22nd Annual International Astrophysics Conference

Santiago de Compostela, Spain; April 6 – 11, 2025

AGENDA

Sunday, April 6th

5:30 PM – 7:00 PM Registration and Welcome Reception

Monday, April 7th

8:15 AM - 8:30 AM Welcome & Orientation - CAPILLA
8:30 AM - 4:00 PM Registration Check-In - CAPILLA
8:30 AM - 5:25 PM General Session - CAPILLA

CHAIR: Zank, G		
8:15 AM – 8:30 AM	Zank, Gary	Welcome
8:30 AM – 8:55 AM	Kornbleuth, Marc	Magnetic Reconnection in the Heliotail and the Effect on Energetic Neutral Atoms
8:55 AM – 9:20 AM	Van der Holst, Bart	Energy distribution of pickup ions in the outer heliosphere
9:20 AM – 9:45 AM	Florinski, Vladimir	Energy distribution of pickup ions in the outer heliosphere
9:45 AM – 10:10 AM	Nikoukar, Romina	Observation of the Heliospheric Energetic Particle “Valley” and Implications for a New Horizons Encounter with the Solar Wind Termination Shock
10:10 AM – 10:35 AM	BREAK	
CHAIR: Strauss, Du Toit		
10:35 AM – 11:00 AM	Bzowski, Maciej	Retrieval of solar wind structure by IMAP GLOWS and implications for ENA observations
11:00 AM – 11:25 AM	Guo, Xiaocheng	Stochastic Simulation of Galactic Cosmic-Rays in the Trapped Region beyond Heliopause
11:25 AM – 11:50 AM	Fuselier, Stephen	Energetic neutral atom fluxes from the Voyager 1 and 2 directions
11:50 AM – 12:15 PM	Shen, Fang	Modelling Energetic Proton Transport in Stream Interaction Regions
12:15 PM – 12:40 PM	Cohen, Christina	Multi-spacecraft observations of the 23 July 2024 Fe-rich SEP event
12:40 PM – 1:40 PM	LUNCH	
CHAIR: Mostafavi, Parisa		
1:40 PM – 2:05 PM	Baker, Daniel	A Small Pathbreaking Spacecraft - Giants of Space Research
2:05 PM – 2:30 PM	Slavin, Jonathan	Seeding the Local Interstellar Cloud and Heliosphere with Supernova Dust
2:30 PM – 2:55 PM	Boldyrev, Stanislav	Relativistic Particle Acceleration in Alfvenic Turbulence

2:55 PM – 3:20 PM	Nakanotani, Masaru	Survival of 2D Turbulence in the Local Interstellar Medium
3:20 PM – 3:45 PM	Husidic, Edin	Modelling Energetic Particles and Gyrosynchrotron Radiation in the Solar Corona and Inner Heliosphere
3:45 PM – 4:10 PM	BREAK	
CHAIR: Terres, Michael		
4:10 PM – 4:35 PM	Huang, Zhenguang	Time Evaluation of the Potential Field Source Surface Height in a Solar Cycle
4:35 PM – 5:00 PM	Tasnim, Ismita	Mode Decomposition in Hydrodynamics for the Outer Heliosphere
5:00 PM – 5:25 PM		
SESSION ADJOURNS		

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Tuesday, April 8th		
8:30 AM – 4:00 PM	Registration Check-In - CAPILLA	
8:30 AM – 5:00 PM	General Session - CAPILLA	
CHAIR: Bellan, Paul		
8:30 AM – 8:55 AM	Phan, Tai	Parker Solar Probe Observations of Flux Rope Merging and Proton Energization up to 400 keV in a Heliospheric Current Sheet
8:55 AM – 9:20 AM	Elliott, Heather	Radial Evolution of the Solar Wind
9:20 AM – 9:45 AM	Alonso Guzman, Juan	Galactic Cosmic Ray Modulation in a Dynamic Heliosheath
9:45 AM – 10:10 A	Richardson, John	Voyager observations of the interstellar medium
10:10 AM – 10:35 AM	BREAK	
CHAIR: Thomas, Edward		
10:35 AM – 11:00 AM	Dialynas, Konstantinos	Anisotropies of 40-139 keV ions from LECP on Voyager 1 in the heliosphere: indications for a new region in the VLISM
11:00 AM – 11:25 AM	Opher, Merav	Did the Sun Always Have a Wind?
11:25 AM – 11:50 AM	Mostafavi, Parisa/ Brandt, Pontus	Preparing for the Termination Shock Encounter with New Horizons *PRESENTED BY: MOSTAFAVI, PARISA*
11:50 AM – 12:15 PM	Yang, Zhongwei	Pickup Ion-Induced Foreshock and Magnetic Reconnection at an Oblique Heliospheric Termination Shock
12:15 PM – 12:40 PM	Mostafavi, Parisa	Pickup Ions and Shock Dynamics in the Outer Heliosphere
12:40 PM – 1:40 PM	LUNCH	
CHAIR: Fraternale, Federico		
1:40 PM – 2:05 PM	Linan, Luis	Modeling CME propagation from the Sun to Earth: Coupling EUHFORIA and COCONUT
2:05 PM – 2:30 PM	Yan, Huirong	Particle transport in MHD turbulence: from simulations to observations
2:30 PM – 2:55 PM	Nicolas, Bian	Multifractal Phenomenology and Gaussian Mixtures in Alfvenic Turbulence: Solar Wind Applications.
2:55 PM – 3:20 PM	Zhang, Ming	Probing the properties of solar wind turbulence with energetic particle scattering and diffusion

3:20 PM – 3:45 PM	Zhao, Siqi	Observations of Turbulence and Particle Transport at Interplanetary Shocks: Transition of Transport Regimes
3:45 PM – 4:10 PM	BREAK	
CHAIR: Pogorelov, Nikolai		
4:10 PM – 4:35 PM	Kontar, Eduard	Compressive Wave Energetics in the Solar Corona from Radio Observations
4:35 PM – 5:00 PM	Silwal, Ashok	Evolution of Solar Wind Turbulence during Radial Alignment of Parker Solar Probe and Solar Orbiter in December 2022
5:00 PM – 5:25 PM	Agapitov, Oleksiy	Tracing the Propagation Across the Heliosphere and Source Triangulation of the Brightest Gamma-Ray Burst, GRB221009A, Using Multi-Spacecraft Particle Detector Observations
SESSION ADJOURNS		

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Wednesday, April 9th		
8:30 AM – 4:00 PM	Registration Check-In - CAPILLA	
8:30 AM – 5:00 PM	General Session - CAPILLA	
CHAIR: Wang, Linghua		
8:30 AM – 8:55 AM	Agapitov, Oleksiy	Whistler Waves in the Young Solar Wind: Properties, Generation Mechanisms, and Effects for Solar Wind Particles
8:55 AM – 9:20 AM	Bellan, Paul	New form of the cold plasma wave equations and their solution for a cylindrical whistler duct
9:20 AM – 9:45 AM	Li, Hui	Solar Wind Evolution and the Near-Sun Transonic Turbulence – Comparing 3D Global Compressible MHD Simulation in a Cone with PSP Observations
9:45 AM – 10:10 AM	Adhikari, Laxman	Physical Processes in the Pickup Ion Mediated Plasma of the Distant Heliosphere
10:10 AM – 10:35 AM	BREAK	
CHAIR: Bian, Nic		
10:35 AM – 11:00 AM	Strauss, Du Toit	Fieldline Random Walk in Radially Evolving Solar Wind Turbulence
11:00 AM – 11:25 AM	Wang, Linghua	In Situ Shock Acceleration of Solar Wind Suprathermal Electrons at 1 AU
11:25 AM – 11:50 AM	Terres, Michael	Novel Reconstruction of Ion Velocity Distribution Functions
11:50 AM – 12:15 PM	Perri, Silvia	Analysis of CME-driven shocks properties as input for a data-based model of solar energetic particles
12:15 PM – 12:40 PM	Pogorelov, Nikolai	Space Weather Forecasts: Uncertainty Quantification and Machine Learning
12:40 PM – 1:40 PM	LUNCH	
CHAIR: Nakanotani, Masaru		
1:40 PM – 2:05 PM	Zank, Gary	Overview of a General Linear Mode Decomposition Method
2:05 PM – 2:30 PM	Thomas, Edward	Scaled laboratory simulations of spacecraft wakes in the near-Earth space environment: experimental observations and modeling

2:30 PM – 2:55 PM	Fraternale, Federico	Modeling plasma properties and compression waves observed by Voyager in the VLISM
2:55 PM – 3:20 PM	Le Roux, Jakobus	Evidence for Tempered Superdiffusive Shock at a Quasi-Perpendicular Interplanetary Shock
3:20 PM – 3:45 PM	Bhattacharjee, Amitava	Compressible MHD turbulence in the Interstellar Medium and the Solar Wind
3:45 PM – 4:10 PM	BREAK	
CHAIR: Yang, Zhongwei		
4:10 PM – 4:35 PM	Karki, Monika	Investigation of Turbulent Modes in the Fast and Alfv`enic Slow Solar Wind at 1 au
4:35 PM – 5:00 PM	Baruwal, Prashrit	Turbulent Modes in Slow, Alfvenic Slow, and Fast Solar Wind at 1AU
SESSION ADJOURNS		
6:00 PM – 9:00 PM	**GROUP DINNER**	

AGENDA

Thursday, April 10th		
8:30 AM – 4:00 PM	Registration Check-In - CAPILLA	
8:30 AM – 5:25 PM	General Session - CAPILLA	
CHAIR: Alonzo Guzman, Juan		
8:30 AM – 8:55 AM	Bowen, Trevor	Kinetic Signatures of Turbulent Heating
8:55 AM – 9:20 AM	Arro, Giuseppe	Spatio-Temporal Energy Cascade in Three-Dimensional Magnetohydrodynamic Turbulence
9:20 AM – 9:45 AM	Consolini, Giuseppe	Investigating the Irreversibility of Magnetic Fluctuations in Sub-Ion Scale Plasma Turbulence
9:45 AM – 10:10 AM	Pitna, Alexander	Density Fluctuation Anisotropy in the Solar Wind Near Characteristic Proton Scales
10:10 AM – 10:35 AM	BREAK	
CHAIR: Bale, Stuart		
10:35 AM – 11:00 AM	Takita, Masato	Sidereal cosmic-ray anisotropy at TeV energies modeled with data from the Tibet ASgamma experiment
11:00 AM – 11:25 AM	Leske, Rick	Updated Observations of the Intensity of Anomalous and Galactic Cosmic Rays at 1 AU from the Advanced Composition Explorer
11:25 AM – 11:50 AM	Oka, Mitsuo	Maximum Energy of Particles in Plasmas
11:50 AM – 12:15 PM	Kontar, Eduard	Flare accelerated electron transport model for Type III solar radio bursts
12:15 PM – 12:40 PM	Pierrard, Viviane	Acceleration of the solar wind due to the global electric potential
12:40 PM – 1:40 PM	LUNCH	
CHAIR: Bhattacharjee, Amitava		

1:40 PM – 2:05 PM	Hao, Yufei	Wave Activities Throughout a Low-Mach Number Quasi-Parallel Shock: 2-D Hybrid Simulations
2:05 PM – 2:30 PM	Asgari-Targhi, Mah	Dynamics of Slow Solar Wind Emerging from an Equatorial Coronal Hole
2:30 PM – 2:55 PM	Bale, Stuart	The fine structure of fast solar wind at ~10 solar radii: discrete velocity microstreams suggest energization at the base of the corona
2:55 PM – 3:20 PM	Fisk, Len	A New Theory for the Solar Cycle
3:20 PM – 3:45 PM	Kransnoselskikh, Vladimir	Plasma instability in the front of ejected energetic electrons and Type III solar radiobursts
3:45 PM – 4:10 PM	BREAK	
CHAIR: Pitna, Alex		
4:10 PM – 4:35 PM	Kolobov, Vladimir	The particle kinetics in spherical plasmas: from dust particle charging to solar wind
4:35 PM – 5:00 PM	Manchester, Chip	AWSoM Simulation of the Solar Wind and CMEs with Comparisons to Turbulence and Proton and Electron Temperature Observations
5:00 PM – 5:25 PM	Baruwal, Prashant	Evolution of Fluctuations during Radial Alignment of Solar Orbiter and WIND
SESSION ADJOURNS		

AGENDA

Friday, April 11th

8:30 AM – 11:25 AM General Session - CAPILLA

CHAIR: Elliot, Heather		
8:30 AM – 8:55 AM	Light, Juandre	Numerical Solutions to Superdiffusive Shock Acceleration: A Finite Difference Approach
8:55 AM – 9:20 AM	Mazelle, Christian	Fast Backstreaming Field-Aligned Proton Beams Observed Upstream of the Martian Bow Shock
9:20 AM – 9:45 AM	Halekas, Jasper	Forever Young: Electron Distributions in the Disappearing Solar Wind
9:45 AM – 10:10 AM	Nakanotani, Masaru	Cyclic Reformation of Perpendicular Magnetized Dusty Plasma Shock Waves
10:10 AM – 10:35 AM	BREAK	

CHAIR: Zank, Gary		
10:35 AM – 11:00 AM	Oka, Mitsuo	Scaling of Particle Heating in Shocks and Magnetic Reconnection
END OF CONFERENCE		

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Adhikari, Laxman	Wed. Apr. 9	9:45 AM – 10:10 AM	Physical Processes in the Pickup Ion Mediated Plasma of the Distant Heliosphere
Agapitov, Oleksiy	Wed. Apr. 9	8:30 AM – 8:55 AM	Whistler Waves in the Young Solar Wind: Properties, Generation Mechanisms, and Effects for Solar Wind Particles
Agapitov, Oleksiy	Tue. Apr. 8	5:00 PM - 5:25 PM	Tracing the Propagation Across the Heliosphere and Source Triangulation of the Brightest Gamma-Ray Burst, GRB221009A, Using Multi-Spacecraft Particle Detector Observations
Alonso Guzman, Juan	Tue. Apr. 8	9:20 AM – 9:45 AM	Galactic Cosmic Ray Modulation in a Dynamic Heliosheath
Arro, Giuseppe	Thur. Apr. 10	8:55 AM – 9:20 AM	Spatio-Temporal Energy Cascade in Three-Dimensional Magnetohydrodynamic Turbulence
Asgari-Targhi, Mah	Thur. Apr. 10	2:05 PM – 2:30 PM	Dynamics of Slow Solar Wind Emerging from an Equatorial Coronal Hole
Baker, Daniel	Mon. Apr. 7	1:40 PM – 2:05 PM	A Small Pathbreaking Spacecraft - Giants of Space Research
Bale, Stuart	Thur. Apr. 10	2:30 PM – 2:55 PM	The fine structure of fast solar wind at ~10 solar radii: discrete velocity microstreams suggest energization at the base of the corona
Baruwal, Prashant	Thur. Apr. 10	5:00 PM – 5:25 PM	Evolution of Fluctuations during Radial Alignment of Solar Orbiter and WIND
Baruwal, Prashrit	Wed. Apr. 9	4:35 PM – 5:00 PM	Turbulent Modes in Slow, Alfvenic Slow, and Fast Solar Wind at 1AU
Bellan, Paul	Wed. Apr. 9	8:55 AM – 9:20 AM	New form of the cold plasma wave equations and their solution for a cylindrical whistler duct
Bhattacharjee, Amitava	Wed. Apr. 9	3:20 PM – 3:45 PM	Compressible MHD turbulence in the Interstellar Medium and the Solar Wind
Boldyrev, Stanislav	Mon. Apr. 7	2:30 PM – 2:55 PM	Relativistic Particle Acceleration in Alfvenic Turbulence

Bowen, Trevor	Thur. Apr. 10	8:30 AM – 8:45 AM	Kinetic Signatures of Turbulent Heating
Brant, Pontus	Tue. Apr. 8	11:25 AM – 11:50 AM	Preparing for the Termination Shock Encounter with New Horizons
Bzowski, Maciej	Mon. Apr. 7	10:35 AM – 11:00 AM	Retrieval of solar wind structure by IMAP GLOWS and implications for ENA observations
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Kornbleuth, Marc	Mon. Apr. 7	8:30 AM – 8:45 AM	Magnetic Reconnection in the Heliotail and the Effect on Energetic Neutral Atoms
Krasnoselskikh, Vladimir	Thur. Apr. 10	3:20 PM – 3:45 PM	Plasma instability in the front of ejected energetic electrons and Type III solar radiobursts

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Le Roux, Jakobus	Wed. Apr. 9	2:55 PM – 3:20 PM	Evidence for Tempered Superdiffusive Shock at a Quasi-Perpendicular Interplanetary Shock
Leske, Rick	Thur. Apr. 10	11:00 AM – 11:25 AM	Updated Observations of the Intensity of Anomalous and Galactic Cosmic Rays at 1 AU from the Advanced Composition Explorer
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Zhao, Siqi	Tue. Apr. 8	3:20 PM – 3:45 PM	Observations of Turbulence and Particle Transport at Interplanetary Shocks: Transition of Transport Regimes

POSTERS BY PARTICIPANT

Ayaz, Syed	Alfvén waves in the solar corona: resonance velocity, damping length, and charged particles acceleration by kinetic Alfvén waves
Brant, Pontus	Decadal Survey Recommendations for Interstellar Probe and Next Steps
Mostafavi, Parisa	Preferential Heating of Solar Wind Ions Near the Alfvenic Surface

SCHEDULE OF TALKS

Monday, April 07: 8:30 AM – 8:55 AM
Presenter: Kornbleuth, Marc

Magnetic Reconnection in the Heliotail and the Effect on Energetic Neutral Atoms

Merav Opher, Boston University, USA
James F. Drake, University of Maryland, USA
Marc Swisdak, University of Maryland, USA
Zhiyu Yin, University of Maryland, USA
Kostas Dialynas, Academy of Athens, Greece
Yuxi Chen, University of Michigan, USA
Justyna M. Sokół, Southwest Research Institute, USA
Matina Gkioulidou, Johns Hopkins Applied Physics Laboratory, USA
Igor Baliukin, Lomonosov Moscow State University, Russia
Vladislav Izmodenov, Lomonosov Moscow State University, Russia
Gary P. Zank, University of Alabama in Huntsville, USA

The shape of the heliosphere has recently been the subject of intense debate in the last decade. There is disagreement whether the heliospheric tail extends to ~10,000 au in a comet-like shape or if it is short (~ 400 au) with a split. Previous work indicated that, in the absence of acceleration of ions in the heliosheath, the shape of the heliotail cannot be distinguished with energetic neutral atoms (ENAs) until 80 keV. Here, we use an updated multi-ion magnetohydrodynamic (MHD) model with three ion fluids and the recently developed kglobal model to simulate the effects of magnetic reconnection within the downwind heliosphere. Unique to the split-tail heliosphere, in the downwind direction at low latitudes is a low-β (ratio of thermal to magnetic pressure) region as the flow of particles are deflected towards high latitudes by the solar magnetic field. The low-β region near the heliopause in the downwind direction provides sufficient magnetic energy for reconnection to accelerate the cold solar wind ions (eV) to keV energies. We explore the effect of these accelerated on high-energy ENAs.

