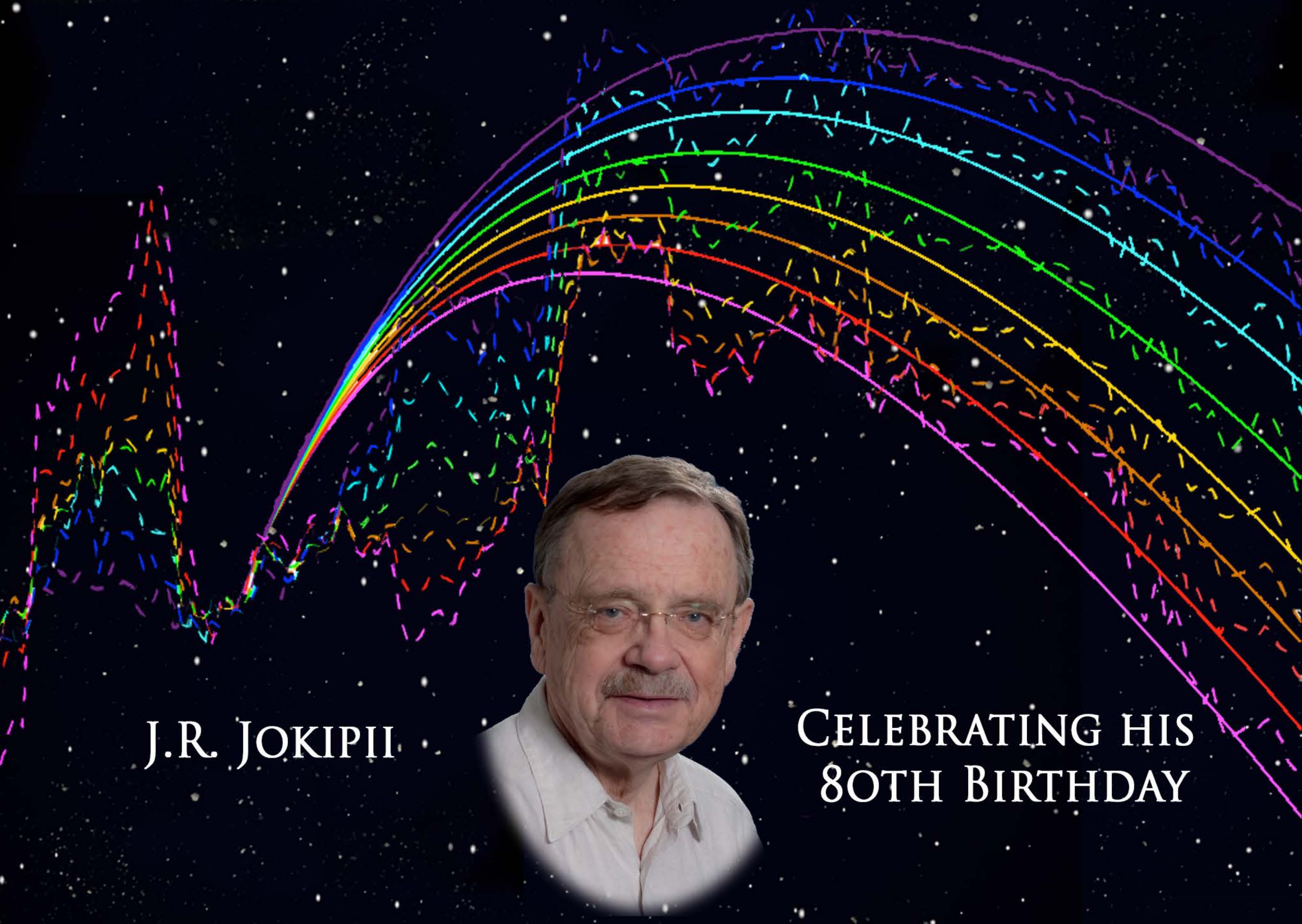
18TH Annual International Astrophysics Conference

The Physics of Energetic Particles:

Universal Processes from the Solar Corona to the Very Local Interstellar Medium and the Physics they Enable

February 18-22, 2019

Pasadena, CA, USA



J.R. Jokipii

Celebrating his 80th Birthday

18th Annual International Astrophysics Conference
Pasadena, CA – February 17-22, 2019

AGENDA

SUNDAY, FEBRUARY 17		
5:00 PM - 8:00 PM	Registration – Lobby	
6:00 PM - 9:00 PM	WELCOME RECEPTION - Piazza Ballroom	

