

Program of PASW26

May 12 (Tue)-15 (Fri) 2026
Shilla Stay Haeundae, Busan, Korea

Presentation Type		
Lecture	50 minutes (45 minute talk + 5 minute Q&A)	total 10
Invited talk	25 minutes (20 minute talk + 5 minute Q&A)	total 16
Contributed talk	15 minutes (12 minute talk + 3 minute Q&A)	total 19
Poster flash talk	3 minutes	total 9

May 11, 2026 (Mon)				
Time	Schedule			
15:00-18:00	Ballroom setup, Registration, Poster panel installation and poster display			
May 12, 2026 (Tue)				
Time	Schedule			
08:30-09:25	Registration			
09:25-09:30	Opening [Dongsu Ryu]			
Session 1 [Chair: Hyesung Kang]				
Time	Name	Affiliation	Present type	Title
09:30-10:20	Jiansen He	PKU, China	Lecture	Turbulence in Heliosphere
10:20-11:10	Hiroya Yamaguchi	ISAS, JAXA, Japan	Lecture	Atomic Processes in Astrophysical Plasmas with XRISM High-Resolution Spectroscopy
11:10-11:40	Coffee Break			
Session 2 [Chair: Dongsu Ryu]				
Time	Name	Affiliation	Present type	Title
11:40-12:30	Luciano Rezzolla	Goethe University Frankfurt, Germany	Lecture	Binary neutron-stars I: Bulk Dynamics and Gravitational Waves
12:30-14:00	중식			
Session 3 [Chair: Quanming Lu]				
Time	Name	Affiliation	Present type	Title
14:00-14:25	Jungyeon Cho	Chungnam National University(CNU), Korea	Invited talk	Sub-Alfvenic MHD Turbulence
14:25-14:40	Yaokun Li	Shandong University, China	Contributed talk	The First Particle-in-Cell Simulation of Three-Dimensional Strong Langmuir Turbulence
14:40-14:55	Yuri Yamashita	Nagoya University, Japan	Contributed talk	Systematic Identification of MHD Turbulence Regimes and Their Physical Properties
14:55-15:10	Ningning Guo	Xiangtan University, China	Contributed talk	Effects of Synchrotron Self-Absorption on Polarization Diagnostics of MHD Turbulence
15:10-15:35	Chuanpeng Hou	University of Potsdam, Germany	Invited talk	The Contribution of Turbulence to Solar Wind Heating in the Inner Heliosphere
15:35-16:00	Huirong Yan	Deutsches Elektronen-Synchrotron(DESY) & University of Potsdam, Germany	Invited talk	Bridging Observational and Numerical Analyses of Turbulence to Cosmic Ray Anisotropy
16:00-16:30	Coffee Break, Group Photo			
Session 4 [Chair: Jianfu Zhang]				
Time	Name	Affiliation	Present type	Title
16:30-16:45	Ziqi Liu	Xiangtan University, China	Contributed talk	Probing Spectral Properties of Magnetized ISM via Polarization Statistics
16:45-17:10	Hui Li	Los Alamos National Laboratory(LANL), USA	Invited talk	Kink-Unstable Jets: Polarization and Particle Acceleration
17:10-17:35	Ken Ohsuga	University of Tsukuba, Japan	Invited talk	Numerical Simulations of Black Hole Accretion Flows and Outflows
17:35-17:50	Ryoji Matsumoto	Chiba University, Japan	Contributed talk	Global Radiation MHD Simulations of Magnetically Supported Disks in Active Galactic Nuclei
17:50-18:05	Weibo Yang	Huazhong University of Science and Technology(HUST), China	Contributed talk	Numerical Simulations of Faraday Rotation in AGN Jet-Lobe Systems
18:05-18:30	Mengke Zhao	Nanjing University, China	Invited talk	Equation vs. AI in the Multiscale ISM: Can Deep Generative Models Internalize the Laws of Star Formation?

May 13, 2026 (Wed)				
Session 5 [Chair: Hyesung Kang]				
Time	Name	Affiliation	Present type	Title
09:00-09:50	Luciano Rezzolla	Goethe University Frankfurt, Germany	Lecture	Binary Neutron-Stars II: Multi-messenger Emission
09:50-10:40	Quanming Lu	University of Science and Technology of China(USTC), China	Lecture	Collisionless Magnetic Reconnection in the Magnetosphere
10:40-11:10	Coffee Break			
Session 6 [Chair: Siming Liu]				
Time	Name	Affiliation	Present type	Title
11:10-12:00	Ryo Yamazaki	Aoyama Gakuin University(AGU), Japan	Lecture	Origin of Galactic cosmic rays, cosmic-ray acceleration and beyond
12:00-12:25	Hirofumi Noda	Tohoku University, Japan	Invited talk	High-Resolution X-ray Spectroscopy of Active Galactic Nuclei with XRISM: Probing the Vicinity of Supermassive Black Holes
12:25-14:00	Lunch			
Session 7 [Chair: Youichi Sakawa]				
Time	Name	Affiliation	Present type	Title
14:00-14:25	Masahiro Kobayashi	National Institute for Fusion Science(NIFS), Japan	Invited talk	Experimental Study of Thermal Instability in Magnetized Plasmas: Bridging Fusion, Astrophysics, and Solar Physics
14:25-14:50	Qingwen Wu	Huazhong University of Science and Technology(HUST), China	Invited talk	The stellar process in dense nuclear environments: dynamics and multi-messenger
14:50-15:15	Kenichi Nagaoka	National Institute for Fusion Science(NIFS), Japan	Invited talk	Experimental Study on Wave-Particle Interactions in Magnetically Confined Plasmas
15:15-15:30	Krushna Chandra Barik	Asia Pacific Center for Theoretical Physics(APCTP), Korea	Contributed talk	Direct MMS Observations of Canonical Vorticity Dynamics during Magnetic Reconnection
15:30-15:45	Fa Yang	University of Science and Technology of China(USTC), China	Contributed talk	Laboratory Observations of Hall Magnetic Field in Electron-only Magnetic Reconnection with a Guide Field
15:45-16:00	Lianyan Fu	Shandong University, China	Contributed talk	Electron-Scale Reconnection as a Micro-Accelerator of Relativistic Electrons in Solar Flares
16:00-16:30	Coffee Break			
Session 8 [Chair: Hui Li]				
Time	Name	Affiliation	Present type	Title
16:30-16:45	Subham Ghosh	Asia Pacific Center for Theoretical Physics(APCTP), Korea	Contributed talk	The Conditions for the Onset of Magnetic Reconnection in an Asymmetric Current Sheet
16:45-17:00	Subhasish Bag	Asia Pacific Center for Theoretical Physics(APCTP), Korea	Contributed talk	An Asymmetric Current-Driven Magnetic Reconnection Thruster
17:00-17:30	Poster flash talks			
17:30-18:30	Discussion 1 [Led by Hui Li]			

May 14, 2026 (Thu)

Session 9 [Chair: Kenichi Nagaoka]

Time	Name	Affiliation	Present type	Title
09:00-09:50	Shuichi Matsukiyo	Kyushu University, Japan	Lecture	Kinetic Simulation Studies on Heliospheric Collisionless Shocks
09:50-10:40	Youichi Sakawa	Osaka University, Japan	Lecture	Laboratory Astrophysics Using Power-Laser Systems: Collisionless Shock and Particle Acceleration
10:40-11:10	Coffee Break			

Session 10 [Chair: Qingwen Wu]

Time	Name	Affiliation	Present type	Title
11:10-11:35	Xuening Bai	Tsinghua University, China	Invited talk	Simulating Cosmic-ray Acceleration, Transport and Feedback Across Scales
11:35-12:00	Yosuke Matsumoto	Chiba University, Japan	Invited talk	Positron accelerations in relativistic magnetized astrophysical shocks
12:00-12:15	Dongsu Ryu	Ulsan National Institute of Science and Technology(UNIST), Korea	Contributed talk	Cosmic Ray Acceleration at Shocks in High-Beta Intracluster Media
12:15-12:30	Zhoufan Mu	Shandong University, China	Contributed talk	Electron Velocity Distribution Function at Different Structures of Quasi-Perpendicular Shock
12:30-12:45	Ka Ho Yuen	Nanjing University, China	Contributed talk	First-Order Fermi Acceleration and Anomalous Scattering of Cosmic Rays in Thermally Instability Mediated Interstellar Turbulence
12:45-13:00	Zebin Zhang	Shandong University, China	Contributed talk	Exploring the Dominant Process of Solar Toroidal Magnetic Flux Loss
13:00-13:25	Sunjung Kim	Kyunghee University, Korea	Invited talk	EPIC-GOD: Energy-Conserving GPU-Accelerated PIC Simulations for Space and Astrophysical Plasmas
13:25-18:30	Lunch & Free time			
18:30-	Banquet			