Monday, April 07: 8:55 AM – 9:25 AM
Presenter: Van der Holst, Bart

Energy distribution of pickup ions in the outer heliosphere

Bart van der Holst, Boston University, USA
Merav Opher, Boston University, USA

The outer heliosphere model in the Space Weather Modeling Framework (SWMF) describes the dynamics of the thermal solar wind, pickup ions, electrons and neutrals. We have extended this model with a kinetic description of the pickup ions (PUIs) and turbulence transport to better capture the interaction of the solar wind with the interstellar medium. The turbulence energy is enhanced via isotropization of newly born PUIs. This increased turbulence can further heat the thermal protons. Additionally, the PUIs are non-thermal. We assume that the PUI are fast pitch-angle scattered into isotropic distribution through wave-particle interaction. Hence, we simulate the PUI velocity distribution function by solving the PUI transport equations under the assumption that the distribution is isotropic and depends only on the velocity magnitude in the PUI rest frame. In the PUI transport equations, we include velocity space advection and diffusion contributions. The diffusion coefficient depends on the rms fluctuating velocity and the correlation length. We have additional source terms containing charge exchange and photoionization.

SCHEDULE OF TALKS

Monday, April 07: 9:20 AM – 9:45 AM
Presenter: Florinski, Vladimir

Effects of plasma anisotropies in the outer heliosheath

Vladimir Florinski, University of Alabama in Huntsville, USA
Dinshaw Balsara, University of Notre Dame, USA
Deepak Bhoriya, University of Notre Dame, USA
Gary Zank, University of Alabama in Huntsville, USA
Shishir Biswas, University of Notre Dame, USA

The wave activity in the outer heliosheath (OHS) is low enough to permit the interstellar plasma to develop significant temperature anisotropies. Using a newly developed computational model of the global heliosphere based on the Chew-Goldberger-Low (CGL) system of equations, we examine the formation of anisotropic regions adjacent to the heliopause from the interstellar side. We find that a narrow region with a parallel pressure excess can develop in the northern hemisphere, coincident with the magnetic trap that is characterized by a plasma flow deformation parallel to the magnetic field lines. Conversely, a region of domimnant perpendicular pressure forms in the southern hemisphere where the magnetic field is compressed. The latter bears a resemblance to the plasma depletion layers around planetary magnetospheres throughout the solar system. This implies that mirror-mode or ion cyclotron waves could be generated if the mirror instability threshold is crossed by the plasma. The overall effect of the anisotropy of the structure of the heliosphere is not large owing to relatively large Coulomb collision frequency in the OHS. However, the effect is expected to be stronger during the times the heliosphere is immersed in the hot low density environment of the Local Bubble.

Monday, April 07: 9:45 AM – 10:10 AM
Presenter: Nikoukar, Romina

Observation of the Heliospheric Energetic Particle “Valley” and Implications for a New Horizons Encounter with the Solar Wind Termination Shock

R. Nikoukar, JHU/APL, USA
M. E. Hill, JHU/APL, USA
P. Kollmann, JHU/APL, USA
R.B. Decker, JHU/APL, USA
K. Dialynas, Academy of Athens, Greece
S. M. Krimigis, JHU/APL, USA
D. Hamilton, University of Maryland, USA
E. Powell, Boston University, USA
A. Elliott, SWRI, USA
J. D. Richardson, MIT, USA
P. Mostafavi, JHU/APL, USA
F. Carcaboso, GFSC, USA
J. Giacalone, University of Arizona, USA
V. Florinski, UAH, USA
M. Zhang, Florida Tech, USA
J. M. Sokol, SWRI, USA
L. Adhikari, UAH, USA
J. Gasser, SWRI, USA
B. Wang, UAH, USA
L. Zhao, UAH, USA
S. Lasley, University of Maryland, USA
J. Manweiler, Fundamental Technologies, USA
S. Reeve, Fundamental Technologies, USA
H., R.L. McNutt, Jr., JHU/APL, USA
, P. C. Brandt, JHU/APL, USA
L. Brown, JHU/APL, USA

M. Opher, Boston University, USA
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Launched in 2006, the New Horizons (NH) spacecraft is currently ~61 AU from the Sun and expected to encounter the solar wind termination shock (TS) as a first step in exiting the heliosphere. Together with Voyager 1 and 2—which crossed the TS at northern heliolatitudes at ~94 AU and southern heliolatitudes at ~84 AU, respectively—NH will provide a third termination shock crossing, but from low heliolatitudes. More importantly, NH's instruments enable measurements that the Voyagers could not: the pressure-dominant, interstellar pickup ion (PUI) populations. Together, the three spacecraft provide the synergistic measurements to yield insight into the outer heliosphere boundary processes and the termination shock. In this work, we focus on energetic particle observations from the Voyager Low Energy Charged Particle (LECP) experiments and Pluto Energetic Particle Spectrometer Science Investigation (PEPSSI) instrument onboard NH at energies from ~40 keV to ~200 keV. The time series of both Voyager/LECP measurements shows a decrease in particle intensities with increasing radial distance from the Sun, reaching a minimum level and increasing again prior to their respective TS; we describe this intensity profile as a heliospheric valley. The time series of NH/PEPSSI observations from 5 AU (2007) to 60 AU (2024) shows a similar decrease in particle fluxes with increasing distance from the Sun. To make a more concrete comparison between the Voyager and New Horizons observations as a function of radial distance from the Sun and to account for temporal variations due to significantly different solar wind conditions, we normalize the particle intensities from both Voyagers and NH with energetic particle observations at 1 AU. For this purpose, we use the Energetic Particles Experiment (EPE) onboard the Interplanetary Monitoring Platform - 8 (IMP-8) and Energetic Proton and Alpha Monitor (EPAM) onboard the Advanced Composition Explorer (ACE). Our analysis of the radial dependence of particle intensities from the three spacecraft shows an approximate power-law dependence with a break beyond ~30 AU. While the plot of intensities vs distance shows a shallower slope (~-1.5 to -2) for distances less than ~30 AU, it exhibits a much steeper slope (~-3.3) for larger distances. This break in radial profile of energetic particles seems to be a general feature in the heliosphere as it is observed by the three spacecraft, covering different parts of the heliosphere. The radial break could be due to temporary changes in the local plasma or unaccounted energetic particle processing, and thus potentially suggests different transport and acceleration processes at play in these regions.

The New Horizons mission team is working towards estimating when the NH termination shock crossing will occur to allow for operational preparations that can maximize the scientific investigation of the TS, filling the gaps left by the historic Voyager crossings. Currently, we expect NH to cross the TS between 2027 and 2034.

SCHEDULE OF TALKS

Monday, April 07: 10:35 AM – 11:00 AM
Presenter: Bzowski, Maciej

Retrieval of solar wind structure by IMAP GLOWS and implications for ENA observations

M. Bzowski
M. Strumik
C. Porowski
M.A. Kubiak
I. Kowalska-Leszczyńska

Space Research Centre PAS (CBK PAN)

Solar wind plasma interacts with interstellar neutral gas by collisions, and the resulting populations of charged and neutral atoms significantly affect the size and shape of the heliosphere, plasma flows in the heliosphere, as well as the production of secondary atoms that have been observed at 1 au as messengers of the physical processes operating in remote regions of the heliosphere. Solar wind is not spherically symmetric – latitudinal profiles of its speed and density evolve during the cycle of solar

activity. These variations have been used, among others, as a sounding tool for the size of the heliosphere and recognition of the solar wins state is a prerequisite for analysis of energetic neutral atom observations.

Variations in the solar wind profiles are reflected in the sky distribution of the heliospheric backscatter glow, to be observed by the GLOWS experiment on the forthcoming IMAP mission. We present a novel machine-learning method of retrieval of the solar wind structure based on helioglow lightcurves and discuss differences with the direct fit method.

We analyze differences between attenuation of ENAs observed by IBEX and those expected at IMAP due to a different and variable observation geometry and energy range of the latter, as well as the fact that IMAP is launched during a maximum of solar activity, which is much stronger than the previous ones observed by IMAP. In particular, we discuss expected variations in the ENA spectral indices and the magnitude of the expected attenuation at the high- and low-energy ranges of the IMAP ENA cameras.

Monday, April 07: 11:00 AM – 11:25 AM
Presenter: Guo, Xiaocheng

Stochastic Simulation of Galactic Cosmic-Rays in the Trapped Region beyond Heliopause

Xiaocheng Guo, National Space Science Center, Chinese Academy of Sciences, Beijing, CHINA

It was proposed previously that Galactic Cosmic-Rays(GCRs) are trapped in a region where the weak local interstellar magnetic field lines are spreaded apart by the heliopause in the northern hemisphere. Such a trapped region acts like a magnetic mirror for GCR particles. Once entering the trapped region from the outside interstellar space, GCR particles will encounter more complicated situtation, besides the bouncing between the mirror points, they will move along the trajectories being perpendicular to the background magnetic field lines due to curvature/gradient drifts. As a result, some GCR particles will be trapped in the region, the nearly non-scattering movement along the magnetic field lines become slow, leading a total decrease of parallel diffusion. In this study, we will carry out the relavant stochastic simulation of GCRs based on the assumption that GCR particles do not move freely along the parallel direction of interstellar magnetic field. Some discussions about the work will be made base on our simulation results.

SCHEDULE OF TALKS

Monday, April 07: 11:25 AM – 11:50 AM
Presenter: Fuselier, Stephen

Energetic neutral atom fluxes from the Voyager 1 and 2 directions

Stephen A. Fuselier, Southwest Research Institute, University of Texas at San Antonio, USA
Eric Zirnstein, Princeton University, USA
Jacob Heerikhuisen, University of Waikato, New Zealand
André Galli, University of Bern, Switzerland,
John D. Richardson, Massachusetts Institute of Technology, USA
Daniel B. Reisenfeld, Los Alamos National Laboratory, USA
Nathan A. Schwadron, University of New Hampshire, USA
Maher A. Dayeh, Southwest Research Institute, University of Texas at San Antonio, USA
David J. McComas, Princeton University, USA
Herbert O. Funsten, Los Alamos National Laboratory, USA
Justyna M. Sokół, Southwest Research Institute, USA
Merav Opher, Boston University, USA
Marc Z. Kornbleuth, Boston University, USA

Jonathan Gasser, Southwest Research Institute, USA

IBEX observes a globally distributed ENA flux from the heliosheath and very local interstellar medium (VLISM). Over a 14-year period, Voyager 1 and Voyager 2 traversed the heliosheath from the termination shock to the heliopause. In situ observations from these spacecraft place important constraints on the parent ion populations of the ENAs from the heliosheath in two directions on the upwind side of the heliosphere. The upwind direction is the direction of motion of the Sun in the local interstellar medium. In this study, an MHD model that is constrained by Voyager in situ observations is used to estimate the contribution from the heliosheath to the total ENA fluxes observed by IBEX. At energies greater than about 1 keV, the heliosheath provides a significant fraction of the observed ENA flux. However, at energies less than about 0.5 keV, the heliosheath provides an insignificant fraction of the observed ENA flux. These results are the same for both directions and, since the Voyager 1 and 2 directions are not particularly unique, the results are likely to be the same for any upwind direction. Fundamentally, it is the physics of the termination shock and the thickness of the heliosheath that determines the energy-dependent contributions from this region to the observed ENA flux. Ultimately, the source of most of the ENAs at energies less than about 0.5 keV is the VLISM.

Monday, April 07: 11:50 AM – 12:15 PM
Presenter: Shen, Fang

Modelling Energetic Proton Transport in Stream Interaction Regions

Fang Shen, State Key Laboratory of Solar Activity and Space Weather, National Space Science Center (NSSC), Chinese Academy of Science (CAS), China
Xinyi Tao, State Key Laboratory of Solar Activity and Space Weather, NSSC, CAS, China
Yuji Zhu, Shandong Institute of Advanced Technology, China
Wenwen Wei, Space Sciences Lab, UC Berkeley, USA
Xi Luo, Shandong Institute of Advanced Technology, China
Xueshang Feng, State Key Laboratory of Solar Activity and Space Weather, NSSC, CAS, China

Stream interaction regions (SIRs) are formed when fast and tenuous streams originating from coronal holes overtake slow and dense ones ahead. In this work, we developed a coupled model composed of a data-driven analytical background model providing solar wind configuration and a particle transport model represented by the focused transport equation (FTE), to examine two SIR-associated energetic particle events.
One event was observed by the Solar-Terrestrial Relations Observatory-A (STEREO-A) from 21 to 24 August 2016. The background model driven by spacecraft observation near 1AU provides the solar wind density, velocity, and magnetic field as functions of r and ϕ, which is simple but can present a more complete description of the solar wind. We simulated proton transport in the SIR region of interest in order to obtain the evolution of proton fluxes and derive the spectra. We find that the simulation is well correlated with the observation. And we suggest that instead of being accelerated by distant shocks, a local mechanism similar to diffusive shock acceleration (DSA) acting in the compression region could explain the flux enhancements of 1.8–10.0MeV nucleon-1 protons.
The other energetic proton events, associated with a stream interaction region (SIR), were observed by twin Solar-Terrestrial Relations Observatory (STEREO) and WIND spacecrafts from 2007 September 19 to 25. Different from other spacecraft observations, the in-situ data from STEREO-B show significant increase and rapid decay of particle intensity in the compound stream region after the SIR passing over the spacecraft. By using the coupled model, our results reproduce the evolution features of proton intensity and energy spectrum from the observation of STEREO-B and confirm the additional energetic particle event is closely related to the previous SIR event. We emphasize the importance of accelerated suprathermal ions as seed.

SCHEDULE OF TALKS

Monday, April 07: 12:15 PM – 12:40 PM
Presenter: Cohen, Christina

Multi-spacecraft observations of the 23 July 2024 Fe-rich SEP event

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G.M. Mason, Johns Hopkins Applied Physics Laboratory, USA
G.D. Berland, Johns Hopkins Applied Physics Laboratory, USA
E.R. Christian, NASA Goddard Space Flight Center, USA
G.C. Ho, Southwest Research Institute, USA
D.J. McComas, Princeton University, USA
G.D. Muro, California Institute of Technology, USA
J. Rodríguez-Pacheco, Universidad de Alcalá, Spain
N.A. Schwadron, University of New Hampshire, USA
R.F. Wimmer-Schweingruber, Christian-Albrechts-Universität zu Kiel
Z. Xu, California Institute of Technology, USA

The solar energetic particle (SEP) event on 23 July 2024 was interesting for a number of reasons. It was observed by four spacecraft, ACE, STEREO-A, and PSP clustered on the Earth-facing side and SolO 160° to the west. PSP was at 0.6 au and nearly radially aligned with STEREO-A. This distribution allows the event characteristics to be examined as a function of distance and longitude. Particularly interesting is that the SEP event was found to be Fe-rich at all spacecraft despite the different magnetic connections to the solar source. The cause of elevated Fe/O abundance ratios in large SEP events associated with fast coronal mass ejections (CMEs) continues to be debated and not fully understood. We present the observations in this event and discuss their implications for possible explanations of Fe-rich large SEP events.