MONDAY, FEBRUARY 18		
7:00 AM - 5:00 PM	Registration -Lobby	
8:00 AM - 6:00 PM	GENERAL SESSION – Justine's Ballroom	
CHAIR: Zank, G.		
7:45 AM - 8:00 AM	Zank, Gary	Welcome Orientation
8:00 AM - 8:25 AM	Schwadron, Nathan	Suprathermal Plasma Structure in the Very Local Interstellar Medium from the IBEX Ribbon
8:25 AM - 8:50 AM	Gopalswamy, Nat	On the Shock Source of Sustained Gamma-ray Emission from the Sun: Understanding Two Unusual Events
8:50 AM - 9:15 AM	Tang, Bofeng	Numerical Modeling of Electron Transport in Solar Wind: Effects of Whistler Turbulence and Coulomb Collisions
9:15 AM - 9:40 AM	Boldyrev, Stanislav	A Coulomb Theory of the Electron Strahl
9:40 AM - 10:05 AM	Salem, Chadi	Understanding Electron-Scale Electric Field Fluctuations in Solar wind Kinetic Turbulence: Artemis Observations
10:05 AM - 10:30 AM	Morning Break - Piazza Ballroom	
CHAIR: Sokol, J.		
10:30 AM - 10:55 AM	Pierrard, Viviane	Consequences of the Presence of Suprathermal Electrons and Ions in the Solar Wind Kinetic Model
10:55 AM - 11:20 AM	Liewer, Paulett	Preparing for Parker Solar Probe: Tracking Solar Wind Features in Images from the Wide-field Imager for Parker Solar Probe (WISPR)
11:20 AM - 11:45 AM	Nakanotani, Masaru	The Propagation and Timing of Interplanetary Shocks to Reach the Heliopause and the VLISM
11:45 AM - 12:10 PM	Shalchi, Andreas	Time-Dependent Perpendicular Transport of Energetic Particles
12:10 PM - 12:35 PM	Li, Gang	Is Parker Field a Food Approximation and the Meandering a Field Line
12:35 PM - 1:30 PM	Lunch Break - Piazza Ballroom	
CHAIR: Ho, G.		
1:30 PM - 1:55 PM	Rieger, Frank	Energetic Particle Acceleration in Shearing Flows
1:55 PM - 2:20 PM	Lin, Yu	Generation of Secondary Instabilities in Strong Guide Field Reconnection
2:20 PM - 2:45 PM	Du, Senbei	Plasma energization in magnetic flux rope coalescence
2:45 PM - 3:10 PM	Che, Haihong	Solar Coronal Electron Acceleration in Multi-island Magnetic Reconnection
3:10 PM - 3:35 PM	Zhao, Lingling	Particle Acceleration Associated with Solar Wind Magnetic Island Dynamics
3:35 PM - 3:55 PM	Afternoon Break - Piazza Ballroom	

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CHAIR: Che, H.		
3:55 PM - 4:20 PM	Guo, Fan	Compression Acceleration during Magnetic Reconnection
4:20 PM - 4:45 PM	Klein, Kristopher	HelioSwarm: Revealing the Transfer of Energy Across Scales and Boundaries in Plasmas in the Universe
4:45 PM - 5:10 PM	Fu, Xiangrong	Heating of Heavy Ions in Low-beta Plasma Turbulence
5:10 PM - 5:35 PM	Li, Xiaocan	The Formation of Power-law Energy Spectrum in 3D low-beta Magnetic Reconnection
5:35 PM - 6:00 PM	Gurnett, Don	The Systematic Increase of the Electron Density and Other Related Effects as Voyager 1 Moves Outward into Interstellar Space
SESSION ADJORNS		

