が行った複数衛星解析の結果より、MMS 衛星の衛星間距離が 20 km 程度の期間では、各衛星におけるホイッスラーモード波動の波形に対応が見られないことが分かっている．この衛星間距離がイオン慣性長程度であることから、ホイッスラーモード波動の空間スケールはイオンスケールよりも小さい電子スケールであることが示唆されている．これを踏まえ、今回の発表では各衛星で独立に行った解析結果を比較することにより、ホイッスラーモード波動の波束の空間スケールや、磁場に対し平行および垂直方向の伝播特性についても議論する．

ピックアップイオンを含む衝撃波の 2 次元構造

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2D structure of pickup ion mediated shocks

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Pickup ion mediated shocks are observed in heliospheric boundary region such as a solar wind termination shock and interplanetary shocks. The effect of pickup ions in the microphysics of these shocks have not been well understood. We perform two-dimensional full particle-in-cell simulations of the pickup ion mediated shocks. Influence of the pickup ions in the microstructures of shock surface rippling and downstream region for various relative pickup ion densities is examined. When the relative pickup ion density is 25%, the spatial scale of the ripple becomes smaller compared with the case without pickup ions. When further increased the pickup ion density to 60%, the ripple disappears. The downstream of the shock is turbulent because of the instabilities caused by temperature anisotropy. The dominant wavelength of the downstream waves is also largest when no pickup ions are included. On the other hand, the spatial scale of the overshoot-undershoot structure downstream increases as the relative pickup ion density increases. We evaluate temperature anisotropy in each case and discuss the properties of expected instabilities.

4 期間にわたる「ひさき」衛星による惑星間空間ヘリウム分布の光学観測

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4-period's optical observation of neutral helium distribution in interplanetary space by Hisaki

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The Hisaki (SPRINT-A) satellite, which has the extreme ultraviolet spectrograph, has a main scientific motivation on the planetary magnetospheric physics and atmospheric evolution by long-term observations. However, it also carried out an observation of helium atom resonance scattering emission in interplanetary space.

A material in the interstellar medium (ISM) travels into the heliosphere over the heliopause due to the relative velocity between the heliosphere and interstellar gases. Helium moves into the neighboring from the sun without ionizing because of its high ionization energy. Its trajectory is bent by sun gravity force along the Keplerian orbit and it results to form a high-density region on the downwind side, which is called helium cone. The distribution of helium atoms in the cone can estimate the speed and direction of the interstellar wind, and the density and temperature of helium in interstellar medium. This study has been carried out since the 1970s, but the interplanetary helium atoms observation is one of powerful tools to recognize the interstellar medium from inside the heliosphere.

The Hisaki satellite carried out the observation of the resonance scattering emission from inside the helium cone during November and December in years of 2015 to 2018. The interstellar parameters derived from the Hisaki's observation results are reported.

「ひさき (SPRINT-A)」衛星の主目的は長期間にわたる継続した惑星大気・プラズマの極端紫外光分光観測であるが、オプション観測として惑星間空間に分布するヘリウム原子からの共鳴散乱光観測を実施している。

惑星間空間ヘリウム原子の主な起源は星間ガスである。星間ガスと太陽圏の相対速度により、星間風として移動する水素・ヘリウム原子がヘリオポーズを超えて惑星間空間に侵入している。高いイオン化エネルギーのため、ヘリウム原子はイオン化することなく太陽近傍にまで侵入し、太陽の星間風風下側に密度の濃い領域を形成する。これをヘリウムコーンと呼ぶ。ヘリウム原子の侵入軌道は放射圧にはほとんど依存しない太陽重力によるケプラー運動に近似できるため、　ヘリウムコーンのヘリウム分布は、星間風の速さと方向、星間空間ヘリウム原子の密度と温度によって決定づけられる。1970 年代から実施されている歴史の長い研究であるが、惑星間空間に滞在しながら星間ガスのパラメータを推定することが可能であるため、星間ガス研究にとって貴重な観測方法のひとつである。

「ひさき」衛星は、ヘリウムコーンを通過する 11 月から 12 月に合わせて惑星間空間ヘリウム原子の共鳴散乱光観測を実施した。今回は 2015～2018 年の 4 期間にわたり観測した結果から推定した星間ガスのパラメータを過去の研究結果とともに報告する。