May 15, 2026 (Fri)				
Session 11 [Chair: MinSup Hur]				
Time	Name	Affiliation	Present type	Title
09:00-09:50	Siming Liu	Southwest Jiaotong University(SWJTU), China	Lecture	Latest Results From LHAASO
09:50-10:40	Katsumi Ida	National Institute for Fusion Science(NIFS), Japan	Lecture	Development of Advanced Spectroscopic Systems for Fusion and Astrophysical Plasmas
10:40-11:10	Coffee Break			
Session 12 [Chair: Jungyeon Cho]				
Time	Name	Affiliation	Present type	Title
11:10-11:25	Suresh Basnet	Asia Pacific Center for Theoretical Physics(APCTP), Korea	Contributed talk	Equation of State for Cylindrically Confined Collisionless Magnetized Plasma: Classical and Quantum Partition Function Approaches
11:25-11:40	Zhangxi Xue	Southwest Jiaotong University(SWJTU), China	Contributed talk	Understanding the Precise Measurements of Cosmic Rays by LHAASO
11:40-12:05	MinSup Hur	Ulsan National Institute of Science and Technology(UNIST), Korea	Invited talk	TBD
12:05-12:30	Inhyuk Nam	Ulsan National Institute of Science and Technology(UNIST), Korea	Invited talk	Laboratory Astrophysics Using Intense Lasers
12:30-14:00	Lunch			
Session 13 [Chair: Ryoji Matsumoto]				
Time	Name	Affiliation	Present type	Title
14:00-14:25	Chulmin Kim	Institute(IFS) & Gwangju Institute of Science and Technology(GIST), Korea	Invited talk	Strong-Field Quantum Electrodynamics and Its Implications to High-Energy Astrophysics
14:25-14:40	Xi Lin	Huazhong University of Science and Technology(HUST), China	Contributed talk	A New Dynamo-Resistive GRMHD Code in the AthenaK Framework
14:40-14:55	Mingyu Ryu	Ulsan National Institute of Science and Technology(UNIST), Korea	Contributed talk	VLBI Detections of Compact Nuclei in Spiral-hosted Double-lobed Radio-loud Active Galactic Nuclei (DRAGNs): Evidence for Weak Parsec-Scale Jet Activity
14:55-16:00	Discussion 2 & Closing [Led by Ryoji Matsumoto]			

May 12(Tue) - May 14(Thu)		
Poster flash talk		
Name	Affiliation	Title
Youngjae Kim	Kyunghee University, Korea	Interpretable Data-Driven Solar Flare Forecasting Model
Jaeho Lee	Ulsan National Institute of Science and Technology(UNIST), Korea	Compensation of Fluctuation Using Gradient-Plasma Photonic Crystal for Laser Pulse Compression
Masato Matsuoka	Nagoya University, Japan	Experimental Observation of Stabilization Effect of Alfvén Eigenmodes due to Resonant Interaction with Energetic Ions in Magnetically Confined Toroidal Plasmas
Dohyun Park	Ulsan National Institute of Science and Technology(UNIST), Korea	TBD
Jingyu Peng	Peking University, China	Ion Stochastic Heating by Wave-Induced Field Line Curvature in Space Plasmas
Hayato Saguchi	Tohoku University, Japan	Analytical Maximum Growth Rates of the Parametric Decay Instability and Beat Instability Derived from Double-Adiabatic/CGL Equations
Yuki Tamaki	Nagoya University, Japan	Fragmentation of Non-thermal Filaments in the Galactic Center Induced by Synchrotron Cooling Instability
Nan Xiang	Shandong University, China	Analysis of Magnetic Field Configuration and Full-Orbit Particle Dynamics Simulation in the NCSX Stellarator

Lecture Turbulence in Heliosphere

Jiansen He [PKU, China]

Lecture Atomic Processes in Astrophysical Plasmas with XRISM High-Resolution Spectroscopy

Hiroya Yamaguchi [ISAS, JAXA, Japan]

Hot plasmas are ubiquitous in the universe, spanning spatial scales from the solar corona to galaxy clusters. This ubiquity reflects the fact that gravitational and nuclear energy are ultimately converted into thermal energy. Consequently, studies of astrophysical plasmas are essential for understanding the dynamical and chemical evolution of the universe.

The X-Ray Imaging and Spectroscopy Mission (XRISM) is opening a new window on such plasmas through high-resolution X-ray spectroscopy. Its onboard X-ray microcalorimeter Resolve achieves an energy resolution of 4.5 eV (FWHM) and an energy scale accuracy of 0.2 eV around the Fe K band, enabling emission and absorption lines to be resolved according to their individual quantum transitions.

These spectral features arise from a variety of atomic processes, including collisional excitation, radiative recombination, resonant scattering, and inner-shell transitions. High-resolution spectroscopy therefore provides powerful diagnostics of plasma conditions such as temperature, ionization state, velocity structure, and elemental abundances.

In this lecture, I will review the key atomic processes responsible for X-ray emission and absorption in hot astrophysical plasmas, and discuss what physical information can be extracted from XRISM observations of objects such as X-ray binaries and supernova remnants.

Lecture Binary neutron-stars I: Bulk Dynamics and Gravitational Waves

Luciano Rezzolla [Goethe University Frankfurt, Germany]

I will argue that if black holes represent one of the most fascinating implications of Einstein's theory of gravity, neutron stars in binary system are its richest laboratory, where gravity blends with astrophysics and particle physics. In the first lecture, I will first discuss the basic techniques employed in the modelling of these systems. Next, I will review the rapid recent progress made in modelling these systems and show how the gravitational signal can provide tight constraints on the equation of state of nuclear matter and evidence for a phase transition to quark matter.

Invited Talk Sub-Alfvénic MHD Turbulence

Jungyeon Cho [Chungnam National University(CNU), Korea]

Many astrophysical fluids are magnetized and turbulent, and can be properly described by magnetohydrodynamics (MHD). In this talk, I will mainly consider MHD turbulence with a strong mean magnetic field whose energy density is greater than the local kinetic energy density. That is, I will focus on sub-Alfvénic turbulence, in which the rms velocity of fluid is smaller than the Alfvén speed. In the presence of a strong mean magnetic field, waves are generated by fluid motions. In such fluids, MHD waves, especially Alfvén waves, play an important dynamical role. Alfvén waves travel along magnetic field lines and collisions of opposite-traveling Alfvén wave packets are essential for turbulence cascade. If the mean magnetic field is very strong, wave packets move very fast and duration of collision is too short to complete turbulence cascade. I will discuss scaling relations in this regime.

Contributed Talk The First Particle-in-Cell Simulation of Three-Dimensional Strong Langmuir Turbulence

Yaokun Li [Shandong University, China]

We present a fully kinetic particle-in-cell simulation of three-dimensional strong Langmuir turbulence (3D SLT). We find that: (1) Coherent Langmuir waves, initially excited as large-scale, propagating localized wave packets, break up into multiple small-scale, standing collapse wave packets. (2) The wave-number broadening in the collapse region is significantly enhanced ($\Delta k \sim 20 \omega_{pe}/c$), and the electric field energy spectrum $E^2(k)$ exhibits a power-law scaling with an exponent of approximately ~ -1.3 . (3) Compared to 2D case, 3D turbulence exhibits more efficient wave energy dissipation, producing a greater number of high-speed electrons ($v > 5 [v]_{te}$). This study presents the first simulation of the full life cycle of 3D SLT, which holds significant importance for understanding the nonlinear collapse and dissipation processes of SLT prevalent in space and laboratory plasmas.