SCHEDULE OF TALKS

Monday, April 07: 1:40 PM – 2:05 PM
Presenter: Baker, Daniel

A Small Pathbreaking Spacecraft - Giants of Space Research

D. N. Baker, Laboratory for Atmospheric and Space Physic, University of Colorado Boulder, USA

The Solar, Anomalous, and Magnetospheric Explorer (SAMPEX) mission launched in July 1992 was the first NASA “Small Explorer” project. It had the goal to show how space missions could be developed much more rapidly than had become the situation in the 1980s and 1990s. The program showed that outstanding research could be done from small spacecraft platforms and could be done with a minimum of bureaucratic paperwork. SAMPEX brought together researchers from the solar, cosmic ray, magnetospheric, and atmospheric disciplines to accomplish a comprehensive sweep of research objectives with a small satellite. In many ways, SAMPEX played a major role in bringing on the “New Space” revolution that has transformed space exploration and scientific research in space. It is defensible to say that SAMPEX led to a rebirth of radiation belt science. This article speaks about the seminal roles of Edward Stone, Dieter Hovestadt, and J. Bernard Blake in the SAMPEX program. They were at the nucleus of a much larger team of researchers at the U. of Maryland, the U. of Colorado, Aerospace Corp., the Max Planck Institute, Caltech, NASA Goddard Space Flight Center, NASA Langley Research Center, and many other institutions. Many dozens of students were trained under the SAMPEX umbrella and research with the SAMPEX data continues to this day. It is fair to say that SAMPEX in many ways exemplified AGU’s motto of unselfish cooperation in research. It certainly attained something that AGU seeks to do by getting space physics, atmospheric science, astrophysics, and solar researchers to cooperate actively. SAMPEX showed that big science could be done with small missions.

SCHEDULE OF TALKS

Monday, April 07: 2:05 PM – 2:30 PM
Presenter: Slavin, Jonathan

Seeding the Local Interstellar Cloud and Heliosphere with Supernova Dust

Jonathan D. Slavin, Center for Astrophysics | Harvard & Smithsonain, USA

The presence of 60Fe in Antarctic snow is evidence for an ongoing influx of supernova created dust into the heliosphere from the Local Interstellar Cloud (LIC). This is consistent with the location of the LIC inside of a large hot bubble that was created by

supernova explosions. However, it is unclear how those grains got into the LIC, since a magnetized cloud will tend to reflect grains incident on it. We examine how the LIC might have been seeded with supernova grains and what this can tell us about the history of the local interstellar medium.

Monday, April 07: 2:30 PM – 2:55 PM
Presenter: Boldyrev, Stanislav

Relativistic Particle Acceleration in Alfvenic Turbulence

Stanislav Boldyrev, University of Wisconsin-Madison, USA

Alfvenic turbulence is common in colisionless astrophysical plasmas and plays a significant role in energizing plasma particles. At smaller scales, it creates intermittent current structures and can be affected by tearing instability or charge starvation effects. We discuss the resent results on relativistic particle acceleration in Alfvenic turbulence [1-3]. We argue that the relative strength of turbulent magnetic fluctuations, compared to the guiding magnetic field, defines the energy spectrum of the accelerated particles. Furthermore, it influences the distribution of the pitch angles of the particles, which may affect the radiative signatures of astrophysical objects.

1. C. Vega, S. Boldyrev, V. Roytershteyn, Particle Acceleration in Relativistic Alfvenic Turbulence, ApJ, 971, 106, 2024
2. S. Boldyrev, N. Loureiro, Tearing-mediated Alfvenic Turbulence in a Relativistic Plasma, ApJ, 979, 232, 2025
3. C. Vega, S. Boldyrev, V. Roytershteyn, Anisotropic particle acceleration in Alfvenic turbulence, ApJ, 2025, submitted.

This work was supported by the U.S. Department of Energy, Office of Science, Office of Fusion Energy Sciences under award number DE-SC0024362.

SCHEDULE OF TALKS

Monday, April 07: 2:55 PM – 3:20 PM
Presenter: Nakanotani, Masaru

Survival of 2D Turbulence in the Local Interstellar Medium

Masaru Nakanotani, CSPAR, Univeristy of Alabama in Huntsville, USA
Gary P. Zank, CSPAR, University of Alabama in Huntsville, USA

The local interstellar medium (LISM) around the heliosphere is a partially ionized plasma, in which the plasma (MHD) and neutral fluid (HD) are coupled via several processes (e.g. charge exchange, elastic collisions, and ionization/recombination). Such a coupling causes damping on turbulence and linear wave modes in a partially ionized plasma. However, in the linear regime, since the 2D mode (magnetic islands or flux ropes) has no velocity fluctuations, there is no damping on the 2D mode due to the presence of neutral atoms. This indicates that Alfvenic and compressible turbulence can be damped while 2D turbulence may survive without a damping in the local interstellar medium. To verify this point, we perform 2D simulations of partially ionized plasma coupled by a charge-exchange process using the spectral method. We find that plasma and neutral velocity fluctuations are immediately damped due to the plasma-neutral coupling while magnetic fluctuations are an affected and become dominant component in the system. The power spectral density of the magnetic energy shows a power-law spectrum with an index of -7/3, and we identify that small scale fluctuations are produced by magnetic reconnection. We also discuss an implication of the results on the diffusion and transport of cosmic rays in the local interstellar medium.

Monday, April 07: 3:20 PM – 3:45 PM
Presenter: Husidic, Edin

Modelling Energetic Particles and Gyrosynchrotron Radiation in the Solar Corona and Inner Heliosphere

Edin Husidic, KU Leuven, Belgium / University of Turku, Finland
Nicolas Wijsen, KU Leuven, Belgium
Immanuel Christopher Jebaraj, University of Turku, Finland
Luis Linan, KU Leuven, Belgium
Rami Vainio, University of Turku, Finland
Stefaan Poedts, KU Leuven, Belgium / University of Maria Curie-Sklodowska, Poland

Solar Energetic Particles (SEPs) are accelerated at solar flare sites and at the fronts of shock waves driven by fast Coronal Mass Ejections (CMEs). These particles can reach relativistic speeds and pose a serious threat to spacecraft and astronauts, making their study essential. In addition to remote sensing and in-situ measurements, physics-based simulation tools capable of realistically computing the acceleration and transport of high-energy particles, alongside CME evolution, can enhance our physical understanding of these processes.

In this talk, we present recent results from the particle acceleration and transport code PARADISE. By stochastically solving the focused transport equation, PARADISE simulates the evolution of energetic particle distributions through background solar wind configurations derived from magnetohydrodynamic (MHD) models. These include the inner heliospheric models EUHFORIA and the MPI-AMRVAC-based Icarus code, both of which incorporate transient structures such as stream interaction regions and CMEs. Recently, PARADISE has been extended by coupling it with the coronal MHD model COCONUT, allowing the study of particle acceleration and transport in the corona.

We present applications of PARADISE in both observational and theoretical studies based on these MHD models. Additionally, we showcase preliminary results from our latest modelling framework, which simulates gyrosynchrotron emission in type IV radio bursts from energetic electrons trapped in a coronal CME flux ropes. We explore how varying electron injection spectra and CME properties influence the resulting radio spectra.

Monday, April 07: 4:10 PM – 4:35 PM
Presenter: Huang, Zhenguang

Time Evaluation of the Potential Field Source Surface Height in a Solar Cycle

Zhenguang Huang, University of Michigan, USA
Gábor Tóth, University of Michigan, USA
Jia Huang, University of California, USA
Nishtha Sachdeva, University of Michigan, USA
Bart van der Holst, University of Michigan, USA
Ward B. Manchester, University of Michigan, USA

A potential field solution is widely used to extrapolate the coronal magnetic field above the Sun’s surface to a certain height. This model applies the current-free approximation and assumes that the magnetic field is entirely radial beyond the source surface height, which is defined as the radial distance from the center of the Sun. Even though the source surface is commonly specified at 2.5 Rs (solar radii), previous studies have suggested that this value is not optimal in all cases. In this study, we propose a novel approach to specify the source surface height by comparing the areas of the open magnetic field regions from the potential field solution with predictions made by a magnetohydrodynamic model, in our case the Alfvén Wave Solar atmosphere Model. We find that the adjusted source surface height is significantly less than 2.5 Rs near solar minimum and slightly larger than 2.5 Rs near solar maximum. We also report that the adjusted source surface height can provide a better open flux agreement with the observations near the solar minimum, while the comparison near the solar maximum is slightly worse.

Monday, April 07: 4:35 PM – 5:00 PM
Presenter: Tasnim, Ismita

Mode Decomposition in Hydrodynamics for the Outer Heliosphere

I. Tasnim
G. P. Zank
L. Adhikari
L. L. Zhao
P. Baruwal
P. Baruwal
M. Karki
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University of Alabama in Huntsville, Huntsville, Alabama 35805, USA

Recently, Zank et al 2023 introduced a mode-decomposition technique to identify low-frequency magnetohydrodynamic (MHD) modes in the magnetized solar wind plasma, including the advected entropy and magnetic island modes. In the distant heliosphere where pickup ions (PUIs) dominate thermodynamically, the NASA New Horizons spacecraft is measuring both the thermal and pickup ion plasma components. But, since it does not have a magnetometer, and is unable to measure magnetic field. In this case, an alternative method is needed to compute the small amplitude fluctuations in hydrodynamic fluids (specifically, the density of thermal protons and PUIs, solar wind velocity, and thermal pressure of both thermal protons and PUIs). Zank et al 2023 included an Appendix that described a technique for calculating the four fundamental hydrodynamic modes, namely the advected entropy and vorticity modes, and the forward ($+$) and backward ($-$) acoustic modes in an unmagnetized fluid. The significant pressure contributed by pickup ions ensures that the plasma beta is large ($>> 1$) rendering a hydrodynamic approximation as approximately reasonable. In a preliminary study, we utilize the hydrodynamic mode-decomposition technique to identify admissible modes through the plasma fluctuations measured at a specific frequency (ω_m') and wavenumber k_m. In this study, we apply the technique to calculate the fundamental modes in plasma parcel measured by the New Horizons spacecraft. With our study, we aim to identify the advected entropy modes for both thermal plasma and PUIs, the vorticity modes, and the forward ($+$) and backward ($-$) acoustic modes for both plasma and PUIs in an unmagnetized fluid for the outer heliosphere.

SCHEDULE OF TALKS

Tuesday, April 08: 8:30 AM – 8:55 AM

Presenter: Phan, Tai

Parker Solar Probe Observations of Flux Rope Merging and Proton Energization up to 400 keV in a Heliospheric Current Sheet

Tai Phan, UC Berkeley, USA
James F. Drake, U of Maryland, USA
Mihir Desai, SWRI, USA
Zhiyu Yin, U of Maryland, USA
and the PSP Team

The Heliospheric Current Sheet (HCS) is the largest current sheet in the solar system. It extends from the Sun to far beyond 1 AU. The HCS is usually thick, measuring thousands to tens of thousands of ion inertial lengths. Based on the observations of HCS at 1 AU, reconnection was thought to be rare in the HCS. Thus, one of the surprises of the PSP mission has been the finding that reconnection occurs almost all the time in the HCS near the Sun. Every PSP crossing of the HCS has revealed new and often puzzling features of large-scale HCS reconnection. Here we describe an Encounter 14 crossing of the HCS where a sunward directed reconnection exhaust was detected. A number of sub-scale current sheets were present in the large-scale exhaust. Remarkably, five SCS showed direct evidence for reconnection, displaying near-Alfvénic outflow jets and bifurcated current sheets. The SCS exhausts were directed predominantly orthogonal to the HCS exhaust direction, suggesting that they could be associated with coalescence of multiple large flux ropes inside the HCS exhaust. Within the HCS exhaust, PSP also detected energetic protons up to ~400 keV, which is ≈1000 times greater than the available magnetic energy per particle. Supporting simulations using the Kglobal model suggest that the trapping and acceleration of protons up to ~400 keV in the reconnection exhaust is likely facilitated by merging magnetic islands, consistent with the observations. These new results, enabled by PSP's proximity to the Sun, suggest the common occurrence of flux rope merging, and that reconnection in the HCS could be a significant source of energetic particles in the near-Sun solar wind.

Tuesday, April 08: 8:55 AM – 9:20 AM
Presenter: Elliott, Heather

Radial Evolution of the Solar Wind

Heather A. Elliott, Southwest Research Institute, USA
Tae K. Kim, University of Alabama Huntsville, USA
John D. Richardson, Massachusetts Institute of Technology, USA
Justyna M. Sokół, Southwest Research Institute, USA
Bishwas L. Shrestha, Princeton University, USA
Eric J. Zirnstein, Princeton University, USA
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Paweł Swaczyna, Space Research Centre PAS, Poland
Merav Opher, Boston University, USA
Maher A. Dayeh, Southwest Research Institute, USA
Matthew E. Hill, John Hopkins Applied Physics Lab, USA
Andrew Poppe, University of California Berkeley, USA
S. Alan Stern, Southwest Research Institute, USA
Pontus C. Brandt, John Hopkins Applied Physics Lab, USA
Kelsi Singer, Southwest Research Institute, USA
Joel Parker, Southwest Research Institute, USA
Anne J. Verbiscer, University of Virginia, USA

We examine radial changes in the solar wind properties with increasing distance using a variety of data sets. At 1 au, the correlations between various solar wind parameters result from different solar wind source regions producing different solar wind properties, and from dynamic interaction between various speed parcels interacting with one another as the solar wind propagates through the heliosphere. For instance, the fast solar wind from coronal holes is hotter and less dense than slow solar wind associated with streamers and/or coronal hole boundaries. Dynamic interactions in compressions (rarefactions) cause the solar wind density, temperature, and field strength to be enhanced (reduced) as fast wind parcels run into (away from) slower ones emitted earlier (later). Such dynamic interactions eventually lead to the merging and wearing down of solar wind structures. We show that most of the merging and wearing down process occurs within 20 au. By about 30 au, the slowing of the solar wind becomes apparent and has a steady rate of about -0.35% au-1 until at least 60 au.

SCHEDULE OF TALKS

Tuesday, April 08: 9:20 AM – 9:45 AM
Presenter: Alonso Guzman, Juan

Galactic Cosmic Ray Modulation in a Dynamic Heliosheath

Juan G Alonso Guzman, University of Alabama in Huntsville, USA
Vladimir A Florinski, University of Alabama in Huntsville, USA
Lingling Zhao, University of Alabama in Huntsville, USA
Alan Cummings, California Institute of Technology, USA
Bryant Heikkila, Goddard Space Flight Center, USA
Matthew Hill, Johns Hopkins University Applied Physics Laboratory, USA
Romina Nikoukar, Johns Hopkins University Applied Physics Laboratory, USA
Merav Opher, Boston University, USA

During its transit through the heliosheath (HS), Voyager 2 (V2) measured dynamic energetic particle behavior with long-periods of flux depressions or enhancements which were temporally coherent over a wide range of rigidities. Although these observations are still not fully understood, it is generally believed that the most relevant factors are cosmic ray diffusion, characterized by the turbulence of the HS plasma, as well as solar cycle effects which are continuously propagating away from the Sun. In order to gain insight into the energetic particle measurements, we present our findings from a time-dependent, numerical modeling of galactic helium and electrons during the times that V2 was in the HS. In this model, the galactic species are treated as test particles, with empirical, data-informed diffusion coefficients, incurring modulation by a spherical heliosphere, which is simulated analytically to account for solar cycle variations as they advect outward. Candidate explanations for the particle observations will be judged based on model results and available theory.

Tuesday, April 08: 9:45 AM – 10:10 AM
Presenter: Richardson, John

Voyager observations of the interstellar medium

John Richardson, MIT 37-655, Cambridge, MA 01742
Voyager Team

The Voyager spacecraft have been in the very local interstellar medium (VLISM) since 2012 and 2018, with Voyager 1 now about 40 AU past the heliopause. We show recent data from all the working Voyager instruments and discuss their implications for how the LISM interacts with the heliosphere. A 2020 pressure front has been followed by almost 5 years of high magnetic fields and electron densities. Magnetic field observations which do not show the expected rotation to the predicted LISM field direction. These

observations have lead to several explanatory hypotheses which we will discuss, ranging from a time dependent solar cycle effect to this boundary being part of the heliopause structure.