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TUESDAY, FEBRUARY 19		
7:00 AM - 5:00 PM	Registration –Lobby	
8:00 AM – 6:00 PM	GENERAL SESSION – Justine's Ballroom	
CHAIR: Klein, K.		
8:00 AM - 8:25 AM	Moebius, Eberhard	Observation of Suprathermal Tails of He+ Pickup Ions across Solar Wind Compression Regions with STEREO PLASTIC
8:25 AM - 8:50 AM	Livadiotis, George	On the Origin of the Polytropic Behavior in Space Plasmas
8:50 AM - 9:15 AM	Golla, Thejappa	Observational Evidence for Langmuir Solitons in Solar Type III Bursts
9:15 AM - 9:40 AM	Manchester, Chip	CME-Turbulence Interaction With Temperature Anisotropies
9:40 AM - 10:05 AM	TenBarge, Jason	Energy Dissipation and Phase-Space Dynamics in Eulerian Vlasov-Maxwell Shocks and Reconnection
10:05 AM - 10:30 AM	Morning Break - Piazza Ballroom	
CHAIR: Ratkiewicz, R.		
10:30 AM - 10:55 AM	McComas, David	Evolution of the Outer Heliosphere
10:55 AM - 11:20 AM	Lembege, Bertrand	Analysis of Energy Spectra Measured by SWAP Experiment on Board of New Horizon Mission: 1D Full Particle Simulation Results versus Recent Experimental Observations
11:20 AM - 11:45 AM	Zank, Gary	The Pickup Ion Mediated Solar Wind
11:45 AM - 12:10 PM	Wood, Brian	Searching for Evidence for non-Maxwellian Velocity Distributions in the Local ISM Using Ulysses and IBEX Data
12:10 PM - 12:35 PM	Sokol, Justyna	Modeling the Interstellar Neutral Gas for the Study of the Pick-up ions inside the Heliosphere
12:35 PM - 1:30 PM	Lunch Break - Piazza Ballroom	
CHAIR: Guo, F.		
1:30 PM - 1:55 PM	Krimigis, Stamatios	Combined Voyager1&2/LECP ion and Cassini/INCA ENA Measurements: Pressure Balance in the Heliosheath
1:55 PM - 2:20 PM	Zirnstein, Eric	Strong Scattering of keV Pickup Ions in the Local Interstellar Magnetic Field Draped Around Our Heliosphere: Implications for the IBEX Ribbon's Source and IMAP
2:20 PM - 2:45 PM	Pogorelov, Nikolai	Energetic Ions in the Heliosphere and Beyond
2:45 PM - 3:10 PM	Bzowski, Maciej	Distribution Function Of Interstellar Neutral He After Processing In The Outer Heliosheath
3:10 PM - 3:35 PM	Swaczyna, Pawel	Temperature and Non-equilibrium Distributions of Interstellar Neutrals
3:35 PM - 3:55 PM	Afternoon Break - Piazza Ballroom	
CHAIR: Bellan, P.		
3:55 PM - 4:20 PM	Medvedev, Mikhail	Plasma Constraints on the Cosmological Abundance of Magnetic Monopoles and the Origin of Cosmic Magnetic Fields
4:20 PM - 4:45 PM	Rahmanifard, Fatemeh	Radiation Pressure from IBEX Observations of the Interstellar Hydrogen Trough Solar Cycle 24
4:45 PM - 5:10 PM	Xu, Siyao	On the Broadband Synchrotron Spectra of Pulsar Wind Nebulae
5:10 PM - 5:35 PM	Mostafavi, Parisa	The Effect of Inner Heliosheath Shocks on Energetic Neutral Atom Observations by IBEX
5:35 PM - 6:00 PM	Raymond, John	Development of Turbulence behind a Radiative Shock
SESSION ADJOURNS		

AGENDA

WEDNESDAY, FEBRUARY 20		
7:00 AM - 5:00 PM	Registration -Lobby	
8:00 AM - 6:00 PM	GENERAL SESSION – Justine's Ballroom	
CHAIR: Yoon P.		
8:00 AM - 8:25 AM	Intriligator, Devrie	Implications of the Voyager 1 and 2 Particle and Field Observations around their Respective Heliopause Crossings
8:25 AM - 8:50 AM	Isenberg, Phil	New Results from an Empirically-Based Model of the Upstream Heliopause and Outer Heliosheath
8:50 AM - 9:15 AM	Zieger, Bertalan	Particle Acceleration by Dispersive Magnetosonic Waves in the Inner Heliosheath
9:15 AM - 9:40 AM	Leske, Richard	Has the Source Intensity of Anomalous Cosmic Rays Decreased?
9:40 AM - 10:05 AM	Roelof, Edmond	Low Intensity "Basins" in Cassini/INCA ENA Images (5-55 keV) of the Heliosheath
10:05 AM - 10:30 AM	Morning Break - Piazza Ballroom	
CHAIR: Zank, G.		
10:30 AM - 10:55 AM	Cummings, Alan	The Anisotropy of Anomalous Cosmic Rays Observed by Voyager 2 in the Inner Heliosheath and Beyond
10:55 AM - 11:35 AM	Giacalone, Joe	The Role of the Magnetic Field in Cosmic-Ray Transport and Interaction with Shocks
11:35 AM - 12:15 PM	Jokipii, J. R.	Thoughts on Nearly 60 years of Attempting to Understand Energetic Particles in Space.
12:15 PM - 1:30 PM	Lunch Break - Piazza Ballroom	
CHAIR: Schwadron, N.		
1:30 PM - 1:55 PM	Stone, Ed	Voyager 2 Joins Voyager 1 in Exploring Different Heliopause Regions
1:55 PM - 2:20 PM	Decker, Robert	Charged Particles Measured during the Voyager 2 Heliopause Crossing
2:20 PM - 2:45 PM	Richardson, John	Plasma Observations Across the Heliopause
2:45 PM - 3:10 PM	Burlaga, Leonard	Magnetic Field Observations Indicate That Voyager 2 Crossed the Heliopause
3:10 PM - 3:35 PM	Lee, Lou-Chuang	Solar Coronal Heating by Fast Shocks and Voyager 1 Observations of Interstellar Electron Turbulence Spectrum
3:35 PM - 3:55 PM	Afternoon Break - Piazza Ballroom	
CHAIR: Dayeh, M.		
3:55 PM - 4:20 PM	Matsukiyo, Shuichi	Kinetic Scale Radial Structure of the Heliopause
4:20 PM - 4:45 PM	Florinski, Vladimir	Some Properties of the Heliopause during Voyager 1 and 2 Crossings
4:45 PM - 5:10 PM	Rankin, Jamie	Galactic Cosmic-Ray Anisotropies: Voyager 1 in the Local Interstellar Medium
5:10 PM - 5:35 PM	Opher, Merav	A Predicted Small and Round Heliosphere
5:35 PM - 6:00 PM	Ratkiewicz, Romana	Heliosphere Under Influence of Sun-originating vs. LISM-originating Fluctuations
SESSION ADJOURNS		
6:30 PM - 9: 30 PM	Group Dinner – Piazza Ballroom	