Contributed Talk Systematic Identification of MHD Turbulence Regimes and Their Physical Properties

Yuri Yamashita [Nagoya University, Japan]

Magnetic turbulence has been suggested to be controlled either by Alfvénic dynamics or by magnetic reconnection, and the relative importance of these two mechanisms has remained an open question. In this work, we examine the physical processes that regulate the evolution of magnetic turbulence by means of numerical simulations. We consider maximally helical MHD turbulence in a magnetically dominated regime, and systematically vary the magnetic field strength, fluid viscosity, and magnetic diffusivity. Because magnetic helicity density is not conserved in non-ideal MHD, we use its decay behavior as a diagnostic to identify the dominant governing mechanism. We find that the turbulent evolution is consistent with the Sweet-Parker reconnection regime for Lundquist numbers in the range $10 \lesssim S \lesssim 100$. While it has been suggested that the characteristic timescale of magnetic turbulence appears to be primarily determined by the Alfvén regime, our results suggest that reconnection appears to play a dominant role in governing magnetic turbulence.

Contributed Talk Effects of Synchrotron Self-Absorption on Polarization Diagnostics of MHD Turbulence

Ningning Guo [Xiangtan University, China]

Statistical techniques based on synchrotron polarization are commonly used to study the properties of magnetohydrodynamic (MHD) turbulence. However, most existing polarization statistical diagnostics are developed under the optically thin approximation and neglect the potential effects of synchrotron self-absorption (SSA). Therefore, based on three-dimensional MHD turbulence simulation, incorporating SSA into the radiative transfer framework of synchrotron emission, and systematically studying the influence of SSA on the statistical characteristics of MHD turbulence.

Invited Talk The Contribution of Turbulence to Solar Wind Heating in the Inner Heliosphere

Chuanpeng Hou [University of Potsdam, Germany]

The solar wind cools more slowly than expected from adiabatic expansion, indicating additional heating. By tracking the same fast solar-wind stream from Solar Orbiter to 1 au, we find that intermittent velocity spikes gradually dissipate during propagation, reducing the cooling rate and increasing plasma temperature and entropy. This evolution is consistent with predictions from Alfvénic turbulence theory. In parallel, kinetic simulations of compressible turbulence show that compressive fluctuations provide an additional pathway for energy transfer and dissipation: at magnetohydrodynamic scales, collisionless damping efficiently generates suprathermal particles. Under solar-wind conditions, this process explains the formation of particle beams, indicating that Alfvénic and compressible turbulence play complementary roles in heating the solar wind.

Invited Talk Bridging Observational and Numerical Analyses of Turbulence to Cosmic Ray Anisotropy

Huirong Yan [[Deutsches Elektronen-Synchrotron\(DESY\) & University of Potsdam, Germany](#)]

Our understanding of turbulence in compressible medium with finite plasma beta has been substantially advanced, particularly thanks to the recent findings on solar wind turbulence. In this talk, I will present first our recent analyses of compressible turbulence, their comparison with the earlier theoretical expectations and numerical simulations. We show that compressible turbulence damping at MHD scales is in quantitative agreement with transit-time damping theory, even in fully developed nonlinear states. On the other hand, the fast modes cascade persists despite phase steepening, revealing a surprising robustness of cross-scale energy transfer under extreme conditions as revealed by our PIC simulations. Applying improved MHD decomposition algorithms to Cluster spacecraft data, we find that both the modes anisotropies and the spatial-temporal properties are in line with our theoretical expectations. Finally, I will demonstrate the excellent agreement between the CR scattering rates predicted by the model from Yan & Lazarian (2008) for scattering with compressible turbulence and the recent analysis of TeV CR anisotropy data by Maalal & Zhang (2025).

Contributed Talk Probing Spectral Properties of Magnetized ISM via Polarization Statistics

Ziqi Liu [[Xiangtan University, China](#)]

Based on MHD turbulence theory, we explore magnetized ISM turbulence using synchrotron polarization statistics. First, we show that polarization gradient (SPG) analysis robustly recovers magnetic turbulence spectra under strong Faraday depolarization. Applying SPG to ATCA Galactic plane data, we obtain the Galactic magnetic turbulence spectrum $\propto k^{-10/3}$. We further investigate the polarization derivative (SPD) and its connection to Faraday rotation measure (RM). Numerical results demonstrate that SPD statistics reconstruct RM scaling, while SPD gradients overcome long-wavelength depolarization to recover turbulence slopes across different regimes. These statistical techniques provide new tools for probing magnetized turbulence with current and future radio observations.

Invited Talk Kink-Unstable Jets: Polarization and Particle Acceleration

Hui Li [[Los Alamos National Laboratory\(LANL\), USA](#)]

Motivated by the recent X-ray polarization observations of IXPE on the galactic jet source SS433, we have carried out high-resolution 3D relativistic MHD global jet simulations to study the jet morphology, magnetic field distributions, particle energization and polarized Syn. (including X-rays) properties. These simulations couple together the relativistic MHD jet with particle energization and polarized ray-tracing. The X-ray polarization observations are found to place very strong constraints on the magnetic field properties, consequently providing interesting implications on the overall jet physics. We also use the multi-wavelength emission properties (from radio to high-energy gamma-ray) from the SS433 jet to investigate the particle acceleration processes, particularly the role of PeV particles. These results also provide insights for understanding the polarization observations of extra-galactic jets.

Invited Talk Numerical Simulations of Black Hole Accretion Flows and Outflows

Ken Ohsuga [University of Tsukuba, Japan]

Accretion flows around black holes are often accompanied by powerful outflows such as disk winds and relativistic jets. In this talk, I will present recent results from numerical simulations that explore the structure and time evolution of accretion flows and outflows in the vicinity of black holes, with particular emphasis on super-Eddington accretion. I will also discuss connections between simulation results and observations.

Contributed Talk Global Radiation MHD Simulations of Magnetically Supported Disks in Active Galactic Nuclei

Ryoji Matsumoto [Chiba University, Japan]

We present results of three-dimensional radiation magnetohydrodynamic simulations of accretion flows in active galactic nuclei. We employ the radiation-MHD code CANS+R, which is based on the M1-closure scheme and includes free-free emission and Compton scattering. For an accretion rate of 0.1 times the Eddington accretion rate, the accretion flow beyond 20 Schwarzschild radii from the super-massive black hole shrinks in the vertical direction due to radiative cooling. Because the total azimuthal magnetic flux is conserved, the toroidal magnetic field is amplified as the disk thins, providing vertical support against gravity. In this regime, the magnetic pressure exceeds both the gas and radiation pressures. We refer to such configurations as toroidal MAD. Magnetic energy dissipation via reconnection heats the plasma, maintaining the disk temperature in the soft X-ray-emitting range within the toroidal MAD region. Consequently, a hard X-ray-emitting radiatively inefficient accretion flow near the black hole coexists with a soft X-ray-emitting toroidal MAD at larger radii. We compute the emergent radiation spectra through post-processing the numerical results using the radiation transfer code RAIKOU. The resulting spectra successfully reproduce the soft X-ray excess observed during state transitions in active galactic nuclei.

Contributed Talk Numerical Simulations of Faraday Rotation in AGN Jet-Lobe Systems

Weibo Yang [Huazhong University of Science and Technology(HUST), China]

Invited Talk Equation vs. AI in the Multiscale ISM: Can Deep Generative Models Internalize the Laws of Star Formation?

Mengke Zhao [Nanjing University, China]

The Interstellar Medium (ISM) operates as a profoundly complex multiscale system, presenting a fundamental challenge driven by coupled physics. While deep generative models map high-dimensional correlations, do they internalize this underlying physics or merely memorize discrete statistical textures? As exemplified by the B-rho gradual transition relation, the ISM undergoes continuous multiphase energy transitions across 10 dex, characterized by deeply coupled gravity, turbulence, and magnetic fields. Unconstrained AI fails to internalize this multiscale continuity. Pushed into unseen physical states, their inherently fragmented nature triggers Jacobian collapse, resulting in unphysical statistical hallucinations. We introduce a Scale-Informed Explainable AI (XAI) framework to resolve this, establishing scale-space continuity as the mathematical signature for AI to capture star formation dynamics.