SCHEDULE OF TALKS

Tuesday, April 08: 10:35 AM – 11:00 AM
Presenter: Dialynas, Konstantinos

Anisotropies of 40-139 keV ions from LECP on Voyager 1 in the heliosphere: indications for a new region in the VLISM

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Decker, R. B., Applied Physics Laboratory, The Johns Hopkins University, Laurel, Maryland, USA
Hill, M. E., Applied Physics Laboratory, The Johns Hopkins University, Laurel, Maryland, USA
Nikoukar, R. Applied Physics Laboratory, The Johns Hopkins University, Laurel, Maryland, USA
Opher, M., Astronomy Department, Boston University, Boston, MA 02215, USA

The Low Energy Charged Particle (LECP; Krimigis et al. 1977) detector on Voyager is capable of sampling the anisotropy of the energetic ion intensity in seven positions spaced by 45 deg in its scan plane (one sector is blocked by intention and is used for calibration purposes). Previous analyses of 40-139 keV ion measurements obtained by the LECP on Voyager 1 (V1) from the supersonic solar wind out to the Very Local Iinterstellar Medium (VLISM), showed the existence of a region of ~9-10 au before the HP where the radial (perpendicular to the magnetic field) anisotropy is negative, suggesting an inflow of suprathermal ions into the heliosheath, and a region of ~30 au beyond the heliopause (HP) where the radial anisotropy of 40-139 keV ions is positive, suggesting an outflow of suprathermal ions leaking from the heliosheath into the VLISM (Dialynas et al. 2021). Recently, Dialynas et al. (2024) further showed that: (1) the azimuthal ion anisotropy (parallel to the magnetic field) turns to -T direction (RTN system) inside the heliosheath and becomes nearly zero from the HP (~121.6 au) out to ~41 au past the HP; and (2) a region of ~10 au, i.e. from the year 2021 up to (at least) 2023 November, where both the radial and azimuthal anisotropies are nearly zero. This feature occurs after the second "pressure front" (pf2), identified with the magnetic field measurement (Burlaga et al. 2023), also associated with an increase (and subsequent plateau) of electron densities (Kurth, 2024) at the same time period. Beyond the year 2022 (~155 au) the magnetic field parameters are consistent with a clear separation of two regions in space with different magnetic field properties (Burlaga et al. 2024a). These LECP observations provide indications that V1 may have entered a new region in the VLISM since (at least) the year 2021, progressively developing characteristics akin to the pristine IS medium. Other analyses, e.g. Fisk & Gloeckler (2022) argue that these Voyager measurements beyond the "pf2" are indicative of the flow of ions through the "helicliff" up to the "heliopause", or as also argued by Burlaga et al. (2024b) an effect of the solar cycle in the VLISM, such as a prolonged compression/shock of solar origin (e.g. Gurnett et al. 2021).

References:
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Tuesday, April 08: 11:00 AM – 11:25 AM
Presenter: Opher, Merav

Did the Sun Always Have a Wind?

Merav Opher, USA
Abraham Loeb, USA
Bart van der Holst, USA

Since Parker's seminal work (1958) and the in-situ detection, it has been established that the Sun sustains a supersonic wind. Such work assumed negligible interstellar medium pressure as compared to the solar corona. Recent work (Opher et al. 2024a,b) argued that the Sun has traversed massive clouds within the last 10 million years. This raises a fundamental question: if the Sun encounters a cold dense cloud with densities of ~10^3 cm^{-3}, will the solar wind still transition from subsonic to supersonic as described by the Parker solution? Additionally, will the accretion rate of the dense cloud suppress the solar wind entirely? Past studies suggested that encounters with dense interstellar clouds (with densities exceeding a few hundred cm-3 and relative speed of order 20km/s) could shut off the solar wind due to high accretion rates. Here, we employ a state-of-the-art 3D magnetohydrodynamic (MHD) model driven by Alfven waves, benchmarked against 1 AU solar wind observations (van der Holst et al 2014), to model for solar wind from the solar surface. The model shows that during an encounter with a dense interstellar cloud of density 3000 cm^{-3} and relative velocity 18 km/s, the solar wind transitions through the sonic point and reaches supersonic speeds with slow winds at low latitudes and fast winds at high latitudes. The heliosphere contracts to sub-AU scales.

SCHEDULE OF TALKS

Tuesday, April 08: 11:25 AM – 11:50 AM
Presenter: Mostafavi, Parisa/Brandt, Pontus

Preparing for the Termination Shock Encounter with New Horizons

Pontus C. Brandt, Johns Hopkins APL, USA
Matt E. Hill, Johns Hopkins APL, USA
Heather A. Elliott, SwRI, USA
Romina Nikoukar, Johns Hopkins APL, USA
Peter Kollmann, Johns Hopkins APL, USA
Parisa Mostafavi, Johns Hopkins APL, USA
Ralph L. McNutt, Johns Hopkins APL, USA
Andrew R. Poppe, UC Berkeley, USA
Elena Provornikova, Johns Hopkins APL, USA
Pawel Swaczyna, Space Research Centre PAS, Poland
Merav Opher, Boston University, USA
Erick Powell, Boston University, USA
Justyna Sokol, SwRI, USA
David J. McComas, Princeton University, USA
K. Dialynas, Academy of Athens, Greece
S. Alan Stern, SwRI, USA
Kelsi N. Singer, SwRI, USA
Anne Verbiscer, SwRI, USA
Joel W. Parker, SwRI, USA
Randy Gladstone, SwRI, USA
Tracy Becker, SwRI, USA
Mihaly Horanyi, LASP, USA
Alex Doner, LASP, USA
Will Grundy, Lowell Observatory, USA
Susan Benecchi, PSI, USA

Across the Termination Shock (TS) the solar wind was expected to transition from supersonic to subsonic and heat by two orders of magnitude. Instead, Voyager 2 observed no apparent transition to subsonic speeds, with only a factor of ten increase in temperature, leaving a conundrum that could not be solved with Voyager instrumentation. These observations indicated that most of the solar wind energy transfers in to Pick-Up Ions (PUIs) elevating their role in the force balance of the global heliosphere.

New Horizons is currently 61 au from the Sun moving outward at 2.88 au/year on a trajectory along almost the same heliospheric longitude as Voyager 2, but near the ecliptic and towards the IBEX ribbon. Scaling the radial profiles of energetic particles measurements across the heliosphere obtained by LECP on Voyager 1 and 2 predicts that New Horizons will cross the TS at no less than 67 au from the Sun, which would occur mid-2027, but perhaps later, as the Voyager 1 and 2 crossings took place at 94 and 84 au at their higher ecliptic latitudes, respectively and at different solar cycles.

During the crossing of the TS NEW HORIZONS currently plans to obtain continuous solar wind plasma moments and H+ (and partly He+) PUI parameters at 29-min resolution with its SWAP instrument and intermittent 64-s resolution plasma moments. Simultaneously, New Horizons PEPSSI plans to produce continuous and simultaneous low- and high-resolution data of He+ PUIs and energetic particle spectra down to 3-s resolution enabling detection of flow anisotropies. Leading up to the TS crossing, and after, during the traversal of the heliosheath, New Horizons will continue to provide the only in-situ measurements of the heating of PUIs ever obtained (the Voyager mission did not include instrumentation to measure few keV to 28 keV). These measurements are important for understanding the apparent model discrepancy of ENA (Energetic Neutral Atom) intensities originating from the outer heliosphere observed by IBEX, Cassini, and soon IMAP.

Continuous in-situ measurements by the New Horizons SDC instrument have for years showed elevated fluxes of sub-micron dust, hinting at a production of ice grains or for other reasons not detected before. As one example, the excess of Kuiper Belt Objects between 60 and 80 au recently discovered by the Subaru Telescope, may also contribute to the elevated dust fluxes. These dust measurements will continue to and through and beyond the TS. Furthermore, New Horizons plans to acquire scans of Lyman-a intensities using its Alice UV spectrograph continue to monitor the column density of interstellar neutral hydrogen along a great circle perpendicular to the radial trajectory. This presentation gives an overview of the New Horizons TS crossing plan, the expected science return, and its impact on our understanding of the heliosphere and its stellar neighborhood.

Tuesday, April 08: 11:50 AM – 12:15 PM
Presenter: Yang, Zhongwei

Pickup Ion-Induced Foreshock and Magnetic Reconnection at an Oblique Heliospheric Termination Shock

Zhongwei Yang, National Space Science Center CAS, China
Hui Li, National Space Science Center CAS, China
Fan Guo, Los Alamos National Laboratory, USA
Gary P. Zank, University of Alabama in Huntsville, USA
Shuichi Matsukiyo, Kyushu University, Japan
Igor Baliukin, Space Research Institute of RAS, Russia
Wence Jiang, National Space Science Center CAS, China
Quanming Lu, USTC, China
Xiaocheng Guo, National Space Science Center CAS, China
Chi Wang, National Space Science Center CAS, China

The Voyager spacecraft's crossing of the heliospheric termination shock (TS) has provided the first in situ observations of the TS's nonstationary magnetic field (Burlaga et al., 2008) and downstream supersonic plasma flow (Richardson et al., 2008). TS models including magnetic reconnection and turbulence (Zank et al., 2015, 2021) suggest that ions can also be accelerated downstream of the TS. The TS at the heliospheric nose is a perpendicular shock, some studies (McComas et al., 2006, 2019) propose that high-energy ions, such as ACRs, downstream of the TS might originate from acceleration regions at the flanks. Their illustrations of heliospheric magnetic field lines and TS locations indicate that the TS near the nose could be either perpendicular or oblique. In this study, we simulate a PUI-mediated oblique TS using 2D Full PIC simulations, indicating that backstreaming PUIs excite upstream low-frequency (ULF) waves that form precursor/foreshock structures. As these ULF waves approach the shock front, they steepen, and the resulting current sheets trigger reconnections. These waves are compressed during the shock crossing, and lots of turbulent reconnections are excited in the downstream (inner heliosheath). These turbulent reconnections resemble the electron-only reconnection observed in Earth's magnetosheath (Phan et al., 2018). To quantitatively investigate the effects of shock normal angle and PUI% on PUI reflection, we conducted a series of 1D PIC simulations. Simulation results show that, under high PUI% conditions, backstreaming PUIs can be observed even at quasi-perpendicular shocks. These backstreaming PUIs disappear when the shock normal angle exceeds 60 degrees. This phenomenon is distinct from inner heliospheric shocks. This suggests that observed downstream magnetic islands and flux ropes (e.g., Zhao et al., 2020) may form spontaneously due to turbulent small-scale current filaments, or by heliospheric current sheets. In addition, the New Horizons spacecraft is continuing its journey toward the heliospheric nose. Published SWAP data now extends to approximately 60 AU (McComas, 2025), providing unprecedented opportunities to remake TS simulations. We will also discuss the preliminary results by using the PUI VDF observed by SWAP and the PUI VDF from models like MOSCOW as upstream inputs to drive TS simulations. Next, we will compare the resulting downstream ion count rates with observational data and aim to gradually understand the relationship between the observed ENA spectra and ion dynamics.

SCHEDULE OF TALKS

Tuesday, April 08: 12:15 PM – 12:40 PM
Presenter: Mostafavi, Parisa

Pickup Ions and Shock Dynamics in the Outer Heliosphere

Parisa Mostafavi, JHU/APL, USA
Laxman Adhikari, UAH, USA
Bishwas L. Shrestha, Princeton University, USA
Gary P. Zank, UAH, USA Merav Opher, BU, USA Matthew E. Hill, JHU/APL, USA Heather A. Elliott, SWRI, USA Pontus C. Brandt, JHU/APL, USA Ralph L. McNutt, JHU/APL, USA David J. McComas, Princeton University, USA Andrew R. Poppe, University of California Berkeley, USA Alan Stern, SWRI, USA And New Horizons team

The outer heliosphere represents a dynamic region formed by interactions between the solar wind and interstellar material. A crucial component in this region is pickup ions (PUIs)—originally neutral interstellar atoms ionized and subsequently energized through interactions with the solar wind. PUIs dominate the plasma pressure beyond approximately 10 au, significantly influencing shock heating, turbulence, and large-scale plasma dynamics within the outer heliosphere. New Horizons (NH), currently located around 62 au, is uniquely positioned as the only active mission directly observing PUIs in the distant heliosphere and soon at the termination shock. NH measurements demonstrate that PUIs considerably dominate solar wind internal pressure at large heliospheric distances, fundamentally modifying the structure and behavior of shocks in this region. Such modifications distinguish these outer heliospheric shocks from those typically observed in the inner heliosphere. Observations from NH further indicate that elevated solar wind dynamic pressures measured at 1 au significantly correlate with increases in PUI temperatures in the distant supersonic solar wind. Additionally, shocks observed in this region substantially enhance PUI heating, preferentially energizing PUIs relative to thermal solar wind ions. This preferential PUI heating can contribute to the enhanced energetic neutral atom (ENA) production observed by the Interstellar Boundary Explorer (IBEX). Despite lacking a magnetometer on NH, we estimate the average magnetic field. Leveraging these estimations, critical plasma parameters such as plasma beta and Mach numbers are calculated, providing insights into the distinct characteristics of shocks in the outer heliosphere compared to those observed closer to the Sun.

SCHEDULE OF TALKS

Tuesday, April 08: 1:40 PM – 2:05 PM
Presenter: Linan, Luis

Modeling CME propagation from the Sun to Earth: Coupling EUHFORIA and COCONUT

Luis Linan, Centre for mathematical Plasma Astrophysics, KU Leuven, Leuven, Belgium
Tinatin Baratashvili, Centre for mathematical Plasma Astrophysics, KU Leuven, Leuven, Belgium
Anwesha Maharana, Centre for mathematical Plasma Astrophysics, KU Leuven, Leuven, Belgium
Jinhan Guo, Centre for mathematical Plasma Astrophysics, KU Leuven, Leuven, Belgium
Brigitte Schmieder, Centre for mathematical Plasma Astrophysics, KU Leuven, Leuven, Belgium
Andrea Lani, Centre for mathematical Plasma Astrophysics, KU Leuven, Leuven, Belgium
Stefaan Poedts, Centre for mathematical Plasma Astrophysics, KU Leuven, Leuven, Belgium

Predicting the geo-effectiveness of coronal mass ejections (CMEs) requires precise modeling of their propagation and interaction with the solar wind. EUHFORIA (EUropean Heliospheric FORecasting Information Asset) is a 3D magnetohydrodynamic (MHD) simulation designed to model the evolution of CMEs in the heliosphere. To improve CME representation, several advanced flux-rope models have been implemented in EUHFORIA, including the spheromak model, Fri3D (Flux-Rope in 3D), a radially contracted spheromak, and two toroidal CME models based on the Soloviev and Miller-Turner equilibria. More recently, a deep learning-based model, PINN, has been introduced to facilitate access to toroidal magnetic field distributions that would otherwise be analytically intractable or computationally prohibitive to obtain.

I will also present the latest advancement in EUHFORIA: its coupling with the global MHD coronal model COCONUT (COolfluid COroNal UnsTructured). Traditionally, EUHFORIA injects CME models at 0.1 AU, but this approach neglects key interactions occurring closer to the Sun, where CMEs interact with the structured solar wind. COCONUT addresses this limitation by modeling the solar corona from the solar surface to 0.1 AU, using observed magnetograms to generate a realistic solar wind environment. By coupling these two models, we can now track the continuous evolution of a CME from its launch at the Sun's surface, through the corona, and into the heliosphere.

This coupling ensures a seamless transfer of CME properties, including its magnetic field structure and plasma characteristics, by aligning the outer boundary of COCONUT with the inner boundary of EUHFORIA. I will present the first results of this coupling, illustrating how different flux-rope CME models (e.g., Titov-Démoulin and RBSL) evolve dynamically within this coupled domain. This novel approach represents a major step forward in improving CME forecasting.

SCHEDULE OF TALKS

Tuesday, April 08: 2:05 PM - 2:30 PM
Presenter: Yan, Huirong

Particle transport in MHD turbulence: from simulations to observations

Huirong Yan, DESY & Uni-Potsdam, Germany

Transport of energetic particles is determined by properties of MHD turbulence, which is largely shaped by the forcing on large scales and damping on small scales. Recent progress on studies of compressible turbulence will be presented along with its implication on particle transport. Both theoretical and observational studies will be presented, showcasing the variation of MHD turbulence properties, particularly, their modes compositions. On small scales, compressible turbulence is much influenced by damping. Based on an improved compressible MHD decomposition algorithm, our analysis of Cluster observations demonstrates that collisionless damping enhances the anisotropy toward the local mean magnetic field, consistent with theoretical expectations and crucial for determining the particle scattering efficiency. Different regimes of particle transport, e.g., diffusion vs. superdiffusion, isotropic vs. anisotropic diffusion, will be discussed in relation to turbulence properties.

Tuesday, April 08: 2:30 PM - 2:55 PM
Presenter: Nicolas, Bian

Multifractal Phenomenology and Gaussian Mixtures in Alfvenic Turbulence: Solar Wind Applications.

N.H. Bian
State Key laboratory of Lunar and Planetary Sciences and CNSA Macau Center for Space Exploration and Science, Macau University of Science and Technology, Macau, China

The multifractal phenomenology of strong anisotropic Alfvenic turbulence, exposed by Bian and Li in the Astrophysical Journal Supplement Series (2024), is reviewed. It is equipped with a set of bridging relations, generalizing the critical balance condition, which connects the field increments taken in the plane perpendicular to the guiding magnetic field and taken along the magnetic field lines. The bridging relations can be justified on the basis of a Lagrangian perspective. The status of the "Onsager conjecture" in collisionless reduced-MHD is examined using the form of the local energy transfer rates. A log-Poisson model is formulated and the mixture distributions of the field variations across perpendicular scales are explicitly derived. The analysis of data from a fleet of space exploration missions reveals that the field fluctuations in the solar wind are consistently described by Gaussian mixtures from inertial to dissipative scales. The multifractal decomposition of the mixture arises from conditioning the fluctuation statistics either on the energy transfer rates or on the singularity strengths. An exact analytical expression for the even-order structure functions is obtained from a normal inverse Gaussian fit to the probability distribution functions, accurate from inertial to kinetic scales in the solar wind. The self-similar kappa distributions describing the kinetic scale solar wind fluctuations result from an inverse chi-square distribution of the variance in the mixture.