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THURSDAY, FEBRUARY 21		
7:00 AM - 5:00 PM	Registration –Lobby	
8:00 AM – 6:00 PM	GENERAL SESSION – Justine's Ballroom	
CHAIR: Aschwandren, M.		
8:00 AM - 8:25 AM	Spence, Harlan	Acceleration of Charged Particles in Earth's Radiation Belts: Transformative Understanding from the Van Allen Probes Mission
8:25 AM - 8:50 AM	Dayeh, Maher A.	Forecasting the Physical Properties of Energetic Storm Particle (ESP) Events at 1 AU
8:50 AM - 9:15 AM	Mewaldt, Richard	The Large Energetic Storm Particle Event of September 18, 2017 Observed by STEREO-A
9:15 AM - 9:40 AM	Hu, Junxiang	Modeling of Energetic Storm Particle (ESP) Events and their Effects on SEP Energy Spectra
9:40 AM - 10:05 AM	Kota, Jozsef	Solar Cycle Variations in the Acceleration of Anomalous Cosmic Rays
10:05 AM - 10:30 AM	Morning Break - Piazza Ballroom	
CHAIR: Wood, B.		
10:30 AM - 10:55 AM	Ho, George	3He-rich Solar Energetic Particle Events with no Measurable 4He Intensity Increases
10:55 AM - 11:20 AM	Wang, Linghua	The in situ Electron Acceleration at ICME-driven Shocks
11:20 AM - 11:45 AM	Wiedenbeck, Mark	Isotopic Fractionation in 3He-rich SEP Events
11:45 AM - 12:10 PM	Wijsen, Nicolas	Modelling Solar Energetic Protons Near and Within a Corotating Interaction Region
12:10 PM - 12:35 PM	Aschwanden, Markus	Global Energetics of Solar Flares and Coronal Mass Ejections
12:35 PM - 1:30 PM	Lunch Break - Piazza Ballroom	
CHAIR: Li, G.		
1:30 PM - 1:55 PM	Bellan, Paul	Experimental Observations of a Cascade from the MHD Scale to the Non-MHD Scale
1:55 PM - 2:20 PM	Adhikari, Laxman	Theory and Transport of Nearly Incompressible Magnetohydrodynamic Turbulence. V. A Coupled Solar Corona and Turbulence Model
2:20 PM - 2:45 PM	Tasnim, Samira	Mapping Magnetic Field Lines for an Accelerating Solar Wind
2:45 PM - 3:10 PM	Klein, Kristopher	A Preferential Ion Heating Zone Near The Sun: What is it, Where is it, and What Drives it?
3:10 PM - 3:35 PM	Hu, Qiang	Radial Evolution of the Properties of Small-Scale Magnetic Flux Ropes in the Solar Wind
3:35 PM - 3:55 PM	Afternoon Break - Piazza Ballroom	
CHAIR: Florinski, V.		
3:55 PM - 4:20 PM	Qin, Gang	Energetic Particles Accelerated by an Interplanetary Coronal Mass Ejection Shock with Magnetic Cloud
4:20 PM - 4:45 PM	Mazelle, Christian	A Fast-Fermi Acceleration at Mars Bow Shock
4:45 PM - 5:10 PM	Cohen, Christina	Solar Energetic Particles Associated with Filament Eruptions
5:10 PM - 5:35 PM	Verkhoglyadova, Olga	Characterization of Solar Wind Driving of the Earth's Ionosphere With Total Electron Content
5:35 PM - 6:00 PM	Kim, Tae	A Time-dependent Model of the Ambient Solar Wind Driven by Boundary Conditions from Observations of Interplanetary Scintillation
SESSION ADJOURNS		