Lecture Binary Neutron-Stars II: Multi-messenger Emission

Luciano Rezzolla [Goethe University Frankfurt, Germany]

In this second lecture, I will concentrate on the non-gravitational aspects of neutron-star mergers and discuss the emission both in terms of electromagnetic radiation, but also in terms of neutrinos. Attention will also be paid to the fate of the matter ejected in the merger and how it provides compelling evidence that neutron-star mergers play a crucial role in the nucleosynthesis of heavy elements such as gold and uranium.

Lecture Collisionless Magnetic Reconnection in the Magnetosphere

Quanming Lu [University of Science and Technology of China(USTC), China]

Magnetic reconnection underlies the physical mechanism of explosive phenomena in the solar atmosphere and planetary magnetospheres, where plasma is usually collisionless. In the standard model of collisionless magnetic reconnection, the diffusion region consists of two substructures: an electron diffusion region is embedded in an ion diffusion region, whose their scales are based on the electron and ion inertial lengths. In the ion diffusion region, ions are unfrozen in the magnetic fields while electrons are magnetized. The resulted Hall effect from the different motions between ions and electrons leads to the production of the in-plane currents, and then generates the quadrupolar structure of out-of-plane magnetic field. In the electron diffusion region, even electrons become unfrozen in the magnetic fields, and the reconnection electric field is contributed by the off-diagonal electron pressure terms in the generalized Ohm's law. The reconnection rate is insensitive to the specific mechanism to break the frozen-in condition, and is on the order of 0.1. In recent years, the launching of Cluster, THEMIS, MMS and other spacecraft has provided us opportunities to study collisionless magnetic reconnection in the Earth's magnetosphere, and to verify and extend more insights on the standard model of collisionless magnetic reconnection. I will review what we have learned beyond the standard model with the help of observations from these spacecraft as well as kinetic simulations.

Lecture Origin of Galactic cosmic rays, cosmic-ray acceleration and beyond

Ryo Yamazaki [Aoyama Gakuin University(AGU), Japan]

Galactic cosmic rays with energies in the GeV-PeV range constitute a major component of the Milky Way Galaxy. While their detailed origin remains unclear, supernova remnants are widely regarded as the leading candidates. Observations of gamma-ray emission from cosmic rays by space- and ground-based instruments such as Fermi Gamma-ray Space Telescope, HESS/MAGIC, and LHAASO have provided important clues to their origin, yet a definitive conclusion has not been reached. A key reason is that the injection efficiency of particles into the acceleration process at shocks is still not well understood. In this lecture, I summarize the current status of the field and discuss future prospects.

Invited Talk High-Resolution X-ray Spectroscopy of Active Galactic Nuclei with XRISM: Probing the Vicinity of Supermassive Black Holes

Hirofumi Noda [Tohoku University, Japan]

X-ray observations provide a powerful means of probing the vicinity of supermassive black holes (SMBHs). In active galactic nuclei (AGNs), a broad-band and highly variable X-ray continuum is produced via inverse Compton scattering in a hot corona near the SMBH, and is subsequently reprocessed by the surrounding material, such as accretion flows and outflows, giving rise to a variety of spectral features. In September 2023, we successfully launched the XRISM satellite and achieved the operation of the onboard X-ray microcalorimeter in orbit for the first time since Hitomi. This accomplishment has enabled high-resolution spectroscopy of key spectral features essential for understanding the immediate environment around SMBHs, including the relativistic Fe-K α line and Fe XXV/XXVI absorption features produced by ultra-fast outflows. In this talk, I will present the latest insights into the vicinity of SMBHs obtained from XRISM observations.

Invited Talk Experimental Study of Thermal Instability in Magnetized Plasmas: Bridging Fusion, Astrophysics, and Solar Physics

Masahiro Kobayashi [[National Institute for Fusion Science\(NIFS\), Japan](#)]

Understanding thermal instability in plasmas remains a major challenge in astrophysics and solar physics, where it plays a crucial role in structure formation across a wide range of natural environments, including molecular clouds, galaxy evolution, and solar phenomena such as coronal rain and prominences. Since the systematic formulation by G. B. Field in 1965 [1], theoretical models have continued to evolve and be refined up to the present day [2, 3], incorporating dependencies on wavenumber, cooling and heating functions, energy transport, magnetic fields, and other factors. However, testing these models at the level of elementary processes remains difficult using observations alone.

On the other hand, nuclear fusion experiments also face challenges related to the control of thermal instability. Radiative cooling of peripheral plasmas is essential for mitigating excessive heat loads on plasma-facing components in fusion devices. However, the strong temperature dependence of impurity radiation makes the plasma inherently susceptible to thermal instability within the relevant operational temperature range [4]. Despite its importance, the dynamics of thermal instability in fusion plasmas have remained largely unexplored experimentally.

In this context, nuclear fusion experimental devices provide a unique and controllable laboratory platform for studying thermal instability, bridging plasma physics across vastly different regimes. Beyond contributing to the optimization of fusion reactors, this work opens a new avenue for experimentally probing the fundamental processes of thermal instability in the interstellar medium and the solar corona.

In this talk, we present a study of thermal instability in plasmas in the Large Helical Device (LHD), a magnetic confinement fusion experiment. For the first time, the spatiotemporal evolution of the thermal instability growth rate has been quantitatively characterized in a laboratory plasma. Distinct transitions between unstable growth and stabilization are observed under different magnetic configurations. Three-dimensional transport simulations, validated against radiation measurements, reveal strong localization of radiation near magnetic X-points. This finding shows striking agreement with observations of cool plasma structures in the solar corona. Furthermore, density-pressure phase diagrams exhibit trajectories analogous to those associated with magnetic field effects in condensation processes in interstellar clouds.

Invited Talk The Stellar Process in Dense Nuclear Environments: Dynamics and Multi-messenger

Qingwen Wu [[Huazhong University of Science and Technology\(HUST\), China](#)]

Galactic nuclei, harboring supermassive black holes (SMBHs) and surrounded by dense nuclear star clusters (NSCs), represent the Universe's most extreme stellar environments. The unique interplay of stellar dynamics, hydrodynamics, and gravity in these regions governs the evolution of stellar populations and drives a rich variety of transient phenomena. In this work, I will review the fundamental stellar processes operating in such dense environments and their potential connections to multi-messenger signals. I will further present results from coupled hydrodynamic and N-body simulations, which self-consistently account for complex two-body and three-body interactions in the presence of a gaseous background. Finally, I will discuss possible observational predictions that may be tested with current and upcoming facilities.

Invited Talk Experimental Study on Wave-Particle Interactions in Magnetically Confined Plasmas

Kenichi Nagaoka [[National Institute for Fusion Science\(NIFS\), Japan](#)]

Wave-particle interactions are fundamental to plasma physics, including high-energy particle generation in space, plasma heating in laboratory plasmas, laser acceleration, etc. In magnetically confined fusion plasmas, energetic-particle transport driven by interactions with various types of Alfvén eigenmodes is a key issue for the stable operation of steady-state fusion-burning plasmas. In this talk, the fundamental process of wave-particle interaction for energetic particles in torus plasma is reviewed, and external control of the energetic particle transport via stability control of Alfvén eigenmodes is explained. Finally, a new experimental plan with the CHD device, which addresses phase space dynamics and transport phenomena, is presented.

Contributed Talk Direct MMS Observations of Canonical Vorticity Dynamics during Magnetic ReconnectionKrushna Chandra Barik [Asia Pacific Center for Theoretical Physics(APCTP), Korea]

Magnetic reconnection is a fundamental plasma process that facilitates the conversion of magnetic energy into kinetic and thermal energy. It is well established that during reconnection, magnetic flux conservation breaks down as dissipative effects due to, e.g., electron inertia and pressure, become dominant. Recent theoretical developments [1,2] show that by focusing on the canonical vorticity Q as the primary variable rather than the magnetic field, the reconnection process can be understood much more intuitively through the examination of exact Q flux conservation and its violation by the pressure tensor.

In this study, we utilize high-resolution observations from NASA's Magnetospheric Multi-Scale (MMS) mission to examine magnetic reconnection through the lens of the canonical vorticity framework. Specifically, we investigate a well-defined magnetic reconnection event that occurred on 11 July 2017, analyzing the contributions of different terms within the framework. The observational results provide insight into the physical mechanisms captured by the canonical vorticity model and offer a broader understanding of the non-ideal processes involved in magnetic reconnection. These will be discussed along with other aspects of magnetic reconnection.