SCHEDULE OF TALKS

Tuesday, April 08: 2:55 PM - 3:20 PM
Presenter: Zhang, Ming

Probing the properties of solar wind turbulence with energetic particle scattering and diffusion

Ming Zhang

The properties of solar wind turbulence are a fundamental problem in heliospheric physics because it is the main driver of solar wind heating and acceleration and various transport mechanisms of solar and heliospheric energetic particles including cosmic rays. Direct magnetic field and plasma measurements are limited along the path of spacecraft passed through by solar wind streams. These one-dimensional measurements cannot completely reveal the true nature of the three-dimensional structure of turbulence. Energetic particles are affected by turbulence, typically resulting in pitch angle scattering and perpendicular diffusion. These energetic particles can be used to probe the properties of solar wind turbulence through different ways of probing the turbulence in the helical paths at much higher speeds, thus making complementary contributions to the investigation of solar wind turbulence. In this talk, we will use quasilinear formulation to study the behaviors of pitch angle scattering and perpendicular diffusion of energetic particles. We investigate how the 3-dimensional nature of the turbulence spectrum and modes of fluctuations, particularly with a highly imbalanced inward-outward asymmetry, can affect the behaviors of energetic particle transport and distribution in the heliosphere.

Tuesday, April 08:3:20 PM - 3:45 PM
Presenter: Zhao, Siqi

Observations of Turbulence and Particle Transport at Interplanetary Shocks: Transition of Transport Regimes

Siqi Zhao, Deutsches Elektronen Synchrotron DESY & Universität Potsdam, Germany
Huirong Yan, Deutsches Elektronen Synchrotron DESY & Universität Potsdam, Germany
Terry Z. Liu, University of California, Los Angeles, USA

The transport of energetic particles is intimately related to the properties of plasma turbulence, a ubiquitous dynamic process that transfers energy across a broad range of spatial and temporal scales. However, the mechanisms governing the interactions between plasma turbulence and energetic particles remain incompletely understood. Here, we present comprehensive observations from the upstream region of a quasi-perpendicular interplanetary (IP) shock on 2004 January 22, using data from four Cluster spacecraft to investigate the interplay between turbulence dynamics and energetic particle transport. Our observations reveal a transition in energetic proton fluxes from exponential to power-law decay with increasing distance from the IP shock. This result provides possible observational evidence of a shift in transport behavior from normal diffusion to superdiffusion. This transition correlates with an increase in the time ratio from $\tau_s/\tau_{c}<1$ to $\tau_s/\tau_{c}\gg1$, where τ_s is the proton isotropization time, and τ_{c} is the turbulence correlation time. Additionally, the frequency-wavenumber distributions of magnetic energy in the power-law decay zone indicate that energetic particles excite linear Alfv\'en-like harmonic waves through gyroresonance, thereby modulating the original turbulence structure. These findings provide valuable insights for future studies on the propagation and acceleration of energetic particles in turbulent astrophysical and space plasma systems.

SCHEDULE OF TALKS

Tuesday, April 08: 4:10 PM - 4:35 PM
Presenter: Kontar, Eduard

Compressive Wave Energetics in the Solar Corona from Radio Observations

Francesco Azzollini, University of Glasgow, UK
A. Gordon Emslie, Western Kentucky University, UK
Daniel L. Clarkson, University of Glasgow, UK
Nicolina Chrysaphi, Sorbonne University, France
Eduard P. Kontar, University of Glasgow, UK

Using a density fluctuation model inferred from solar solar radio burst observations, we deduce the plasma velocities required to explain observations of spacecraft signal frequency broadening and compare with the spacecraft broadening data. The inferred radial velocities appear consistent with the sound or proton thermal speeds, while the speeds perpendicular to the radial direction are consistent with nonthermal motions measured via coronal Doppler-line broadening, interpreted as Alfvénic fluctuations. Landau damping of parallel propagating ion-sound waves allows an estimate of the proton heating rate. The energy deposition rates due to ion-sound wave damping peak at a heliocentric distance of solar radius are comparable to the rates available from a Alfvenic turbulent cascade at large scales, suggesting a coherent picture of energy transfer, via the cascade or/and parametric decay of Alfvén waves to the small scales where heating takes place.

Tuesday, April 08: 4:35 PM - 5:00 PM
Presenter: Silwal, Ashok

Evolution of Solar Wind Turbulence during Radial Alignment of Parker Solar Probe and Solar Orbiter in December 2022

Ashok Silwal, Department of Space Science, University of Alabama in Huntsville, USA
Lingling Zhao, Department of Space Science, University of Alabama in Huntsville, USA
Xingyu Zhu, CSPAR, University of Alabama in Huntsville, USA
Luca Sorriso-Valvo, Institute for the Science and Technology of Plasmas, National Research Council, Italy
Lina Z. Hadid, LPP, CNRS, Observatoire de Paris, Sorbonne Université, Université Paris Saclay, École polytechnique, Institut Polytechnique de Paris, France
Gary P. Zank, Department of Space Science, University of Alabama in Huntsville, USA

We investigate the radial evolution of solar wind turbulence based on the same plasma parcel identified during the radial alignment of Parker Solar Probe (PSP) and Solar Orbiter (SO) on December 10, 2022, with PSP at about 0.11 au and SO near 0.88 au. We use a ballistic propagation model with constant acceleration, constrained by in-situ measurements of proton speed from PSP and SO, to identify nearly the same plasma parcel crossing both spacecraft. We also employ potential field source surface (PFSS) model to trace the magnetic footpoint of the plasma parcel in the photosphere, using a Global Oscillations

Network Group (GONG) synoptic map. Using field and plasma observations from PSP and SO, we perform standard diagnostics of power spectral density (PSD), spectral scaling, magnetic compressibility, and fluctuation intermittency for intervals observed by PSP and SO. Our analysis reveals that (1) as the plasma parcel propagates from about 0.11 au to 0.88 au, the trace PSD of the magnetic fluctuations in the inertial range becomes steeper with increasing radial distance, while in the dissipation range it becomes flatter; (2) the spectral break frequency between the inertial range and dissipation range shifts toward the lower frequency at the SO location; (3) using the Castaing distribution to model the probability density function (PDF) of the intermittent magnetic field fluctuations in the inertial range, the plasma parcel observed by PSP and SO exhibits multifractal scaling of intermittency, with slightly reduced intermittent strength at the SO distance. Our results from analyzing the propagation of the same plasma parcel are consistent with the statistical analysis of the radial evolution of turbulence, which may provide insight into the theoretical modeling of turbulence in the inner heliosphere.

SCHEDULE OF TALKS

Wednesday, April 09: 8:30 AM – 8:55 AM
Presenter: Agapitov, Oleksiy

Whistler Waves in the Young Solar Wind: Properties, Generation Mechanisms, and Effects for Solar Wind Particles

Oleksiy Agapitov, SSL University of California Berkeley, USA
Kyung-Eun Choi, SSL University of California Berkeley, USA
Lucas Colomban,SSL University of California Berkeley, USA
Tien Vo, LASP, University of Colorado, USA

In the interplanetary space solar wind plasma, whistler waves are observed in a wide range of heliocentric distances and are known to interact with solar wind suprathermal electrons (strahl and halo) and to regulate the solar wind heat flux through scattering the strahl electrons. We present the results of processing Parker Solar Probe (PSP) wave observations from Encounter 1-11. Our findings show that (1) the enhancement of the whistler wave occurrence rate and wave amplitudes observed between 25 and 35 RS is predominantly due to the sunward-propagating whistler wave population associated with the switchback-related magnetic dips; (2) the whistler waves are observed with predominantly field-aligned (or opposite) wave vectors; (3) the anti-sunward or counter-propagating cases are observed at 35–50 RS; (5) between 35 and 45 RS, sunward and antisunward whistlers are observed with comparable occurrence rates; and (6) almost no sunward or counterpropagating whistlers were observed at heliocentric distances above 50 RS. Through test particle simulations, we demonstrate that a magnetic gradient can significantly enhance the efficiency of scattering and energization of the strahl electrons by quasi-parallel whistlers, through the phase trapping effect due to the gyrosurfing mechanism. We identify quasi-linear and nonlinear regimes of these interactions for different combinations of wave amplitude (Bw/B0) and the strength of the magnetic field gradient with magnetic field depletion level (Bh/B0) as a proxy. Nonlinear effects are observed for Bw/B0$\gtrsim$10e–3 and Bh/B0$\gtrsim$ 0.1. We estimated the extending of the resonant energy range due to the wave and the magnetic field gradient interplay and demonstrated that these mechanisms result in the broadening of the strahl electron pitch-angle distribution typically observed in situ.

SCHEDULE OF TALKS

Wednesday, April 09: 8:55 AM – 9:20 AM
Presenter: Bellan, Paul

New form of the cold plasma wave equations and their solution for a cylindrical whistler duct

Paul Bellan, Caltech, USA

The cold plasma wave equations are expressed as coupled second order differential equations (CSODE) involving the wave magnetic flux and the wave electric current as the fundamental parameters. This approach is far simpler than the traditional method which has the wave electric field as the fundamental parameter.

Unlike the traditional method, the new full wave method easily describes wave propagation in a non-uniform plasma. Solutions for a cylindrical whistler duct will be presented. These ducts have non-uniform density in the direction perpendicular to the background magnetic field and are believed to act as channels that enable whistler waves to bounce losslessly between conjugate magnetic locations in Earth's north and south hemispheres. Solutions to the CSODE show that the waves have radial spatial oscillatory dependence in the duct and decay radially outside the duct with zero radial Poynting flux at all radii so no power leaks from the duct.

Numerical and analytical calculations of the CSODE show that distinct radial fast and slow modes having the same axial wavenumber exist in the duct, that there is a mode conversion location at a radius associated with the axial wavenumber, and that outside this mode conversion radius the waves spatially decay with spatial radial oscillations. Inside the mode conversion radius, there is an outward propagating fast wave that propagates to the mode conversion radius where this it mode converts into an inward propagating slow wave. Furthermore, there is simultaneously an outward propagating slow wave that mode converts into an inward propagating fast wave. The result is that there are effectively trapped standing slow and fast waves inside the mode conversion radius which can be considered to act like an effective mirror for the slow and fast waves. The spatial wavelength of the radially decaying spatially oscillating wave outside the mode conversion radius is intermediate between the radial wavelengths of the fast and slow waves inside the mode conversion radius.

An interesting additional result is that if a uniform Cartesian plasma has the parameters of the mode conversion location, then the assumption that the wave spatial oscillation is of the form ‘exp(ikx)’ in Cartesian coordinates is inadequate as there is also a spatial oscillation of the form ‘x exp(ikx)’. This latter is a solution of the fourth order system missed by the traditional matrix determinant method as the traditional method forces the solution to be only in the ‘exp(ikx)’ form.

SCHEDULE OF TALKS

Wednesday, April 09: 9:20 AM – 9:45 AM
Presenter: Li, Hui

Solar Wind Evolution and the Near-Sun Transonic Turbulence – Comparing 3D Global Compressible MHD Simulation in a Cone with PSP Observations

Hui Li, LANL, USA
Zhaoming Gan, NMC, USA
Xiangrong Fu, LANL, USA
Lingling Zhao, UAH, USA

Recent in-situ measurements by the Parker Solar Probe (PSP) have offered new results on both the near-Sun SW turbulence and its radial evolution, particularly the turbulent sonic Mach number (the ratio of the amplitude of velocity fluctuations to the sound speed) and its relationship to density fluctuations. In near-Sun regime, density fluctuations are consistently observed to exceed 10% and the turbulent Mach number can become relatively large (even approaching unity, Zhao et al. 2025). Motivated by these observations, we have carried out high-resolution global cone-shaped 3D compressible MHD simulations of the solar winds up to 40-60 solar radii with an opening half angle of 2.5 degrees. Specifically, we use turbulence injection at the solar boundary as the main driver for both producing the turbulence in the solar wind and eventually heating of the solar wind due to turbulent dissipation. Simulations capture both the integral scale of turbulence and the turbulent cascade. The simulated SW is observed to accelerate from the sub-Alfvenic bulk flow to become super-Alfvenic, generating both the mean radial profiles as well as the turbulent magnetic, velocity and density fields. These simulations are compared in detail with the PSP observations, showing good agreement.

Wednesday, April 09: 9:45 AM – 10:10 AM
Presenter: Adhikari, Laxman

Physical Processes in the Pickup Ion Mediated Plasma of the Distant Heliosphere

Laxman Adhikari, University of Alabama in Huntsville, USA
Gary P. Zank, University of Alabama in Huntsville, USA
Bishwas L. Shrestha, Princeton University, USA
Samira Tasnim, German Aerospace Center (DLR), Germany
Lingling Zhao, University of Alabama in Huntsville, USA
Heather Elliott, Southwest Research Institute, San Antonio, USA
Merav Opher, Boston University, USA
Bingbing Wang, University of Alabama in Huntsville, USA
Jakobus Le Roux, University of Alabama in Huntsville, USA
David J. McComas, Princeton University, USA
Parisa Mostafavi, Johns Hopkins Applied Physics Laboratory, USA
John Richardson, Massachusetts Institute of Technology, USA
Xingyu Zhu, University of Alabama in Huntsville, USA
Yihong Wu, University of Alabama in Huntsville, USA

H+ pickup ions (PUIs), formed through charge exchange between solar wind protons and interstellar neutral hydrogen (ISN H) atoms or by the photoionization of ISN H atoms, play a key role in governing solar wind dynamics. These PUIs induce MHD waves by generating instabilities, driving turbulence in the outer heliosphere. The ionization cavity size is the distance at which the ISN H density becomes 1/e, which is smaller in the upwind direction than the downwind direction. Consequently, the turbulent shear source affects the solar wind over a larger distance in the downwind direction than the upwind direction. Here we integrate the continuity, momentum, and pressure equations for ISN H with the three fluid (protons, electrons, and H+ PUIs) equations, and the turbulence transport equations. We numerically solve the coupled four-fluid and turbulence transport equations between 10 and 68 au, and 10 and 115 au before the Heliospheric Termination Shock in the New Horizons and Pioneer 10 directions, respectively. We present the comparison of the theoretical results with the solar wind proton and PUI data of New Horizons and the solar wind proton data of Pioneer 10. We present the theoretical results of the low-frequency MHD turbulence and the cosmic rays mean free paths along these directions. Finally, we derive the equation for the scattering angle of radio waves by assuming isotropic and Gaussian density turbulence and calculate the scattering angle in the NH and P10 directions.

SCHEDULE OF TALKS

Wednesday, April 09: 10:35 AM – 11:00 AM
Presenter: Strauss, Du Toit

Fieldline Random Walk in Radially Evolving Solar Wind Turbulence

Johan Joubert, Centre for Space Research, South Africa
Du Toit Strauss, Centre for Space Research, South Africa
Juandre Light, Centre for Space Research, South Africa

Working in the fieldline random walk limit, we investigate how energetic particles may spread perpendicular to the mean magnetic field by following diffusing fieldlines. We derive a fieldline diffusion equation from the particle transport equation and solve it numerically by first transforming it into a set of stochastic differential equations. We then investigate how fieldlines, originating from a point-source close to the Sun, diffuse into the interplanetary medium, by calculating the corresponding fieldline probability densities. The role of non-homogenous radially evolving 2D turbulence in a Parkerian magnetic field geometry is also investigated.

Wednesday, April 09: 11:00 AM – 11:25 AM
Presenter: Wang, Linghua

In Situ Shock Acceleration of Solar Wind Suprathermal Electrons at 1 AU

Linghua Wang, Peking University, China
Xinnian Guo, Peking University, China
Liu Yang, University of Kiel, Germany
Robert F. Wimmer-Schweingruber, University of Kiel, Germany
Stuart D. Bale, University of California at Berkeley, USA

The shock acceleration is an important particle acceleration mechanism in the interplanetary space, but the electron shock acceleration process is not fully understood yet. Here we summarize the observational properties of in situ shock acceleration of solar wind suprathermal electrons at 1 AU, using the Wind measurements and MMS measurements. For both the Earth' s bow shock and shocks driven by interplanetary coronal mass ejections (ICMEs), the observed power-law spectral index of shocked suprathermal electrons is significantly larger than the theoretical prediction of first-order Fermi acceleration, while the flux enhancement ratio between the downstream shocked and upstream unshocked suprathermal electrons peaks near 90° pitch angle. These observations favor the shock drift acceleration process. However, the shocked electron spectra appear to exhibit different behaviors for ICME-driven shocks and terrestrial bow shock. At ICME-driven shocks, the significantly shocked suprathermal electrons generally have a double-power-law spectrum bending upwards at a break near 2keV with a low-energy spectral index of ~3.7 and high-energy spectral index of ~2.5, similar to the upstream unshocked suprathermal electrons. At the terrestrial bow shock, the strongly shocked suprathermal electrons show a double-power-law spectrum bending downwards at a break near 65 keV with a low-energy spectral index of ~3.1 and high-energy index of ~7.6, different from the upstream unshocked suprathermal electrons. Furthermore, the observed break energy is comparable to a critical electron energy with its cross-shock gyrodiameter equal to the bow shock's ramp thickness. These results suggest that the shock drift acceleration process of suprathermal electrons could strongly depend on the electron trapping efficiency at the shock.