AGENDA

FRIDAY, FEBRUARY 22		
7:00 AM - 5:00 PM	Registration -Lobby	
8:00 AM – 6:00 PM	GENERAL SESSION – Justine's Ballroom	
CHAIR: Pogorelov, N.		
8:00 AM - 8:25 AM	Yoon, Peter	Weakly Turbulent Nonlinear Wave-Particle Interactions in Space and Astrophysical Plasmas
8:25 AM - 8:50 AM	Alonso Guzman, Juan	Theoretical Model of Ion-Acoustic Shock Wave Structure in Dusty Plasma
8:50 AM - 9:15 AM	Hill, Matthew	A New Cosmic Ray Monitor in the Outer Heliosphere: The PEPSSI Experiment on New Horizons
9:15 AM - 9:40 AM	Jian, Lan	Long-Term Observations of Large-Scale Solar Wind Structures and Their Relationship with Energetic Storm Particle Events in the STEREO Era
9:40 AM - 10:05 AM	Cooper, John	Energy-Dependent Hysteresis in Long-Distance Propagation of Solar Energetic Particles
10:05 AM - 10:30 AM	Morning Break - Piazza Ballroom	
CHAIR: Zank, G.		
10:30 AM - 10:55 AM	Ip, Wing	Nanodust and ENAs in the Near-Solar Region
10:55 AM - 11:20 AM	Lazarian, Alex	Turbulent Reconnection: Generic type of 3D Astrophysical Reconnection
END OF CONFERENCE		

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TALKS BY PARTICIPANT

Adhikari, Laxman	Thu, Feb 21	1:55 PM - 2:20 PM	Theory and Transport of Nearly Incompressible Magnetohydrodynamic Turbulence. V. A Coupled Solar Corona and Turbulence Model
Alonso Guzman, Juan	Fri, Feb 22	8:25 AM - 8:50 AM	Theoretical Model of Ion-Acoustic Shock Wave Structure in Dusty Plasma
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Boldyrev, Stanislav	Mon, Feb 18	9:15 AM - 9:40 AM	A Coulomb Theory of the Electron Strahl
Burlaga, Leonard	Wed, Feb 20	2:45 PM - 3:10 PM	Magnetic Field Observations Indicate That Voyager 2 Crossed the Heliopause
Bzowski, Maciej	Tue, Feb 19	2:45 PM - 3:10 PM	Distribution Function Of Interstellar Neutral He After Processing In The Outer Heliosheath
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Giacalone, Joe	Wed, Feb 20	10:55 AM - 11:35 AM	The Role of the Magnetic Field in Cosmic-Ray Transport and Interaction with Shocks
Golla, Thejappa	Tue, Feb 19	8:50 AM - 9:15 AM	Observational Evidence for Langmuir Solitons in Solar Type III Bursts
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Klein, Kristopher	Mon, Feb 18	4:20 PM - 4:45 PM	HelioSwarm: Revealing the Transfer of Energy Across Scales and Boundaries in Plasmas in the Universe
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Lembege, Bertrand	Tue, Feb 19	10:55 AM - 11:20 AM	Analysis of Energy Spectra Measured by SWAP Experiment on Board of New Horizon Mission: 1D Full Particle Simulation Results versus Recent Experimental Observations
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Manchester, Chip	Tue, Feb 19	9:15 AM - 9:40 AM	CME-Turbulence Interaction With Temperature Anisotropies
Matsukiyo, Shuichi	Wed, Feb 20	3:55 PM - 4:20 PM	Kinetic Scale Radial Structure of the Heliopause
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Medvedev, Mikhail	Tue, Feb 19	3:55 PM - 4:20 PM	Plasma Constraints on the Cosmological Abundance of Magnetic Monopoles and the Origin of Cosmic Magnetic Fields
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Rankin, Jamie	Wed, Feb 20	4:45 PM - 5:10 PM	Galactic Cosmic-Ray Anisotropies: Voyager 1 in the Local Interstellar Medium
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Raymond, John	Tue, Feb 19	5:35 PM - 6:00 PM	Development of Turbulence behind a Radiative Shock
Richardson, John	Wed, Feb 20	2:20 PM - 2:45 PM	Plasma Observations Across the Heliopause
Rieger, Frank	Mon, Feb 18	1:30 PM - 1:55 PM	Energetic Particle Acceleration in Shearing Flows
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Zirnstein, Eric	Tue, Feb 19	1:55 PM - 2:20 PM	Strong Scattering of keV Pickup Ions in the Local Interstellar Magnetic Field Draped Around Our Heliosphere: Implications for the IBEX Ribbon’s Source and IMAP

SCHEDULE OF TALKS

NOTES

Monday, February 18: 8:00 AM - 8:25 AM
Presenter: Schwadron, Nathan

Suprathermal Plasma Structure in the Very Local Interstellar Medium from the IBEX Ribbon