[1] Y. D. Yoon and P. M. Bellan, *Phys. Plasmas* 26, 100702 (2019)

[2] M. Laishram, G. S. Yun, and Y. D. Yoon, *Phys. Rev. Res.* 6, L032052 (2024)

Contributed Talk Laboratory Observations of Hall Magnetic Field in Electron-only Magnetic Reconnection with a Guide FieldFa Yang [University of Science and Technology of China(USTC), China]

Recently, electron-only reconnection, in which there is no obvious ion bulk flow and ion heating, has been pervasively observed in the Earth's magnetosphere. In this Letter, we realize electron-only reconnection with a guide field in the Keda Linear Magnetized Plasma (KLMP) device. By measuring the magnetic field, we identify unambiguously a distorted quadrupolar structure of the magnetic field in the out-of-plane direction. At the same time, electrons are obviously heated in the current sheet with the half-width about 0.8 electron inertial length. The maximum velocity of the estimated electron flow in the reconnection plane is about 8 Alfvén speed.

Contributed Talk Electron-Scale Reconnection as a Micro-Accelerator of Relativistic Electrons in Solar FlaresLianyan Fu [Shandong University, China]

How solar flares accelerate a huge number of electrons to relativistic energies in a short time is a major puzzle in modern astro-plasma physics. By performing full-particle simulations with the realistic proton-to-electron mass ratio, this study reveals for the first time that electron-scale magnetic reconnection acts as a powerful particle accelerator under solar conditions of low-beta with a strong magnetic field. We find that nonlinear electrostatic solitary waves excited within low-density cavities along reconnection separatrices can generate intense localized electric fields ($\sim 105\text{V/m}$). These fields, together with the reconnection-induced electric field, accelerate electrons most efficiently in the electron diffusion region. This "ESW-boost" mechanism dominates the production of the highest-energy electrons. Furthermore, whistler waves also provide an efficient acceleration channel. In total, $\sim 0.23\%$ of electrons within the separatrix region are accelerated to energies exceeding 300 keV within sub-microseconds. Our research establishes that electron-scale reconnection, embedded with strong plasma waves, serves as a microscopic, highly efficient engine for generating relativistic electrons in low-beta plasmas of the Sun (and other stars).

Contributed Talk The Conditions for the Onset of Magnetic Reconnection in an Asymmetric Current Sheet

Subham Ghosh [Asia Pacific Center for Theoretical Physics(APCTP), Korea]

Magnetic reconnection in the dayside magnetopause region is of immense interest, as various spacecraft missions over the years have provided direct evidence. Data from these missions, traversing the asymmetric magnetopause, reveal regions both with and without magnetic reconnection exhausts, raising questions about the onset conditions of asymmetric magnetic reconnection. Numerical studies of magnetic reconnection generically employ perturbation to an equilibrium, in which reconnection almost always occurs. However, there is ample observational evidence that the plasma beta plays an important role in the onset of reconnection. In fact, recent studies show that when considering an initially non-equilibrium current sheet that pinches down to smaller scales, the plasma beta acts as a controller of the final thickness of the current sheet, which, if reduced to kinetic scales, may spontaneously trigger reconnection [1]. Here we extend this concept to asymmetric reconnection by considering an initially non-equilibrium asymmetric current sheet. In the presence of a driver such as the solar wind, it is shown that the plasma beta, more exclusively the difference in the plasma beta across the asymmetric current sheet, indeed be a controller of the degree of pinching of the asymmetric current sheet and thus controls the onset of reconnection. This idea is tested with a series of particle-in-cell simulations.

[1] Y. D. Yoon, T. E. Moore, D. E. Wendel, M. Laishram, G. S. Yun, *Geophys. Res. Lett.* 51, e2024GL112126 (2024)

Contributed Talk An Asymmetric Current-Driven Magnetic Reconnection Thruster

Subhasish Bag [Asia Pacific Center for Theoretical Physics(APCTP), Korea]

Recently, plasma thruster concepts using magnetic reconnection have gained significant attention for simultaneously providing high specific impulse and thrust [1,2]. In these systems, the reconnection process quickly transforms magnetic energy stored in a plasma into kinetic energy, propelling charged particles to high speeds and producing thrust. In contrast to widely researched symmetric or anti-parallel configurations, a new oblique reconnection mechanism that causes a unidirectional outflow has been proposed and studied. We performed an MHD simulation to study the dynamics in this magnetic reconnection geometry and discuss the results here.

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Lecture Kinetic Simulation Studies on Heliospheric Collisionless Shocks

Shuichi Matsukiyo [Kyushu University, Japan]

Collisionless shocks are well known as particle accelerators in space. Among the acceleration mechanisms operating at shocks, diffusive shock acceleration—often referred to as shock Fermi acceleration—is particularly famous. However, for this mechanism to operate, a population of nonthermal particles must already be generated in the vicinity of the shock. The production of these nonthermal particles is closely linked to the kinetic, microscopic structure of the shock transition region, and many aspects remain unresolved due to its complexity.

Self-consistent kinetic simulations capable of reproducing both the transition-region structure and the associated particle acceleration processes began to advance significantly in the 2000s, and research in this direction continues today. In this talk, I will introduce the injection method commonly used to generate shocks in simulations, review the development of particle-acceleration studies in heliospheric collisionless shocks based on kinetic simulations, and discuss recent trends and advances in the field.

Lecture Laboratory Astrophysics Using Power-Laser Systems: Collisionless Shock and Particle Acceleration

Youichi Sakawa [Osaka University, Japan]

Collisionless shocks are common in various astrophysical environments, such as supernova remnants and pulsar wind nebulae. These shocks are thought to generate high-energy cosmic rays. Thanks to the development of high-energy and high-intensity power lasers, it is now possible to study the formation/evolution of collisionless shocks and the resulting particle acceleration in the laboratory. In this lecture, we present experimental and computational studies of power-laser-driven collisionless shock generation and particle acceleration.

Invited Talk Simulating Cosmic-ray Acceleration, Transport and Feedback Across Scales

Xuening Bai [Tsinghua University, China]

Cosmic-rays are energetic charged particles. Their origin, transport and feedback of are of fundamental importance over a wide range of astrophysical systems. Typically, the kinetic physics of the CRs lies in their gyro-scale and above, while conventional kinetic simulation methods require resolving much smaller microscopic scales of the background plasmas. This issue can be substantially alleviated thanks to the development of the magnetohydrodynamic-particle-in-cell (MHD-PIC) type of methods. In particular, I will describe our MHD-PIC simulations of the CR gyro-resonant instabilities, which enable first-principle characterization of the CR transport coefficients. On the other hand, cosmic-ray feedback on macroscopic scale generally requires treating CRs as a fluid, requiring CR subgrid models that properly incorporate the microphysics of CR transport. I will then describe our recent two-moment CR-MHD framework with a more general treatment of CR scattering to serve this purpose. Finally, I will describe the extension of the MHD-PIC method to MHD-gPIC, where particles are integrated under the guiding center approximation, enabling even greater level of scale separation to study particle acceleration in turbulence and magnetic reconnection toward macroscopic scales.

Invited Talk Positron accelerations in relativistic magnetized astrophysical shocksYosuke Matsumoto [Chiba University, Japan]

We will present a new acceleration mechanism of positrons in magnetized relativistic shocks in electron-positron-ion plasma. We found that positrons are efficiently accelerated during an interaction with the wakefield in the upstream region. The result suggests the pulsar wind as a source of high-energy positron cosmic rays.