SCHEDULE OF TALKS

Wednesday, April 09: 11:25 AM – 11:50 AM
Presenter: Terres, Michael

Novel Reconstruction of Ion Velocity Distribution Functions

Michael Terres, Smithsonian Astrophysical Observatory, Cambridge, MA, USA
Srijan Bharati Das, Smithsonian Astrophysical Observatory, Cambridge, MA, USA

Particle velocity distribution functions (VDFs) are key to understanding solar wind plasma, but standard bi-Maxwellian parameterizations often fail to capture crucial kinetic effects. To address this, we first demonstrate the effectiveness of Slepian basis functions—spatially concentrated orthogonal functions—for parameterizing ion VDFs using MMS and Solar Orbiter (SolO) data, maximizing the utility of electrostatic analyzer (ESA) measurements. Building on this, we introduce a new gyrotropic fitting procedure for reconstructing VDFs from Parker Solar Probe (PSP) observations. With this approach, we can investigate plasma moments from these fits in comparison to SPAN-i measurements during encounter 22 and explore potential signatures of wave-particle interactions. This work establishes a framework for improved VDF reconstruction and paves the way for future multi-spacecraft optimizations, such as those planned for HelioSwarm.

SCHEDULE OF TALKS

Wednesday, April 09: 11:50 AM – 12:15 PM
Presenter: Perri, Silvia

Analysis of CME-driven shocks properties as input for a data-based model of solar energetic particles

Silvia Perri, Università della Calabria, Italy
Francesco Pucci, CNR, Institute for Plasma Science and Technology, Italy
Federica Chiappetta, Università della Calabria, Italy
Francesco Malara, Università della Calabria, Italy
Giuseppe Nisticò, Università della Calabria, Italy
Luca Sorriso-Valvo,CNR, Institute for Plasma Science and Technology, Italy; KTH, Sweden
Gaetano Zimbardo, Università della Calabria, Italy

One of the main goals of space weather science is to understand how the so-called solar energetic particles (SEPs), propagate through the inner heliosphere. They represent a natural hazard for the functioning of commercial and scientific satellites. On the other hand, shock waves driven by coronal mass ejections (CMEs) are the most relevant particle accelerators in the interplanetary space, giving rise to SEP gradual events that can have a strong geomagnetic impact. In this study, we aim at investigating the transport properties of energetic protons up to energies of hundreds of MeV by means of an innovative test-particle model, where SEPs interact with a 3D anisotropic turbulence. To do this, we analyze magnetic field turbulence close to CME-driven shocks by using in-situ measurements from different satellites, at different radial distances, in order to capture the main properties of the environment close to the acceleration source. Thus, parameters such as the power spectral density of magnetic field fluctuations, the level of intermittency, the degree of turbulence anisotropy will serve as input for the test particle numerical code, since all these parameters can be tuned in the simulations. The possibility in the model of adapting turbulence parameters to observations allows us to obtain a description of SEP transport throughout the inner heliosphere. We find a strong influence of turbulence properties on the spatial diffusion coefficients parallel and perpendicular to the mean magnetic field and on the distribution of the scattering times.

SCHEDULE OF TALKS

Wednesday, April 09: 12:15 PM – 12:40 PM
Presenter: Pogorelov, Nikolai

Space Weather Forecasts: Uncertainty Quantification and Machine Learning

Nikolai Pogorelov, The University of Alabama in Huntsville, USA
Talwinder Singh, Georgia State University, USA
Dinesha V. Hegde, The University of Alabama in Huntsville, USA
Tae K. Kim, The University of Alabama in Huntsville, USA
Timothy Newman, The University of Alabama in Huntsville, USA
Syed Raza, The University of Alabama in Huntsville, USA

The solar wind (SW) is a key driver of space weather (SWx) at Earth and throughout the solar system. The structuring of the SW into fast and slow streams is the source of recurrent geomagnetic activity. The largest geomagnetic storms are caused by solar coronal disturbances called coronal mass ejections (CMEs) that propagate through and interact with the SW. The connection of the interplanetary magnetic field to CME-related shocks and impulsive solar flares determine where solar energetic particles propagate. Therefore, data-driven modeling of stream interactions in the background SW, and CMEs propagating through it, is a necessary part of space weather forecasting. Such modeling should necessarily be based on time-dependent connections between eruptive events, magnetic phenomena on the Sun, and SW structures in the solar atmosphere and inner heliosphere (IHS). Substantial success has been achieved in numerical modeling of the IHS, but predictive capabilities are far from satisfactory. While there are likely several reasons for this, two difficulties can be addressed relatively rapidly through improved models. The first issue is that numerical approaches used to attack space weather problems are rather outdated and may not adequately capture important features of discontinuity formation, interaction, and propagation from the Sun towards Earth. The second is that global modeling of the time-dependent IHS requires boundary conditions (b.c.'s) that incorporate remote and in situ observations of the Sun. The b.c.'s being incomplete, predictive capabilities of numerical simulations become uncertain. They require ensemble modeling and uncertainty quantification. Our analysis of the ambient SW and CMEs propagating through it show that uncertainties are typically not acceptable, even for determining CME arrival time at Earth. We propose machine

learning (ML) techniques that make it possible to substantially improve SWx forecasts. We discuss the application of ML to prediction of solar flare eruption and demonstrate its high capabilities.

Wednesday, April 09: 1:40 PM – 2:05 PM
Presenter: Zank, Gary

Overview of a General Linear Mode Decomposition Method

G.P. Zank, Center for Space Plasma and Aeronomic Rsearch (CSPAR) and Department of Space Science, University of Alabama in Huntsville, USA
Masaru Nakanatoni, Center for Space Plasma and Aeronomic Rsearch (CSPAR) and Department of Space Science, University of Alabama in Huntsville, USA
Lingling Zhao, Center for Space Plasma and Aeronomic Rsearch (CSPAR) and Department of Space Science, University of Alabama in Huntsville, USA
Laxman Adhikari, Center for Space Plasma and Aeronomic Rsearch (CSPAR) and Department of Space Science, University of Alabama in Huntsville, USA
A. Pitna, Center for Space Plasma and Aeronomic Rsearch (CSPAR) and Department of Space Science, University of Alabama in Huntsville, USA
Prashant Buruwal, Center for Space Plasma and Aeronomic Rsearch (CSPAR) and Department of Space Science, University of Alabama in Huntsville, USA
Prashrit Buruwal, Center for Space Plasma and Aeronomic Rsearch (CSPAR) and Department of Space Science, University of Alabama in Huntsville, USA
Sujan Prasad Gautam, Center for Space Plasma and Aeronomic Rsearch (CSPAR) and Department of Space Science, University of Alabama in Huntsville, USA
Monika Karki, Center for Space Plasma and Aeronomic Rsearch (CSPAR) and Department of Space Science, University of Alabama in Huntsville, USA
I. Tasnim, Center for Space Plasma and Aeronomic Rsearch (CSPAR) and Department of Space Science, University of Alabama in Huntsville, USA

A linear mode decomposition technique for magnetohydrodynamics (MHD) was introduced in the mid-1990s by Glassmeier et al [1995] and Motschmann et al [1998] and used extensively since [e.g., S.Q. Zhao et al 2022, L.-L. Zhao et al 2021]. In the original approach, an observed interval of fluctuations is decomposed into three sets of forward and backward eigenmodes, namely the Alfvénic, fast, and slow modes. However, besides these six modes, MHD admits two non-propagating or “pseudo-modes,” viz., the entropy and magnetic island/flux rope/plasmoid modes that are not included in the original linear mode decomposition method. Small-scale magnetic flux ropes are prevalent throughout the heliosphere and advected density fluctuations have been identified as well. In recent simulations [Gan et al 2022. Fu et al 2022, Arro et al 2025], low-frequency (omega ~ 0) fluctuations are ubiquitous and appear to dominate the fluctuations in the simulation. Consequently, any decomposition of a plasma parcel into its constituent modes should include not only the propagating modes but the advected modes. To overcome this, Zank et al [2023, 2024] developed a new linear mode decomposition (LMD) method that incorporates the advected modes and incorporates phase information. Since several papers and posters at this meeting are utilizing the new LMD method, this talk provides an overview and analysis of the LMD approach.

Wednesday, April 09: 2:05 PM - 2:30 PM
Presenter: Thomas, Edward

Scaled laboratory simulations of spacecraft wakes in the near-Earth space environment: experimental observations and modeling

Edward Thomas, Jr., Elon Price, Blake Koford, Siddharth Bachoti, Saikat Chakraborty Thakur, Cameron Royer and the MPRL Team, Auburn University, USA

The movement of objects, from satellites to the International Space Station, through the local geospace environment can significantly impact plasma conditions. These disturbances lead to the formation of wakes, which can interfere with measurements of electric potentials, electric fields, and even serve as a mechanism for generating waves and instabilities. The development of scaled laboratory studies can provide valuable insights for understanding satellite observations. Experimental studies are performed in the Magnetized Plasma Research Laboratory (MPRL) collaborative user facility at Auburn University. Here, the magnetized dusty plasma experiment (MDPX) device, a superconducting, 4-Tesla, capacitively coupled plasma system, is used to produce strongly magnetized low temperature plasmas. A moving probe is inserted into a weakly ionized, low temperature, argon plasma. As the probe is withdrawn, an “imprint” or “wake” from the probe in the form of a channel of diminished visible light emission that persists for several seconds, much longer than would be expected by standard diffusive processes. Nonetheless, these observations are reproducible over a range of neutral pressures for magnetic fields, $B \geq 1$ Tesla. This presentation will show that MDPX experiments can be scaled to near-earth plasma conditions. The presentation will describe the experimental configuration and provide images and videos of this phenomenon. The presentation will also present results from a molecular dynamics model of the wake channel that is formed in the plasma and the cross-field diffusion.

This work is supported by the US Department of Energy and the NSF EPSCoR Program.

Wednesday, April 09: 2:30 PM - 2:55 PM
Presenter: Fraternale, Federico

Modeling plasma properties and compression waves observed by Voyager in the VLISM

Federico Fraternale, The University of Alabama in Huntsville, USA
Nikolai V. Pogorelov, The University of Alabama in Huntsville, USA
Ratan K. Bera, The University of Alabama in Huntsville, USA
Tae K. Kim, The University of Alabama in Huntsville, USA

The very local interstellar medium (VLISM) is characterized by large-scale gradients in plasma and neutral atom quantities, as well as significant perturbations driven by the motion of the heliopause. Remarkably, the Voyager spacecraft continue to provide unique in situ measurements from this region, reaching beyond 160 AU from the Sun. In mid-2020, a sudden increase in magnetic field magnitude—potentially a shock or pressure front—was observed by Voyager 1 (V1). Surprisingly, unlike all previously detected GMIR-driven shocks, which typically exhibit a jump-ramp profile, this event featured a unique ‘hump’ feature, where the magnetic field magnitude increased behind the shock and has remained sustained at approximately 0.5 nT to this day. Current models have struggled to fully reproduce these observations, leading to various hypotheses about their origin.
In this study, using data-driven MHD models, we demonstrate that these peculiar V1 observations can be explained by a combination of factors: (i) global, solar cycle-related dynamics leading to prolonged heliopause outward motion, producing the pressure front and the large-scale region of compressed interstellar plasma; (ii) the presence of finer-scale compressible waves catching up behind the pressure front; and (iii) the unperturbed LISM conditions. and that V1 might not observe a decrease in magnetic field strength (B) until 2027.
Voyager measurements are also critical for inferring the properties of the unperturbed LISM. However, their interpretation requires a kinetic treatment of neutral H and He atoms. Using MHD/Kinetic models, we discuss the effects on the H wall, atom filtration, and background plasma quantities resulting from the self-consistent inclusion of suprathermal ions in modeling charge exchange processes.

Wednesday, April 09: 2:55 PM - 3:20 PM
Presenter: Le Roux, Jakobus

Evidence for Tempered Superdiffusive Shock at a Quasi-Perpendicular Interplanetary Shock

Jakobus A. le Roux, University of Alabama In Huntsville, USA
Rubaiya K. Shikha, University of Alabama In Huntsville, USA

Prete et al. (2021) discussed that the quasi-perpendicular shock observed at 1 AU on August 26, 1998 with the ACE spacecraft is a good example of an event where solar energetic particle (SEP) propagation and acceleration occur in a superdiffusive manner. To investigate this claim, we have investigated the observed enhanced SEP fluxes and turbulent magnetic fields of this event in more detail. This was accomplished partly by fitting our analytical solution for tempered superdiffusive shock acceleration of SEPs at a perpendicular shock (le Roux and Shikha 2025) to the observed SEP fluxes for several energy channels upstream and downstream of the shock. Tempered superdiffusion indicates that the solution models SEP superdiffusion and its transition to normal diffusion further away from the shock. The results indicate that SEP transport across the shock is clearly not diffusive, but superdiffusive. With the aid of the data fits we derived the fractional index for SEP superdiffusion and found that SEPs are more superdiffusive at higher energies and downstream compared to upstream. The latter result was unexpected so that we investigated the statistical properties of the non-Gaussian magnetic turbulence coinciding with the enhanced SEP fluxes. Preliminary results show that the kurtosis values of the turbulence are larger downstream (turbulence is more non-Gaussian and intermittent downstream) which might shed light on this issue. We identified where the transition from superdiffusion to normal diffusion potentially occurred in the SEP fluxes both sides of the shock.

Wednesday, April 09: 3:20 PM - 3:45 PM
Presenter: Bhattacharjee, Amitava

Compressible MHD turbulence in the Interstellar Medium and the Solar Wind

Amitava Bhattacharjee, Princeton University, USA

Compressible magnetohydrodynamic (MHD) turbulence is a ubiquitous state for many astrophysical plasmas, including the solar wind and the interstellar medium of our galaxy. Yet, basic statistics describing compressible, magnetized turbulence remain uncertain. Utilizing unprecedented grid resolutions of up to 10,080 cube cells, we simulate magnetized compressible turbulence in the world's largest MHD simulation. We measure two coexisting kinetic energy cascades in the turbulence, separating the plasma into scales that are non-locally interacting, supersonic and weakly magnetized (with the power-law exponent $n \sim 2$) and locally interacting, subsonic and highly magnetized ($n \sim 3/2$), in wave number space. We show that the 3/2 spectrum can be explained with both scale-dependent energy fluxes and velocity-magnetic field alignment. The magnetic energy spectrum forms a local cascade ($n \sim 9/5$), deviating from any known ab initio theory. Within the 3/2 cascade, the plasma becomes aligned in a scale-dependent manner, with all primitive variables and their curls tending towards parallel and anti-parallel states in localized regions, Beltramizing, Taylorizing, and Alfvenizing the plasma on these scales. We associate this with the tendency of turbulence to deplete its nonlinearities, which has significant implications for the asymptotic state of MHD turbulence, challenging existing theories.

SCHEDULE OF TALKS

Wednesday, April 09: 4:10 PM - 4:35 PM
Presenter: Karki, Monika

Investigation of Turbulent Modes in the Fast and Alfv`enic Slow Solar Wind at 1 au

Monika Karki, University of Alabama in Huntsville, USA
Gary P. Zank, University of Alabama in Huntsville, USA
Laxman Adhikari, University of Alabama in Huntsville, USA

We study the turbulent modes present in the Alfv`enic slow and fast solar wind. This analysis covers the time period from January 26-29 to February 6-9, 2002 based on Wind observations at 1 AU. Our study examined Alfv`enic slow wind with β < 1 and fast wind with β < 1 (~ O(1)), employing superposed epoch analysis to investigate the different turbulent mode and their power spectral densities. We find that the Alfv`enic slow and fast wind exhibits similar density fluctuation, primarily comprising of forward and backward propagating fast magnetosonic modes. In the Alfv`enic slow regime, the incompressible magnetic fluctuations dominate over compressible contributions from fast and slow MS modes. While in the fast solar wind, compressible velocity fluctuations from the fast magnetosonic mode dominate over incompressible Alfv`enic fluctuations. We also find that the magnetic field fluctuations are predominantly associated with magnetic island modes, with some contribution from the forward-propagating fast magnetosonic mode. The longitudinal components of the magnetosonic modes have larger contributions than transverse component in both regime. Understanding these fundamental building blocks of solar wind fluctuations in the Alfv`enic slow and fast solar wind regime is essential for understanding the dynamic nature of solar wind turbulence in the radially expanding solar wind.