N. A. Schwadron, University of New Hampshire, USA
D. J. McComas, Princeton University, USA

The Interstellar Boundary Explorer (IBEX) mission discovered the presence of a structure in energetic neutral atom emissions not predicted by any model. In the search for possible explanations, observations have pointed to a plausible source from neutral atoms produced through charge-exchange with the outflowing solar wind, the secondary solar wind, which then undergoes charge-exchange again beyond the heliopause within the very local interstellar medium. However, a major uncertainty remains in explaining how the emissions broaden so significantly at the highest energies observed by IBEX. Here we discuss the creation of plasma structure within the very local interstellar medium from a range of secondary neutral atoms created by charge-exchange with: the solar wind, pickup ions inside the termination shock, and suprathermal ions in the inner heliosheath. All of these particle sources should populate the plasma environment of the very local interstellar medium, but the emission signature of energetic neutral atoms depends strongly on how these sources form plasma structure. We show that at the high-end of the observational range of IBEX (centered on 4.29 keV) the significantly broadened energetic neutral atom signature of the ribbon suggests plasma structure associated primarily with secondary atoms created from pickup ions and suprathermal ions in the inner heliosheath. These components of the ribbon combine to form relatively high suprathermal particle pressure that significantly affects the interaction of the heliosphere with the local interstellar medium. These findings suggest that the ribbon is composed of a mixture of surpathermal particles within the very local interstellar medium. In the extension to other astrospheres, these observations suggest that suprathermal ions play a significant role in influencing the structure and time-variation associated with the interactions between stellar winds and the interstellar medium local to the host star.

Monday, February 18: 8:25 AM - 8:50 AM
Presenter: Gopalswamy, Nat

On the Shock Source of Sustained Gamma-ray Emission from the Sun: Understanding Two Unusual Events

Nat Gopalswamy, NASA/GSFC, USA
Pertti Mäkelä, Catholic University, USA
Seiji Yashiro, Catholic University, USA
Alejandro Lara, UNAM, Mexico
Hong Xie, Catholic University, USA
Sachiko Akiyama, Catholic University, USA

It has recently been shown that the spatially and temporally extended gamma-ray emission in solar eruptions are caused by >300 MeV protons precipitating on the Sun from shocks driven by coronal mass ejections (CMEs). The gamma-rays result from the decay of neutral pions produced in the proton-proton interaction when the >300 MeV protons collide with those in the chromosphere. The evidence comes from the close correlation between the durations of the sustained gamma-ray emission (TSGRE) and the associated interplanetary (IP) type II radio bursts (TII) (Gopalswamy et al., 2018, ApJ 868, L19). The linear relation TSGRE = (0.9±0.1)TII + (0±1.6) was obtained using 13 SGREs that lasted for >5 hr. The relation continues to hold when an additional 6 events with duration >3 hr were considered. However, there were two significant exceptions, which need to be explained. (1) The 2011 June 02 SGRE event had a duration of ~7 hr, but the IP type II burst had two brief episodes within the SGRE time interval. Furthermore, the solar energetic particle event (SEP) observed by STEREO-Behind was very tiny. (2) The large SEP event on 2012 March 13 had >300 MeV protons, yet there was no SGRE event. In this paper, we provide explanations for these two events and show that they are consistent with the IP shock source for SGRE events. In the 2011 June 2 event, CME interaction seems to have played a major roles in that a preceding CME mirrored the protons back to the primary CME shock to get reaccelerated before precipitating on the Sun. In the case of the 2012 March 13 event, there was no solar exposure during the first 90 minutes of the eruption, so an SGRE event is likely missed. The later exposures suggest the possibility of SGRE decaying toward the background. According to the criterion for SGRE duration established in Gopalswamy et al. (2018), the duration from the peak of the associated soft X-ray flare to the mid time between the last gamma-ray signal data point and the background data point is ~5.6 hr. This duration matches with the duration of the associated IP type II radio burst. While the SGRE event would not have been identified without the presence of the type II burst, the consistency is remarkable. This study uses gamma-ray data from Fermi, CME data from SOHO and STEREO, and type II burst data from Wind and STEREO.

Monday, February 18: 8:50 AM - 9:15 AM
Presenter: Tang, Bofeng

Numerical Modeling of Electron Transport in Solar Wind: Effects of Whistler Turbulence and Coulomb Collisions

Bofeng Tang, Gary Zank, Vladimir Kolobov, University of Alabama in Huntsville, USA

The electron distribution function (eVDF) in the solar wind deviates significantly from an equilibrium Maxwellian distribution, and is comprised of a Maxwellian core, a suprathermal halo, a field-aligned component strahl, and a higher energy superhalo. Charged particle Coulomb collisions are ineffective in relaxing such a velocity distribution beyond a few solar radii. Therefore wave-particle interactions need to be considered. A wave-particle interaction term was introduced into the kinetic equation that describes the interaction of electrons with whistler waves, as well as particle collision terms. The kinetic equation has the form of an advection-diffusion-like equation in which the advection and diffusion coefficients describe the scattering and drag of electrons in whistler turbulence. A reliable numerical method has been developed to solve a full form of the advection-diffusion-like kinetic equation. Preliminary applications of the numerical method to the solar wind electron problem are presented. Comparison and analysis of the electron VDFs in the presence of Coulomb collisions and resonant wave-particle interactions are made.