Contributed Talk Cosmic Ray Acceleration at Shocks in High-Beta Intracluster MediaDongsu Ryu [Ulsan National Institute of Science and Technology(UNIST), Korea]

The growth of large-scale structure in the Universe drives complex baryonic gas flows toward cosmic filaments and sheets, producing shocks through cluster mergers and supersonic accretion. Within the virial radius of galaxy clusters, the hot intracluster medium (ICM) hosts weak internal shocks with Mach numbers ($M_s \sim 2-4$) and high plasma beta ($\sim 50-100$), generated by turbulent motions and interactions among substructures. In contrast, external accretion shocks in cluster outskirts arise from the inflow of cold gas from cosmic voids or the warm-hot intergalactic medium (WHIM) and can reach much higher Mach numbers ($M_s \sim 10-100$). Diffusive shock acceleration (DSA) is widely regarded as the primary mechanism responsible for the production of cosmic-ray (CR) electrons at these shocks, yet the injection of thermal electrons into the DSA process remains a major unresolved problem. We suggest that an electron pre-acceleration mechanism mediated by multi-scale plasma waves in the shock transition layer. In particular, at supercritical shocks in high-beta ICM plasmas with $M_s > \sim 2.3$, electron pre-acceleration becomes efficient due to the growth of several microinstabilities, including the Alfvén ion cyclotron, electron firehose, and whistler instabilities. These wave-particle interactions energize suprathermal electrons and enable their subsequent injection into the DSA process.

Contributed Talk Electron Velocity Distribution Function at Different Structures of Quasi-Perpendicular ShockZhoufan Mu [Shandong University, China]

The injection of thermal electrons and the subsequent formation of flat-top velocity distributions of low- β , low-Mach number (MA) quasi-perpendicular collisionless shock are not well understood. We employed two-dimensional, full kinetic particle-in-cell simulations with a realistic mass ratio ($m_i/m_e = 1836$) and typical shock parameters ($\beta_e = \beta_i = 0.02$, $\theta_{Bn} = 85^\circ$, $MA \sim 5$) to analyze the evolution of electron velocity distributions across key shock regions. Our results show that field-aligned electron beams form at the shock ramp, undergo bulk parallel acceleration in the overshoot, and finally evolve into a flat-top distribution in the downstream. Trajectory analysis reveals that: (1) shock drift acceleration dominates beam generation at the ramp; (2) electrons are accelerated adiabatically in the overshoot; (3) in the downstream, electrons are heated and scattered by the parallel electric fields of whistler-wave turbulence, leading to flat-top distributions. This study provides, for the first time in a realistic mass-ratio simulation, a complete depiction of electron velocity distributions throughout a shock, elucidating the continuous process from injection to thermalization.

Contributed Talk First-Order Fermi Acceleration and Anomalous Scattering of Cosmic Rays in Thermally Instability Mediated Interstellar TurbulenceKa Ho Yuen [Nanjing University, China]

Recent high-precision cosmic-ray measurements by AMS-02 and DAMPE, together with TeV-PeV observations from LHAASO, reveal persistent deviations from simple quasilinear transport models, including spectral hardenings and a pronounced break near ~ 200 TeV. We demonstrate, using SOTA multiphase magnetohydrodynamic simulations, that chemistry-driven thermal instability naturally produces dense filamentary structures with long-lived convergent flows and an asymmetric velocity divergence field. This environment enables a non-resonant first-order Fermi acceleration mechanism, yielding efficient cosmic-ray energization beyond linear-theory expectations. The same filamentary structures act as effective scatterers, producing an altered rigidity dependence of the parallel mean free path in the sub-PeV regime. These results identify thermally unstable multiphase turbulence as a physically motivated propagation mechanism capable of imprinting TeV-PeV spectral features observed in Galactic cosmic rays.

Contributed Talk Exploring the Dominant Process of Solar Toroidal Magnetic Flux LossZebin Zhang [Shandong University, China]

As the solar magnetic cycle evolves, subsurface toroidal magnetic flux is systematically generated and lost, and this work aims to identify the dominant process behind the flux loss. By employing a data-driven dynamo model and holding surface magnetic flux transport identical across the cycles 12-21, we conducted numerical experiments to isolate and assess the loss of subsurface toroidal flux, and then compared the results with two observational constraints: the butterfly diagram and the observed correlation between the polar field at cycle minimum and the strength of the next cycle. We found that under weak bulk diffusivity, the loss of the previous cycle's toroidal flux is dominated by cancellation with newly generated flux, causing the new cycle's actual flux to differ from its generated value and thereby preventing the simulation of the observed polar field-cycle strength correlation. When diffusivity is increased to a level where it dominates flux loss, residual flux is more effectively removed, restoring the polar field-cycle strength correlation, yet operating in the diffusion-dominated regime suppresses the formation of the butterfly diagram. In contrast, active region emergence acts as an efficient mechanism for removing residual flux, and when it dominates the flux loss, both the correlation and the butterfly diagram are successfully reproduced. Thus, we conclude that active region emergence dominates the subsurface toroidal flux loss.

Invited Talk EPIC-GOD: Energy-Conserving GPU-Accelerated PIC Simulations for Space and Astrophysical PlasmasSunjung Kim [Kyunghee University, Korea]

Particle-in-cell (PIC) simulations are a powerful tool for investigating kinetic processes in space and astrophysical plasmas. However, conventional PIC approaches often suffer from accumulated violations of charge and energy conservation, particularly in long-term and multi-scale simulations, leading to degraded accuracy and physical fidelity.

In this talk, we present Full EPIC-GOD and Hybrid EPIC-GOD, two newly developed PIC frameworks that rigorously enforce both local charge conservation and total energy conservation. These properties are achieved through a tightly coupled, iterative solution of particle dynamics and electromagnetic fields, where charge conservation is strictly maintained via the continuity equation and energy conservation is ensured through iterative convergence.

We demonstrate the accuracy and robustness of these methods across a wide range of plasma phenomena, including wave propagation, kinetic instabilities, collisionless shocks, and magnetic reconnection. The results show excellent agreement with analytical predictions and established benchmark tests.

Furthermore, both codes are optimized for multi-GPU architectures using OpenACC, enabling substantial performance gains compared to conventional CPU-based implementations.

By combining strict conservation properties with high computational efficiency, Full EPIC-GOD and Hybrid EPIC-GOD provide a powerful and reliable framework for advancing kinetic plasma simulations in space and astrophysical environments.

Lecture Latest Results From LHAASO

Siming Liu [Southwest Jiaotong University(SWJTU), China]

Lecture Development of Advanced Spectroscopic Systems for Fusion and Astrophysical Plasmas

Katsumi Ida [National Institute for Fusion Science(NIFS), Japan]

Visible spectrometers have been widely used as magnetically confined plasma diagnostics to measure various parameters (impurity concentration, ion temperature, magnetic field pitch angle, isotope ratio, ion velocity-space distribution function). Recently, spectroscopy has been applied to measure ion velocity distribution in fusion plasma by improving the time resolution above the ion-ion collision time scale. Then, the phase-space (real space and velocity space) dynamics of plasma becomes a new research area in the magnetically confined fusion research. In Astrophysical Plasmas research, a hyperspectral camera that can provide a two-dimensional (2D) aurora image with full spectrum was developed to study auroral physics as one of the interdisciplinary applications to astrophysical plasma. The hyperspectral camera provides spectral information in a range of 400-800 nm with a spectral resolution higher than that of a conventional camera using an interference filter. In the lecture, experimental study of phase-space dynamics in Large Helical Device (LHD) and initial observation of Hyper Spectral Camera for Auroral Imagin (HySCAI) installed at the KEOPS (Kiruna Eorange Optical Platform Site) of the SSC (Swedish Space Corporation) in Kiruna, Sweden are discussed.

References

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- [2] M.Yoshinuma, K.Ida, Y.Ebihara, Development of hyperspectral camera for auroral imaging (HySCAI), *Earth, Planets and Space* 76 (2024) 96.
- [3] K. Ida , M. Yoshinuma , Y. Ebihara , and K. Shiokawa, Estimate of N₂⁺ Altitude Profile Using Blue Auroral Resonant-Scattering 427.8 nm Emission Observed With HySCAI During Astronomical Twilight, *Geophys. Res. Lett.* 52 (2025) e2025GL118375.