Wednesday, April 09: 4:35 PM - 5:00 PM
Presenter: Baruwal, Prashrit

Turbulent Modes in Slow, Alfvenic Slow, and Fast Solar Wind at 1AU

Prashrit Baruwal, Center for Space Plasma and Aeronomic Research (CSPAR) and Department of Space Science, University of Alabama in Huntsville, USA

G.P. Zank, Center for Space Plasma and Aeronomic Research (CSPAR) and Department of Space Science, University of Alabama in Huntsville, USA

Laxman Adhikari, Center for Space Plasma and Aeronomic Research (CSPAR) and Department of Space Science, University of Alabama in Huntsville, USA

Prashant Baruwal, Center for Space Plasma and Aeronomic Research (CSPAR) and Department of Space Science, University of Alabama in Huntsville, USA

Lingling Zhao, Center for Space Plasma and Aeronomic Research (CSPAR) and Department of Space Science, University of Alabama in Huntsville, USA

Masaru Nakanotani, Center for Space Plasma and Aeronomic Research (CSPAR) and Department of Space Science, University of Alabama in Huntsville, USA

Alexander Pitňa, Department of Surface and Plasma Science, Faculty of Mathematics and Physics, Charles University, Prague, Czechia

Sujan Prasad Gautam, Center for Space Plasma and Aeronomic Research (CSPAR) and Department of Space Science, University of Alabama in Huntsville, USA

Monika Karki, Center for Space Plasma and Aeronomic Research (CSPAR) and Department of Space Science, University of Alabama in Huntsville, USA

I. Tasnim, Center for Space Plasma and Aeronomic Research (CSPAR) and Department of Space Science, University of Alabama in Huntsville, USA

The characterization of fluctuations in the solar wind provides considerable insight into the nature of turbulence in a magnetofluid. The slow solar wind with high Alfvenicity, often described as the Alfvenic slow solar wind (ASSW) [D'Amicis et al., 2015], possesses a bulk speed similar to that of the slow wind, but the fluctuations are largely similar to those found in the fast wind. These ASSWs represent different regimes of a region of interest since fewer turbulence studies have been performed compared to classical slow and fast wind flows. Recently, Zank et al. 2023 developed a novel linear mode decomposition (LMD) technique, which identifies eight modes in the magnetized solar wind plasma, namely entropy, fast and slow (+/-) magnetosonic, Alfven (+/-), and the magnetic island modes. Here, we apply the LMD technique to identify the characteristic modes found in CSSW, ASSW, and FSW. For this purpose, the WIND dataset is used. In this study, we investigate and describe the properties of the eight MHD modes and how their characteristics differ relative to the solar wind plasma at 1 AU.

SCHEDULE OF TALKS

Thursday, April 10: 8:30 AM – 8:55 AM
Presenter: Bowen, Trevor

Kinetic Signatures of Turbulent Heating

Tamar Ervin, UC Berkeley, USA
Alexandros Chasapis, LASP, USA,
Andrea Larosa, CNR-ISTP, IT
Kris Klein, U Arizona, USA
Alfred Mallet, UC Berkeley, USA
Stuart Bale, UC Berkeley, USA
Abby Azari, U Alberta, CA

Understanding the nature and importance of various proposed heating processes that result from turbulent dissipation is imperative in describing a range of collisionless systems. We highlight the importance of kinetic phase space signatures of heating as pivotal in providing necessary constraints on turbulent dissipation. Understanding mechanisms through diffusive approximation schemes is largely a tractable problem that can be studied with modern plasma instrumentation. We highlight

recent progress in understanding signatures of kinetic dissipation and particle heating using the Parker Solar Probe (PSP) mission. Importantly, our observations reveal that a range of heating mechanisms (stochastic heating, cyclotron resonance, and Landau damping) are likely important in explaining observed phase-space plasma signatures. The use of non-parametric approximations to particle distribution functions (via Hermite polynomials, Radial Basis Functions, Machine Learning Methods) is pivotal in understanding and characterizing these heating mechanisms. While our observations are from PSP, we discuss future implementation of these techniques on current and future plasma missions (MMS and Plasma Observatory).

SCHEDULE OF TALKS

Thursday, April 10: 8:55 AM – 9:20 AM
Presenter: Arrò, Giuseppe

Spatio-Temporal Energy Cascade in Three-Dimensional Magnetohydrodynamic Turbulence

Giuseppe Arrò, Los Alamos National Laboratory, USA
Hui Li, Los Alamos National Laboratory, USA
William H. Matthaeus, University of Delaware, USA

We present a new scale decomposition method to investigate turbulence in wavenumber-frequency space. Using 3D magnetohydrodynamic turbulence simulations, we show that magnetic fluctuations with time scales longer than the nonlinear time exhibit an inverse cascade toward even smaller frequencies. Low frequency magnetic fluctuations support turbulence, acting as an energy reservoir that is converted into plasma kinetic energy, the latter cascading toward large wavenumbers and frequencies, where it is dissipated. Our results shed new light on the spatio-temporal properties of turbulence, potentially explaining the origin and role of low frequency quasi-2D turbulent fluctuations observed in the solar wind.

Thursday, April 10: 9:20 AM – 9:45 AM
Presenter: Consolini, Giuseppe

Investigating the Irreversibility of Magnetic Fluctuations in Sub-Ion Scale Plasma Turbulence

Giuseppe Consolini, INAF-Istituto di Astrofisica e Planetologia Spaziali, Italy

A notable feature of space plasma turbulence is the presence of an additional power-law spectral domain with a spectral exponent close to 8/3, observed at scales near and below the ion-inertial length. The origin of this spectral domain has been attributed to a distinct turbulent regime involving alternative wave modes and a novel cascading energy transfer mechanism. However, this interpretation remains contentious, as does the irreversible nature of energy fluctuations at these scales. In this study, we analyze the irreversibility of magnetic field fluctuations at ion and sub-ion scales, leveraging high-resolution magnetic field measurements from the Parker Solar Probe (PSP) mission. Additionally, we compare these findings with predictions from Hall-MHD shell model turbulence and evaluate the applicability of the Fluctuation Theorem for the entropy production rate.

Thursday, April 10: 9:45 AM – 10:10 AM
Presenter: Pitna, Alexander

Density Fluctuation Anisotropy in the Solar Wind Near Characteristic Proton Scales

Alexander Pitna, Charles University, Czech Republic
Jana Safrankova, Charles University, Czech Republic
Zdenek Nemecek, Charles University, Czech Republic
Gary Zank, University of Alabama in Huntsville, USA
Eduard Kontar, University of Glasgow, UK
Du Toit Strauss, North-West University, South Africa
Owen Roberts, Aberystwyth University, UK

Density fluctuations in the solar wind span a wide range of scales, from large-scale turbulence to small-scale kinetic effects. At inertial (MHD) scales, these fluctuations can be viewed as a combination of entropic, slow, and fast mode contributions, whereas around and below kinetic scales, they are shaped by the kinetic counterparts of fast, slow, and Alfvén MHD modes. These fluctuations also play a crucial role in the scattering of radio signals from sources both within and beyond the heliosphere.

To investigate the density fluctuation spectra from inertial to kinetic scales, we introduce a toy model for the spectrum, S(k), in which anisotropy varies with scale—remaining isotropic at large scales and becoming anisotropic near proton characteristic scales. This model provides insight into observed fluctuation spectra, some features of which may be influenced by the Taylor hypothesis.

We describe observations from a five-hour-long solar wind interval detected by the BMSW instrument (with a 32 ms sampling rate for ion density) on board the Spektr-R spacecraft. Analysis of density fluctuations reveals that at large scales, the fluctuations are nearly isotropic, whereas in the kinetic range, they exhibit strong anisotropy. Furthermore, we present a statistical analysis of density fluctuations using data from the 3DP instrument on board the Wind spacecraft. Finally, we discuss the role of compressible wave modes in shaping density fluctuations in the solar wind.

SCHEDULE OF TALKS

Thursday, April 10: 10:35 AM – 11:00 AM
Presenter: Takita, Masato

Sidereal cosmic-ray anisotropy at TeV energies modeled with data from the Tibet ASgamma experiment

Masato Takita for the Tibet ASgamma collaboration, ICRR, the University of Tokyo, Japan

Various experiments have reported on the anisotropy in the arrival directions of galactic cosmic rays at the sidereal time frame, including underground muon telescopes and ground-based air-shower arrays.
The sidereal anisotropy of the order of 0.1 % at TeV energies observed at the Earth has two distinct large-scale structures: a deficit region ranging from ~150◦ to ~240◦ in right ascension (so-called Loss-Cone) and an excess region from ~40◦ to ~90◦ (so-called Tail-In). Recent experiments with high statistics have shown the unexpected change in the amplitude and phase above ~100 TeV from those below ~100 TeV.In this presentation, we make an attempt to model the anisotropy at the heliospheric outer boundary at TeV energies, by applying the idea of Liouville mapping with an MHD-model heliosphere to the experimental data from the Tibet ASgamma experiment.

Thursday, April 10: 11:00 AM – 11:25 AM
Presenter: Leske, Rick

Updated Observations of the Intensity of Anomalous and Galactic Cosmic Rays at 1 AU from the Advanced Composition Explorer

R. A. Leske, California Institute of Technology, USA
A. C. Cummings, California Institute of Technology, USA
C. M. S. Cohen, California Institute of Technology, USA
M. E. Wiedenbeck, Jet Propulsion Laboratory, Caltech, USA

The Advanced Composition Explorer (ACE) was launched in 1997 and has observed both anomalous cosmic rays (ACRs) and galactic cosmic rays (GCRs) at 1 AU ever since. These observations now include 3 solar minima, two A>0 minima (1997 and 2020) as well as the intervening opposite polarity A<0 minimum (2009), and cover the relatively weak solar cycle 24 in which record-setting GCR intensities were observed in a quiet heliosphere. We have previously reported that measurements from the Solar Isotope Spectrometer (SIS) on ACE show that peak ACR oxygen intensities above ~8 MeV/nucleon in the recent A>0 solar minimum were slightly below the levels seen during the 1997 A>0 minimum, while GCR iron intensities at ~300 MeV/nucleon from the Cosmic Ray Isotope Spectrometer (CRIS) exceeded those in 1997 by ~30%. Also, in the 2009 A<0 minimum, peak ACR intensities were similar to those measured by others in the 1987 A<0 cycle, yet GCR intensities reached record high levels. The GCR intensities show that there was a decrease in heliospheric modulation during recent solar minima, but this did not increase the ACR intensities, leading us to speculate that the ACR source intensity may have changed. Modeling by Strauss et al. (ApJ 944:114, 2023) has demonstrated that a decrease in turbulence would lead to both less modulation of GCRs and simultaneously lower intensities of ACRs due to reduced acceleration efficiency at the solar wind termination shock, replicating our oxygen observations. Another possible factor contributing to a change in the ACR source intensity may be a drop in the production of pickup ions (ACR seed particles) due to less ionization during the weaker solar cycles. Since the ionization rate is different for different elements, it might be possible to test this hypothesis if the elemental composition of ACRs changes from cycle to cycle.

We review more than 27.5 years of ACR and GCR intensities measured by ACE throughout more than two complete solar cycles and discuss possible reasons for the differences in the behavior of ACRs relative to GCRs in the recent solar minima. The latest measurements during the ongoing solar maximum show that present GCR intensities are similar to those during the 2002 solar maximum, significantly lower than in the last maximum in 2014. Together with the high sunspot number that has exceeded predictions, this suggests that the epoch of weak solar maximum activity appears to be over.

SCHEDULE OF TALKS

Thursday, April 10: 11:25 AM – 11:50 AM
Presenter: Oka, Mitsuo

Maximum Energy of Particles in Plasmas

Mitsuo Oka, UC Berkeley, USA
Kazuo Makishima, The University of Tokyo, Japan
Toshio Terasawa, The University of Tokyo, Japan

Particles are accelerated to very high, non-thermal energies in space, solar, and astrophysical plasma environments. In cosmic ray physics, the Hillas limit is often used as a rough estimate (or the necessary condition) of the maximum energy of particles. This limit is based on the concepts of one-shot direct acceleration by a system-wide motional electric field, as well as stochastic and diffusive acceleration in strongly turbulent environments. However, it remains unclear how well this limit explains the actual observed maximum energies of particles. Here we show, based on a systematic review, that the observed maximum energy of particles — those in space, solar, astrophysical, and laboratory environments — often reach the energy predicted by the Hillas limit. We also found several exceptions, such as electrons in solar flares and jet-terminal lobes of radio galaxies, as well as protons in planetary radiation belts, where deviations from this limit occur. We discuss possible causes of such deviations, and we argue in particular that there is a good chance of detecting ultra-high-energy (~100 GeV) solar flare electrons that have not yet been detected. We anticipate that this study will facilitate further interdisciplinary discussions on the maximum energy of particles and the underlying mechanisms of particle acceleration in diverse plasma environments.

Thursday, April 10: 11:50 AM – 12:15 PM
Presenter: Kontar, Eduard

Flare accelerated electron transport model for Type III solar radio bursts

Eduard P. Kontar, University of Glasgow, UK
Francesco Azzollini, University of Glasgow, UK
Olena Lyubchyk, Bogomolets National Medical University, Ukraine

The electron beams travelling in the solar corona and heliosphere along magnetic field lines generate Langmuir waves and quasilinearly relax towards a plateau in velocity space. The relaxation of the electron beam over the short distance in contrast to

large beam-travel distances observed is often referred to as Sturrok's dilemma. I will present a new electron transport model with quasilinear distance/time self-consistently changing in space and time. The model results in a nonlinear advection-diffusion equation for the electron beam density with nonlinear diffusion term that inversely proportional to the beam density. The solution predicts slow super-diffusive (ballistic) spatial expansion of a fast propagating electron beam. The model also provides the evolution of the spectral energy density of Langmuir waves, which determines brightness temperature of plasma radiation in solar bursts. The model solution is consistent with the results of numerical simulation using kinetic equations and can explain some characteristics of type III solar radio bursts.

SCHEDULE OF TALKS

Thursday, April 10: 12:15 PM – 12:40 PM
Presenter: Pierrard, Viviane

Acceleration of the solar wind due to the global electric potential

Viviane Pierrard, Royal Belgian Institute for Space Aeronomy and Université Catholique de Louvain, Belgium
Maximilien Péters de Bonhome, Katholiek Universiteit Leuven and Royal Belgian Institute for Space Aeronomy, Belgium

The acceleration of the solar wind can mainly be due to the global electric potential that ensures the charge quasi-neutrality of the plasma and no net current despites the mass disparity between electrons and protons. This is especially well demonstrated using kinetic models where Maxwellian or Kappa non-thermal velocity distribution functions can be simulated. Suprathermal particles, as observed in the solar wind even at low radial distances, can be taken into account, but are not necessary to accelerate the wind to supersonic velocities. The kinetic models show that the difference between the fast and slow wind comes from the altitude of the exobase, i.e. the altitude where the Coulomb collisions become sufficiently negligible to allow the wind to blow to the interplanetary space. The number density in the coronal holes is lower than in the equatorial streamers, enabling an acceleration starting at lower altitudes in the corona. Comparing the electric field derived from the sunward deficit of velocity distribution functions observed by Parker Solar Probe (PSP) between 13.3 and 50 solar radii with the electric field found self-consistently by the kinetic exospheric model, we show that the solar wind profiles observed in average by PSP, Solar Orbiter and OMNI correspond well to the results of the kinetic models. This suggests that the electric potential is of major importance in explaining the solar wind acceleration.

Thursday, April 10: 1:40 PM – 2:05 PM
Presenter: Hao, Yufei

Wave Activities Throughout a Low-Mach Number Quasi-Parallel Shock: 2-D Hybrid Simulations

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Quanming Lu, USTC, China
Dejin Wu, Purple Mountain Observatory, CAS, China
Liang Xiang, Purple Mountain Observatory, CAS, China

Two-dimensional hybrid simulations are used to study wave excitation and evolution throughout a low-Mach number quasi-parallel shock. Simulation results show that quasi-parallel fast magnetosonic waves, ion Bernstein waves with harmonics and possible Alfven/ion cyclotron waves can be excited in the upstream region, and their small phase velocities compared to injected flow velocity results in the convection to the shock front where they are mode converted into several groups of downstream waves, including Alfven waves along the directions parallel to downstream average magnetic fields and perpendicular to the shock normal, the quasi-perpendicular kinetic slow waves and possible kinetic Alfven waves. We suggest that downstream Alfven waves originate from the mode conversion of upstream quasi-parallel fast magnetosonic waves with left-hand polarization in the downstream rest frame under helicity conservation, while the downstream left-hand polarized kinetic slow waves and right-hand polarized kinetic Alfven waves can be from the upstream quasi-perpendicular ion Bernstein waves.

SCHEDULE OF TALKS

Thursday, April 10: 2:05 PM - 2:30 PM
Presenter: Asgari-Targhi, Mah

Dynamics of Slow Solar Wind Emerging from an Equatorial Coronal Hole

M. Asgari-Targhi, CfA, USA
K. Fujiki, Nagoya University, Japan,
M. Hahn, Columbia University, USA,
A. Kourkas, Columbia University, USA,
and D. W. Savin, Columbia University, USA

We present a three-dimensional reduced magnetohydrodynamics (RMHD) model to depict turbulence induced by Alfv'en waves within an open magnetic field positioned in a coronal hole near the solar equator. The nonlinear interactions between outward and inward propagating waves result in turbulence. As part of this investigation, we examine the conditions prevailing in an equatorial coronal hole using the Interplanetary Scintillation (IPS) observations. From IPS observations, we measure the magnetic field and velocity, both input parameters of our Alfv'en wave turbulence model. We show the conditions of the equatorial corona, a contributor to the slow solar wind, can generate Alfv'en wave turbulence that accelerates and energizes the slow wind.