SCHEDULE OF TALKS

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Monday, February 18: 9:15 AM - 9:40 AM
Presenter: Boldyrev, Stanislav

A Coulomb Theory of the Electron Strahl

Stanislav Boldyrev, University of Wisconsin - Madison, USA

Energetic electrons streaming along the magnetic-field lines from the solar corona, experience relatively weak Coulomb collisions. They form a tail (a strahl) in the electron velocity distribution function, aligned with the direction of the magnetic field. The strahl can contribute to the energy transport and heating of the solar wind. I will overview some recent analytic results allowing one to predict the shape of the electron strahl and establish its possible relation to the formation of the electron halo [1, 2]. These results take into account Coulomb collisions and the Parker-spiral shaped magnetic field lines. Srahls wider than those predicted by the Coulomb theory should indicate anomalous broadening of the electron beam by plasma fluctuations.
[1] Horaites, K.; Astfalk, P.; Boldyrev, S.; Jenko, F. MNRAS 480 (2018) 1499;
[2] Horaites, K., Boldyrev, S., Medvedev, M., MNRAS 484 (2019) 2474.

Monday, February 18: 9:40 AM - 10:05 AM
Presenter: Salem, Chadi

Understanding Electron-Scale Electric Field Fluctuations in Solar wind Kinetic Turbulence: Artemis Observations

Chadi Salem, University of California, Berkeley CA, USA
John Bonnell, University of California, Berkeley CA, USA
Elizabeth Hanson, University of California, Berkeley CA, USA
Christopher Chaston, University of California, Berkeley CA, USA
Kristopher Klein, University of Arizona, USA
Luca Franci, Queen Mary College, UK
Daniel Verscharen, University College of London, UK

We present here an analysis of kinetic-scale electromagnetic fluctuations in the solar wind up to electron scales based on data analysis from the THEMIS/ARTEMIS spacecraft. We focus on an interval characterized by a plasma beta of 2 and analyze magnetic, electric field, and density fluctuations from the 0.01 Hz (well in the inertial range) up to 1 kHz. We compute parameters such as the electric to magnetic field ratio, the magnetic compressibility, magnetic helicity, compressibility and other relevant quantities in order to diagnose the nature of the fluctuations at those scales between the ion and electron cyclotron frequencies, extracting information on the dominant modes composing the fluctuations. We also use the linear Vlasov-Maxwell solver, PLUME, to determine the various relevant modes of the plasma with parameters from the observed solar wind intervals. We discuss the results and the relevant modes as well as the major differences between our results in the solar wind and results in the magnetosheath.

SCHEDULE OF TALKS

NOTES

Monday, February 18: 10:30 AM - 10:55 AM
Presenter: Pierrard, Viviane

Consequences of the Presence of Suprathermal Electrons and Ions in the Solar Wind Kinetic Model

Viviane Pierrard, Royal Belgian Institute for Space Aeronomy, Belgium

Velocity distribution functions of plasma particles measured by spacecraft in the solar wind and many other space plasmas show enhanced suprathermal tails. Such distributions can be fitted by different velocity distribution functions such as Kappa distributions decreasing as a power law of the velocity or with a sum of Maxwellians with different temperatures. The presence of nonthermal populations in space plasmas, and in particular in the solar corona and the solar wind, has important consequences concerning particle acceleration and plasma heating [1]. These effects are well described by the kinetic approach using non thermal distributions. A kinetic model of the solar corona and the solar wind has been developed for electrons, protons and minor ions [2]. It allows us to test the effects of enhanced populations of suprathermal particles. We show important consequences for the temperature of the different species. Moreover, the presence of suprathermal electrons plays an important role in the acceleration of the solar wind. We also show the evolution of the suprathermal particles with the radial distance as observed by different spacecraft and how wave-particle interactions can explain some observed features like the temperature anisotropies [3]. Using machine learning, we also improved the boundary conditions obtained from photospheric observations to obtain the best predictions at 1 AU with the kinetic exospheric model we have developed. Solar wind observations from Cluster, Helios, OMNI and Ulysses are studied to compare with the predictions of the model. References [1] V. Pierrard, M. Lazar, Kappa distributions: theory and applications in space plasmas, Solar Physics, vol. 287, N° 1, 2010, 153-174, doi: 10.1007/s11207-010-9640-2. [2] V. Pierrard, M. Pieters, Coronal heating and solar wind acceleration for electrons, protons and minor ions obtained from kinetic models based on Kappa distributions, J. Geophys. Res. Space Physics, 119, 2014, 9441-9455, doi: 10.1002/2014JA020678. [3] V. Pierrard, M. Lazar, S. Poedts, S. Stverak, M. Maksimovic, P. M. Tranicek, The Electron Temperature and Anisotropy in the Solar Wind. 1. Comparison of the core and halo populations, Solar Phys. 291(7), 2016, 2165-2179, doi: 10.1007/s11207-016-0961-7.