Contributed Talk Equation of State for Cylindrically Confined Collisionless Magnetized Plasma: Classical and Quantum Partition Function Approaches

Suresh Basnet [Asia Pacific Center for Theoretical Physics(APCTP), Korea]

In this work, we have constructed the generalized classical and quantum partition functions to study the thermodynamic properties of collisionless magnetized plasma bounded in a finite-size cylindrical geometry. In contrast to the conventional assumptions for the equation of state, the thermodynamics of confined collisionless magnetized plasma is determined by the anisotropic parameter, system size relative to Larmor radius, and quantum parameter, resulting in the finite-size corrections to the canonical free energy, pressure, entropy, and magnetization of the system. The geometrical confinement affects the possible microstate configuration over the phase space, which induces the pressure anisotropy on the bounded system. Based on this pressure anisotropy, the diamagnetic and paramagnetic behavior of magnetized plasma is also explored. With the help of the generalized partition function, we recover the widely used Chew-Goldberger-Low (CGL) relation (CGL 1st equation) expressed in terms of the physical variable of the system. We extend these classical thermodynamics to the quantum regime in account of the quantization of Landau energy levels in the perpendicular plane. The invariance of the magnetic moment modifies the population of particles on the Landau levels, affecting the quantum thermodynamics. To forbid the overlapping of Landau energy levels on the surface, the maximum number of allowed quantum states on the system is determined, depending on the geometrical size of the system. Furthermore, we present a comparative study of classical and quantum thermodynamic properties of the bounded system in which the quantum parameter governs the transition of the discrete Landau quantum regime to a classical continuous regime.

Contributed Talk Understanding the Precise Measurements of Cosmic Rays by LHAASO

Zhangxi Xue [[Southwest Jiaotong University\(SWJTU\), China](#)]

Cosmic rays have been measured with high accuracy by different experiments. Recently, Large High Altitude Air Shower Observatory (LHAASO) has reported measurements of cosmic ray spectra and mean logarithmic mass. Detailed structures are found. In this presentation, I will consider the influence of local interstellar environment and reproduce these observations with two models. Besides, transient large-scale anisotropy in TeV cosmic rays caused by interplanetary coronal mass ejection is observed by LHAASO. I will also present a numerical study on the propagation of cosmic rays in the magnetic field.

Invited Talk TBD

MinSup Hur [[Ulsan National Institute of Science and Technology\(UNIST\), Korea](#)]

Invited Talk Laboratory Astrophysics Using Intense Lasers

Inhyuk Nam [[Ulsan National Institute of Science and Technology\(UNIST\), Korea](#)]

Laboratory astrophysics utilizing ultra-intense lasers enables the recreation and study of extreme astrophysical environments in a controlled setting. This approach allows for the investigation of high-energy-density (HED) plasmas, revealing the interior dynamics of planetary bodies like Neptune and Uranus. Moreover, these lasers facilitate the exploration of quantum electrodynamics (QED) effects, which are critical for understanding extreme phenomena with strong fields. Beyond fundamental astrophysics, compact laser-plasma accelerators provide a tabletop source of high-energy particles such as electron beams, protons, gamma rays, and positrons. This presentation will summarize the diverse applications and recent advancements of ultra-intense lasers in laboratory astrophysics.

Invited Talk Strong-Field Quantum Electrodynamics and Its Implications to High-Energy Astrophysics

Chulmin Kim [[Institute\(IFS\) & Gwangju Institute of Science and Technology\(GIST\), Korea](#)]

Strong-field quantum electrodynamics (SFQED) [1] is the high-intensity regime of quantum electrodynamics (QED) that provides the most fundamental understanding of light-matter interactions. Although SFQED has been considered since the burgeoning period of QED, it remained an esoteric theoretical subject until the necessary level of light intensity became accessible in the laboratory using ultra-intense lasers. In this talk, we introduce two recent results in SFQED from the Center for Relativistic Laser Science: the first demonstration of nonlinear Compton scattering, the lowest-order process in SFQED, in the strongly nonlinear regime [2], and an analysis of field-induced vacuum polarization [3], a direct manifestation of the quantum vacuum. In addition, we present some implications of SFQED research for high-energy astrophysics. Such a connection should be nontrivial, considering that SFQED processes occur under extreme conditions similar to those in highly energetic astrophysical phenomena.

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Contributed Talk A New Dynamo-Resistive GRMHD Code in the AthenaK Framework

Xi Lin [Huazhong University of Science and Technology(HUST), China]

In this work, we have constructed the generalized classical and quantum partition functions to study the thermodynamic properties of collisionless magnetized plasma bounded in a finite-size cylindrical geometry. In contrast to the conventional assumptions for the equation of state, the thermodynamics of confined collisionless magnetized plasma is determined by the anisotropic parameter, system size relative to Larmor radius, and quantum parameter, resulting in the finite-size corrections to the canonical free energy, pressure, entropy, and magnetization of the system. The geometrical confinement affects the possible microstate configuration over the phase space, which induces the pressure anisotropy on the bounded system. Based on this pressure anisotropy, the diamagnetic and paramagnetic behavior of magnetized plasma is also explored. With the help of the generalized partition function, we recover the widely used Chew-Goldberger-Low (CGL) relation (CGL 1st equation) expressed in terms of the physical variable of the system. We extend these classical thermodynamics to the quantum regime in account of the quantization of Landau energy levels in the perpendicular plane. The invariance of the magnetic moment modifies the population of particles on the Landau levels, affecting the quantum thermodynamics. To forbid the overlapping of Landau energy levels on the surface, the maximum number of allowed quantum states on the system is determined, depending on the geometrical size of the system. Furthermore, we present a comparative study of classical and quantum thermodynamic properties of the bounded system in which the quantum parameter governs the transition of the discrete Landau quantum regime to a classical continuous regime.

Contributed Talk VLBI Detections of Compact Nuclei in Spiral-hosted Double-lobed Radio-loud Active Galactic Nuclei (DRAGNs): Evidence for Weak Parsec-Scale Jet Activity

Mingyu Ryu [Ulsan National Institute of Science and Technology(UNIST), Korea]

Active galactic nucleus (AGN) jets transport energy via plasma from parsec to kiloparsec scales. Traditionally, powerful radio jets and lobes have been thought to form exclusively in elliptical galaxies, but recent discoveries of kiloparsec-scale radio lobes in several spiral galaxies challenge this paradigm. In this study, we analyze the parsec-scale jet plasma structures of four spiral DRAGNs using very long baseline interferometry observations. Compact cores are detected in all sources, with weak jet structures identified in two. The measured brightness temperatures are on the order of $\sim 10^9$ K, lower than those of typical relativistic jets, and the intrinsic jet speeds are constrained to be less than about 0.6 times the speed of light. A comparison based on black hole mass and X-ray and radio luminosities shows that these sources follow the same empirical relation observed in other AGNs. This indicates that, despite their unusual host galaxy type, the central engines of spiral DRAGNs share the same underlying plasma physics and jet production mechanisms as those of typical AGNs. These results suggest that the parsec-scale jets in spiral DRAGNs are relatively weak and slow, while the kiloparsec-scale radio lobes are likely associated with earlier phases of stronger jet activity. This difference between small- and large-scale structures implies that AGN jet properties may evolve over time, and that spiral DRAGNs may represent systems at different evolutionary stages. Our results demonstrate that very long baseline interferometry observations can constrain key plasma properties of AGN jets, including their speed and energy state, and highlight spiral DRAGNs as important laboratories for studying the evolution of jet plasma.

Poster Interpretable Data-Driven Solar Flare Forecasting Model

Youngjae Kim [Kyunghee University, Korea]

Solar flares are explosive phenomena accompanied by magnetic reconnection in the solar corona. In this paper we present interpretable major-flare(>M) forecasting models that combine deep learning with symbolic regression using time-series magnetic field parameters of solar active regions. Our models achieved competitive TSS=0.76 in 5-fold cross validation with simple mathematical formulae. A representative formula indicates that flare productivity peaks when total amount and asymmetry of current helicity, a proxy of magnetic twist and shear in solar active regions, are simultaneously high. This formula successfully forecasts first major flares in the most flare-productive active regions NOAA 12673 and 13664 where the conventional empirical models failed. Our investigation suggests that flare triggering is governed by the squared sum of current helicity at the largest scales. Our approach can be extended to other astronomy fields or related fields to find new physical relationships.