Thursday, April 10: 2:30 PM - 2:55 PM
Presenter: Bale, Stuart

The fine structure of fast solar wind at ~10 solar radii: discrete velocity microstreams suggest energization at the base of the corona

Stuart D. Bale, University of California, Berkeley, USA
The PSP/FIELDS and PSP/SWEAP teams

The NASA Parker Solar Probe (PSP) spacecraft has just completed its first pass (‘Encounter 22’) at its lowest perihelion distance of ~9.86 Rs. This encounter appears to have occurred in ambient fast solar wind emerging from a southern latitude coronal hole. Previous Encounters have elucidated the discrete ‘microstream’ nature of coronal hole outflows, revealed power law tails on the solar wind ion distributions beyond 100 keV, and associated those microstreams with interchange reconnection within the network magnetic field. However, it has also become clear that the large amplitude (dB/B~1) Alfvén waves (termed ‘switchbacks’) observed at all altitudes with PSP play a role in the energy budget of the expanding solar wind. Previous higher altitude, measurements of switchbacks are rather strongly associated with the microstreams, which has led to the suggestion that the microstreams themselves are a result of the radial energization of the wind. Measurements from PSP Encounter 22 show that the microstreams in the fast solar wind are rather ‘granular’ and discrete on spatial scales of the underlying network field. Furthermore, switchback occurrence and amplitude seems to be diminishing at lower altitudes. Taken together, these results suggest that the discrete microstreams are the result of localized wind sources that impart the energy and pressure at the base of the corona.

SCHEDULE OF TALKS

Thursday, April 10: 2:55 PM - 3:20 PM
Presenter: Fisk, Len

A New Theory for the Solar Cycle

L A. Fisk, University of Michigan, USA
L. Zhao, University of Michigan, USA
J. R. MacTaggart, University of Michigan, USA
K. Ballard, University of Michigan, USA

The foundation for this theory of the solar cycle is a reasonable expectation and an observable fact: The reasonable expectation is the Sun has a dipole magnetic field, resulting from a dynamo in its core, as do many planetary bodies, offset from the rotation axis of the Sun, and essentially fixed in time. The observable fact is the Sun has a surface layer which is highly magnetically permeable. The surface layer shields the fixed dipole field from the so-called open magnetic field of the Sun, the component of the solar magnetic field carried outward with the solar wind. The open magnetic field is observed to move freely along the solar surface. During solar minimum, the open magnetic field accumulates at the location of the polar axis of the fixed dipole. The open flux over-expands and reconnects in the canopy of coronal loops at low latitudes, a process that creates a magnetic field in the surface layer, which is an extension of the open flux. The magnetic field in the surface layer is concentrated in network lanes, grows in time, emerges as sunspots, and during the ensuing activity phase is eliminated by reconnection with the open magnetic field. The theory provides an explanation for why the solar cycle is ~11 years in length and yields simple formulae that depend only on the open magnetic flux at solar minimum to predict the duration of the activity phase and the maximum and average number of sunspots. Excellent agreement with observations is attained when the formulae are applied to Cycles 21-24, and the beginning of Cycle 25.

Thursday, April 10:3:20 PM - 3:45 PM
Presenter: Kransnoselskikh, Vladimir

Plasma instability in the front of ejected energetic electrons and Type III solar radiobursts

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Type III radio bursts are signatures of near-relativistic electron beams ejected during solar flares and are frequently observed by spacecraft such as the Parker Solar Probe. Traditionally, it is believed that these electron beams generate Langmuir waves through a two-stream instability, which are subsequently converted into electromagnetic waves. In this study, we revise that model by examining how the electron distribution becomes truncated due to the “time-of-flight” effect as the beam travels through an inhomogeneous plasma like the solar wind. This truncation, rather than the two-stream instability, destabilizes the distribution and leads to the generation of Langmuir waves. The instability grows until slower electrons arrive and dampen the waves. We qualitatively
show that the growth and decay of the resulting wave intensity closely match the intensity-time profile of observed Type III radio bursts at the fundamental frequency, supporting this modified theory.

Thursday, April 10: 4:10 PM - 4:35 PM
Presenter: Kolobov, Vladimir

The particle kinetics in spherical plasmas: from dust particle charging to solar wind

Vladimir Kolobov

Despite enormous differences in spatial scales, there are striking similarities between the screening of dust particles in plasma, satellite charging in the ionosphere, operation of Langmuir probes, and particle kinetics in the solar wind. In our presentation, we will describe these similarities, outline obstacles in understanding basic phenomena, and discuss the potential benefits of knowledge diffusion between relevant fields. We will emphasize the critical role of the electrostatic fields in controlling the particle and energy fluxes in both collisional and near-collisionless plasmas, which must be computed self-consistently with the particle kinetics in plasma. Similarities of non-magnetized spherical plasmas and magnetized solar wind plasmas will be identified. The fundamental nature of the uncertainty associated with the distribution function of trapped particles moving on finite orbits and their role in charge screening will be emphasized. We will describe our current efforts to develop a kinetic model of spherical plasmas to analyze these phenomena.

Thursday, April 10: 4:35 PM - 5:00 PM
Presenter: Manchester, Chip

AWSoM Simulation of the Solar Wind and CMEs with Comparisons to Turbulence and Proton and Electron Temperature Observations

Chip Manchester, University of Michigan , USA
Nishtha Sachdeva, University of Michigan , USA
Zhenguang Huang, University of Michigan , USA
Igor Sokolov, University of Michigan , USA
Jia Huang, University of California Berkeley , USA
Lulu Zhao, University of Michigan , USA

We simulate the solar wind including CMEs during the PSP era including the September 05, 2022 (Labor Day) CME Event from eruption to interplanetary propagation with the Alfven Wave Solar Model (AWSoM). The model includes energy partitioning between parallel and perpendicular proton and isotropic electron temperature. This fast CME was well observed by Parker Solar Probe (PSP) and Solar Orbiter (SOLO) with both remote and in situ instruments providing unprecedented wealth of information of the CME's structure and evolution. With an average transit speed of roughly 2000 km/s, the CME produced a wide range of disturbances in the corona and heliosphere including intense solar energetic particles. We begin by simulating with SOLO/Extreme Ultraviolet Imager (EUI) data to characterize the pre-eruption state of this far-side event. CME simulation results are compared with situ observations from the SOLO Solar Wind Plasma Analyzer (SWA), both ion sensors and electron analyzer and data from the PSP/Solar Wind Electrons Alphas and Protons (SWEAP) instrument and the PSP/FIELDS instrument. These wealth of data, we compare simulation results to the large-scale plasma distribution and magnetic fields structure of the CME as well as the detailed state of the entrained plasma including isotropic electron temperature, anisotropic proton temperature and turbulent energy density. All combined, model and data provide a broad view of the detailed CME plasma structure and its interaction with Alfvenic turbulence.

SCHEDULE OF TALKS

Thursday, April 10: 5:00 PM – 5:25 PM
Presenter: Baruwal, Prashant

Evolution of Fluctuations during Radial Alignment of Solar Orbiter and WIND

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Masaru Nakanotani, Center for Space Plasma and Aeronomic Research (CSPAR) and Department of Space Science, University of Alabama in Huntsville, USA
Alexander Pitna, Department of Surface and Plasma Science, Faculty of Mathematics and Physics, Charles University, Prague, Czechia

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Monika Karki, Center for Space Plasma and Aeronomic Research (CSPAR) and Department of Space Science, University of Alabama in Huntsville, USA
I. Tasnim, Center for Space Plasma and Aeronomic Research (CSPAR) and Department of Space Science, University of Alabama in Huntsville, USA

Small-amplitude fluctuations in the magnetized solar wind are measured typically by a single spacecraft. In the magnetohydrodynamic (MHD) description, fluctuations are expressed in terms of the fundamental modes admitted by the system. An important question is how to resolve an observed set of fluctuations, typically plasma moments such as density, velocity, pressure, and magnetic field fluctuations, into their constituent fundamental modal components. In particular, the identification of the fundamental modal components of the fluctuations of the same plasma parcel observed at two different radially aligned locations has not yet been investigated in detail. Zank et al. 2023 proposed a method that distinguishes between wave modes and advected structures such as magnetic islands or entropy modes and calculates the phase information associated with the eligible MHD modes. Linear MHD admits a set of fundamental modes, six of which correspond to waves and two to advected modes, namely fast and slow magnetosonic (+/-) modes, Alfven (+/-) modes, and the entropy and magnetic island modes. We use this recently developed technique to identify eight modes in the same plasma parcel dataset measured by Solar Orbiter (SolO) and WIND in the inner heliosphere resulting from the radial alignment of the two spacecraft. We study how the properties of eight modes vary as a function of distance (radial evolution) in the inner heliosphere. This study gives us a more precise picture of how fluctuations evolve with increasing radial distance.

SCHEDULE OF TALKS

Friday, April 11: 8:30 AM – 8:55 AM
Presenter: Light, Juandre

Numerical Solutions to Superdiffusive Shock Acceleration: A Finite Difference Approach

Juandre Light, Centre for Space Research, NWU, South Africa
Du Toit Strauss, Centre for Space Research, NWU, South Africa

Superdiffusive transport may describe the power-law particle distributions observed within the heliosphere. Utilising a newly developed 1D finite difference model to solve for diffusive shock acceleration, and adapting for superdiffusive transport by solving fractional diffusion equations, we investigate the spatial and momentum distributions of particles subject to (super-) diffusive shock acceleration. We investigate the spectral indices of the momentum spectra for different shock compression ratios and different anomalous diffusion exponents. These are compared to the expected spectral index for Gaussian (normal) diffusion. The intricacies and difficulties of using a finite difference numerical method to simulate superdiffusion are also investigated.

Friday, April 11: 8:55 AM – 9:20 AM
Presenter: Mazelle, Christian

Fast Backstreaming Field-Aligned Proton Beams Observed Upstream of the Martian Bow Shock

Christian Mazelle, IRAP, CNRS, University of Toulouse, CNES, France
Karim Meziane, Physics Department, University of New Brunswick, NB, Canada
Jasper S. Halekas, Department of Physics and Astronomy, University of Iowa, Iowa City, Iowa, USA
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Abdelhaq Hamza, Physics Department, University of New Brunswick, NB, Canada
David L. Mitchell, Space Sciences Laboratory, University of California, Berkeley, USA
Jared R. Espley, NASA Goddard Space Center, Greenbelt, Maryland, USA

The bow shock of Mars provides a compelling example of a mass-loaded, supercritical shock. A key challenge in space plasma physics is understanding the mechanisms of particle acceleration that occur at collisionless shocks. Due to extensive studies, the terrestrial foreshock is often considered a benchmark for interactions between planetary magnetospheres and the solar wind. The MAVEN mission at Mars is offering a wealth of data, simultaneously opening a window to study the Martian foreshock in detail. In this context, we present new measurements of velocity distribution functions of suprathermal protons upstream of Mars' bow shock. We identify backstreaming beams aligned (FAB) with the interplanetary magnetic field (IMF) direction for various shock geometries. FAB bulk velocities are found to be well-distributed in relation to the shock speed. Our analysis reveals that, compared to their terrestrial counterparts, Martian FABs exhibit slower sunward motion. Additionally, it appears that these FABs originate from a shock region where the IMF lines form an angle of 20-50 degrees with the shock normal— a smaller source region than that of Earth's bow shock. These findings rule out specular reflection as the mechanism behind beam production. Typically, terrestrial FABs are produced through a quasi-adiabatic process that preserves the first invariant to some extent. In contrast, the new Martian observations provide a valuable comparison between the foreshocks of Earth and Mars, shedding light on key differences and enhancing our understanding of these planetary phenomena.

SCHEDULE OF TALKS

Friday, April 11: 9:20 AM – 9:45 AM
Presenter: Halekas, Jasper

Forever Young: Electron Distributions in the Disappearing Solar Wind

Jasper Halekas, University of Iowa, USA
Phyllis Whittlesey, University of California Berkeley, USA
Davin Larson, University of California Berkeley, USA
Michael Stevens, Smithsonian Astrophysical Observatory, USA
Stuart Bale, University of California Berkeley, USA

Solar wind electron velocity distribution functions (eVDFs) are shaped by a variety of influences, including large-scale electromagnetic fields, wave-particle interactions, and Coulomb collisions. These competing effects alter the eVDF as the solar wind expands, to such a degree that we find it difficult to infer the properties of the corona from the eVDFs we observe in the nominal solar wind at 1 AU.
With Parker Solar Probe (PSP), we now have measurements far closer to the Sun than ever before, revealing the eVDFs in a younger and less altered state. The near-Sun eVDFs contain information difficult to access at 1 AU, including the magnitude of the solar electrostatic potential, and a measure of the temperature of the coronal electrons. However, even at PSP's closest approach, the effects of collisions and wave-particle interactions can still obscure the original form of the eVDF in the lower corona.
In this work, we attempt to approach the initial coronal eVDF in two dimensions, by focusing on the closest PSP orbits, and by investigating very low-density "disappearing solar wind" intervals. In these conditions, we find a distinctly different eVDF from the core+suprathermal distribution typically observed in the solar wind. We describe these unique distributions and discuss their implications for the initial conditions in the lower corona and the evolution of the solar wind.

Friday, April 11: 9:45 AM – 10:10 AM
Presenter: Nakanotani, Masaru

Cyclic Reformation of Perpendicular Magnetized Dusty Plasma Shock Waves

Masaru Nakanotani, CSPAR, University of Alabama in Huntsville, USA
Gary P. Zank, CSPAR, University of Alabama in Huntsville, USA
Edward Thomas Jr., Physics Department, Auburn University, USA

The system of dusty plasmas can be easily found in several places in space, such as Saturn's ring, comet tails, nebulae, interstellar medium, molecular clouds, and so on. Since dust grains are usually charged, their collective motion modifies the dynamics of plasmas by carrying currents, and exchanging momentum and energy between the dust grains and plasma. Several studies of dusty plasmas in the past have treated dust grains and plasmas as a fluid, and it is not well known how the kinetic effect of dust grains affect the system. In the dust kinetic regime, dust grains can resonant with waves, and the time and spatial scale becomes comparable to the scale of the dust gyro motion. In this presentation, we discuss the evolution of perpendicular magnetized dusty plasma shock waves using 1D PIC-MHD methods, in which dust grains are solved as a particle, and the plasma as a fluid. We solve the Vlasov equation for dust grains to include the dust kinetic effect. A supercritical shock wave (MA~5) is considered. We find that when the dust mass density is comparable or larger than the plasma mass density, dust grains form a magnetic ramp and overshoot and are reflected at the ramp. The reflected dust grain component creates a new magnetic structure. This can be interpreted as a cyclic reformation process, which have been observed in standard plasmas. We also discuss the dust velocity distribution function.

SCHEDULE OF TALKS

Friday, April 11: 10:35 AM – 11:00 AM
Presenter: Oka, Mitsuo

Scaling of Particle Heating in Shocks and Magnetic Reconnection

Mitsuo Oka, UC Berkeley, USA
Tai Phan, UC Berkeley, USA
Marit Øieroset, UC Berkeley, USA
Daniel J. Gershman, NASA/GSFC, USA
Roy B. Torbert, University of New Hampshire, USA
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Vassilis Angelopoulos, UCLA, USA

Particles are heated efficiently through energy conversion processes such as shocks and magnetic reconnection in collisionless plasma environments. While empirical scaling laws for the temperature increase have been obtained, the precise mechanism of energy partition between ions and electrons remains unclear. Here we show, based on coupled theoretical and observational scaling analyses, that the temperature increase, ΔT, depends linearly on three factors: the available magnetic energy per particle, the Alfvén Mach number (or reconnection rate), and the characteristic spatial scale L. Based on statistical datasets obtained from Earth's plasma environment, we find that L is on the order of (1) the ion gyro-radius for ion heating at shocks, (2) the ion inertial length for ion heating in magnetic reconnection, and (3) the hybrid inertial length for electron heating in both shocks and magnetic reconnection. With these scales, we derive the ion-to-electron ratios of temperature increase as ΔTi/ΔTe = (3βi/2)1/2(mi/me)1/4 for shocks and ΔTi/ΔTe = (mi/me)1/4 for magnetic reconnection, where βi is the ion plasma beta, and mi and me are the ion and electron particle masses, respectively. We anticipate that this study will serve as a starting point for a better understanding of particle heating in space plasmas, enabling more sophisticated modeling of its scaling and universality.

POSTER PRESENTATIONS

Ayaz, Syed	**Alfvén waves in the solar corona: resonance velocity, damping length, and charged particles acceleration by kinetic Alfvén waves** Ayaz, Syed – The University of Alabama in Huntsville
Brant, Pontus	**Identification of Turbulent Modes in the Magnetosheath** Brant, Pontus – Johns Hopkins APL
Mostafavi, Parisa	**Solar Wind Speed Maps through a Full Solar Cycle from UVCS/SoHO and Recent Metis/Solar Orbiter Results** Mostafavi, Parisa – Johns Hopkins University Applied Physics Lab

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