Poster Compensation of Fluctuation Using Gradient-Plasma Photonic Crystal for Laser Pulse Compression

Jaeho Lee [Ulsan National Institute of Science and Technology(UNIST), Korea]

Chirped pulse amplification (CPA) has driven the development of high-power lasers up to the petawatt regime. However, scaling CPA to exawatt or zettawatt peak powers would require diffraction gratings on the scale of several hundred meters, presenting an insurmountable technological barrier. To address this, we recently demonstrated an approximately 225-fold pulse compression in a smooth, quadratic density-gradient plasma using particle-in-cell (PIC) simulations [1]. This scheme relies on the frequency-dependent reflection path differences of a long, negatively chirped pulse. Nevertheless, this approach demands a large-scale plasma at near-critical density-conditions that are exceptionally challenging to achieve experimentally. More critically, the compression efficiency is highly susceptible to density fluctuations; while prior studies indicate that fluctuations must remain below 1% to avoid severe degradation, such uniformity is practically unattainable. In this study, we propose a robust pulse compression scheme utilizing a gradient-plasma photonic crystal (GPPC). Through 1D PIC simulations, we demonstrate that the GPPC structure inherently compensates for plasma density fluctuations, successfully delivering a 32-fold intensity gain even in the presence of fluctuations as high as 10%.

Poster Experimental Observation of Stabilization Effect of Alfvén Eigenmodes due to Resonant Interaction with Energetic Ions in Magnetically Confined Toroidal Plasmas

Masato Matsuoka [Nagoya University, Japan]

Wave-particle interaction between energetic ions and shear Alfvén waves is a universal process in many plasma environments. In magnetically confined fusion plasmas, energetic ions such as fusion-born alpha particles strongly interact with Alfvén Eigenmodes (AEs), leading to anomalous transport. This interaction decreases heating efficiency of future thermonuclear reactors. Thus, the understanding of interactions between energetic ions and AEs is essential for the realization of controlled nuclear fusion.

Phase-space structure of energetic ions plays a key role in the wave-particle interaction. In magnetically confined toroidal plasmas, the free energy that destabilizes AEs is the radial gradient of the energetic-ion distribution function. The resulting transport of energetic ions is intensively investigated. In contrast, the gradient in energy can stabilize AEs through Landau damping, because the energy gradient is typically negative due to collisional slowing-down. However, the experimental investigations of the dynamics of energetic ions in energy space has been limited.

We have investigated the interaction between bursting AE activity and energetic ions using the Large Helical Device, one of the largest stellarator-type plasma confinement devices. The energy distribution function of energetic ions was measured by Neutral Particle Analyzer (NPA) with high time resolution (> 1 MHz). The line of sight of NPA was designed to observe the dynamics of energetic ions in the core region, where AEs are commonly observed.

AE bursts were separated into growth and decay phases based on the temporal evolution of power spectrum. The energetic-ion energy spectra were compared with those in a reference phase which AE activities were negligible. In both phases, the energy gradient was reduced at the energy where the Landau resonance condition is satisfied. This response suggests that Landau damping of AEs by energetic ions has been directly observed. Importantly, Landau damping was identified even during the growth phase of AEs. This result demonstrates that energetic ions simultaneously contribute to AE bursts in two competing ways: destabilization through the radial gradient, and stabilization through the energy gradient.

Poster TBD

Dohyun Park [Ulsan National Institute of Science and Technology(UNIST), Korea]

Poster Ion Stochastic Heating by Wave-Induced Field Line Curvature in Space Plasmas

Jingyu Peng [Peking University, China]

Finite-amplitude low-frequency Alfvén waves are commonly found in space plasmas, and play a crucial role in ion heating. The nonlinear interaction between oblique Alfvén wave spectrum and ions is studied. As the number of wave modes increases, ions are more likely to exhibit chaotic motion and experience stochastic heating. Analysis of magnetic moment variations reveals that the physical origin of chaos is pitch-angle scattering induced by wave-driven field-line curvature (WFLC), which disrupts adiabatic invariance and leads to stochastic ion energization. The onset condition for chaos can be expressed by an effective relative curvature radius, $P_{\text{eff}} < 25$. The results show excellent agreement with the chaotic regions identified in test-particle simulations. The anisotropic characteristics of stochastic heating are explained using a uniform solid-angle distribution model. The stochastic heating rate Q is calculated, and its relationship with wave conditions is expressed as $\frac{Q}{\Omega_i m_i v_A^2} = H(\alpha) \tilde{v}^3 \tilde{B}_w^3 \tilde{\omega}_1 \left(\tilde{\omega}_1 + \Delta \tilde{\omega} \right)$. This study emphasizes the important role of magnetic field line deformation in stochastic heating in the absence of turbulence electric fields.

Poster Analytical Maximum Growth Rates of the Parametric Decay Instability and Beat Instability Derived from Double-Adiabatic/CGL Equations

Hayato Saguchi [Tohoku University, Japan]

We derive analytical forms for the maximum growth rate of Alfvén wave parametric instabilities—specifically the parametric decay instability (PDI) and the beat instability—within the CGL (double-adiabatic) framework. The behavior is organized by a single control parameter that measures the ratio of the compressive (sound-like) phase speed and the Alfvén-wave phase speed in the presence of both the finite-amplitude circularly polarized Alfvén wave and the temperature anisotropy. When the compressive mode is slower than the Alfvénic mode, the dominant channel is the PDI, driven by coupling between a sound-like branch and an Alfvénic sideband. When the compressive mode becomes comparable to or faster than the Alfvénic mode, the dominant channel switches to the beat instability, which can be viewed as a resonant interaction between two Alfvénic sidebands mediated by a low-frequency compressive response. We validate the resulting formulas by comparison with numerical solutions of the full dispersion relation and show that the analytical expressions reproduce the numerical trends well in the small-amplitude limit. This framework provides both physical interpretability and a practical tool for estimating parametric-instability growth rates in the presence of the temperature anisotropy.

Poster Fragmentation of Non-thermal Filaments in the Galactic Center Induced by Synchrotron Cooling Instability

Yuki Tamaki [Nagoya University, Japan]

In recent years, high-resolution observations by MeerKAT have revealed numerous non-thermal filaments (NTFs) in the Galactic center region (Heywood et al. 2022). As these NTFs are oriented nearly perpendicular to the Galactic plane, they suggest magnetic fields perpendicular to the plane, making them important probes of the magnetic field configuration and plasma environment in the Galactic center. However, their origin remains poorly understood.

Among these NTFs, some exhibit bundled structures consisting of multiple thin, linear filaments. One proposed scenario is that a single filament undergoes fragmentation due to a synchrotron cooling instability (Simon & Axford 1967), leading to the formation of multiple filaments (Yusef-Zadeh et al. 2022). However, the analysis by Simon & Axford (1967) does not adequately address situations in which the background state undergoes cooling, and concludes that the system is thermally stable in cooling state. In contrast, energy losses due to synchrotron radiation dominate in NTFs and should make the NTFs short lived, which may explain the non-existence of filaments highly deformed by turbulence. This highlights the importance of investigating their stability in overall cooling condition. In this study, we revisit the linear stability analysis of time-dependent unperturbed state using the short-wavelength approximation and show that the system can be unstable. We derive the instability criteria under cooling conditions, compare them with those of Simon & Axford (1967), and discuss their applications for NTFs in the Galactic center.

Poster Analysis of Magnetic Field Configuration and Full-Orbit Particle Dynamics Simulation in the NCSX Stellarator

Nan Xiang [Shandong University, China]

In the fundamental theoretical study of stellarators, an accurate description of particle dynamics within complex three-dimensional magnetic fields is central to understanding the mechanisms of transport and confinement. This research first utilizes a magnetic field line tracing code to compute the Poincaré plots and safety factor profiles of the NCSX stellarator's vacuum magnetic field at various toroidal angles, allowing for a systematic analysis of its magnetic surface structure, magnetic island distribution, and other topological features. Building on this, we employed the full-orbit relativistic particle simulation code APT (Accurate Particle Tracer), which is based on a structure-preserving algorithm, to simulate the long-term dynamical evolution of particles in the NCSX magnetic field. The results were compared with those from a guiding-center model. Our simulations clearly reveal the trajectory characteristics of collisionless passing and trapped particles. Furthermore, the evolution of the energy, pitch angle, and magnetic surface position of the trapped particles over time was analyzed. This study validates the necessity and effectiveness of structure-preserving algorithms with long-term stability for fundamental stellarator research, providing a crucial numerical tool and new physical insights for a deeper understanding of 3D magnetic confinement and for the optimization of stellarator design.