Monday, February 18: 10:55 AM - 11:20 AM
Presenter: Liewer, Paulett

Preparing for Parker Solar Probe: Tracking Solar Wind Features in Images from the Wide-field Imager for Parker Solar Probe (WISPR)

Paulett Liewer, JPL/Caltech, USA
Jiong Qiu, MSU, USA
Paulo Penteado, JPL/Caltech, USA
Arnaud Thernisien, NRL, USA
Angelos Vourlidas, JHU/APL, USA
Russell Howard, NRL, USA

The Parker Solar Probe (PSP) trajectory, approaching within 10 solar radii, will allow the white light imager, WISPR, to view the inner corona with unprecedented spatial resolution. WISPR, with a field-of-view extending from 13.5° to 108° elongation angle from the Sun, will image the fine-scale coronal structure with ~arcminute resolution at high cadence (~5 - 60 min). The dependency of Thomson scattering on the distance between the observer and the Sun dictates that WISPR will be a “local” heliospheric imager, and thus can provide a crucial link between the visible corona and PSP’s in-situ measurements. As PSP files through the corona on its elliptical orbit, the viewpoint and the radial extent of WISPR’s field-of-view change constantly. To prepare for this unprecedented viewing of the corona, we are creating synthetic white light images and animations, viewed from the PSP trajectory, using the white-light ray-tracing package developed at NRL (available through SolarSoft) to study how these changes will affect the analysis of WISPR images. We investigate how the changing viewpoint can be used to obtain 3D information on coronal features and to determine which features were sampled in-situ. In particular, we investigate whether the 3-D trajectory (direction and velocity) of a density enhancement (flux rope or "blob") observed by WISPR can be determined to provide information on its solar source. Here, we show that, assuming the density enhancement moves radially at a constant velocity, the 3-D trajectory can be determined using a curve fitting procedure if the track can be followed in a series of WISPR images. This is the case even though the spacecraft is moving rapidly with respect to the density enhancement. We also investigate obtaining 3D information on the location of more stationary coronal structures such as streamers.

SCHEDULE OF TALKS

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Monday, February 18: 11:20 AM - 11:45 AM
Presenter: Nakanotani, Masaru

The Propagation and Timing of Interplanetary Shocks to Reach the Heliopause and the VLISM

G.P. Zank, Space Science Department/UAH, CSPAR/UAH, USA
L.-L. Zhao, CSPAR/UAH, USA
L. Adhikari, CSPAR/UAH, USA
H. Washimi, CSPAR/UAH, USA
W. Webber*, New Mexico State University, USA
*Deceased

The Voyager 1 and 2 spacecraft observed major radio emission events when they were both beyond 12 AU [Kurth et al.1984 , Kurth et al. 1987, Cairns et al. 1992, Gurnett et al. 1993]. Although several mechanisms have been suggested that might trigger the radio events [McNutt 1988, Grzedzelski & Lazarus 1993, Gurnett et al. 1993], the most plausible mechanism is that an interplanetary shock encounters the heliopause and enters the the very local interstellar medium (VLISM) where the radio emission turns on [Cairns & Zank, 2001]. A key point in support of the shock hypothesis was the timing of the 1982-83 and the 1992-93 radio events, both being observed to turn-on ~410 days after a major interplanetary shock associated with a significant Forbush decrease was observed in the solar wind. Here we investigate the characteristics of shocks as they propagate through the supersonic solar wind into the inner heliosheath until they reach the heliopause. Zank et. al [2001] used a simple spherically symmetric 1D model of the solar wind governed by ideal MHD with pickup ion source terms. They calculated the propagation of an interplanetary shock and showed that the inclusion of pickup ions greatly changes the propagation characteristics of shocks. In this talk, we treat pick up ions separately from the thermal plasma and include the effects of low-frequency turbulence [Zank et al. 2018]. We solve the model equations using the cubic interpolated profile (CIP) scheme [Yabe et al. 2001] and investigate the propagation of an interplanetary shock wave. We conclude by comparing the predicted shock propagation space-time curves with those of interplanetary shock waves observed by multiple spacecraft, finding that timing results of Zank et al 2001 in fact predicted that the heliopause was located at ~120 AU. Besides reconsidering interplanetary shocks and the timing of the radio events and the location of the heliopause, this work provides insight into the propagation of interplanetary shocks into the VLISM.

Monday, February 18: 11:45 AM - 12:10 PM
Presenter: Shalchi, Andreas

Time-Dependent Perpendicular Transport of Energetic Particles

Andreas Shalchi, University of Manitoba, Canada

The motion of energetic particles in magnetic turbulence across a mean magnetic field can be explored analytically. The approach presented in this talk allows for a full time-dependent description of the transport, including compound sub-diffusion. For the first time it is shown systematically that as soon as there is transverse structure of the turbulence, diffusion is restored even if no Coulomb collisions are invoked. Compared to other non-linear theories the new approach has the advantage that a diffusion approximation is no longer part of that theory. Criteria for sub-diffusion and normal Markovian diffusion are discussed as well. A comparison with test-particle simulations is also shown.

SCHEDULE OF TALKS

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Monday, February 18: 12:10 PM - 12:35 PM
Presenter: Li, Gang

Is Parker Field a Food Approximation and the Meandering a Field Line

Lulu Zhao, Florida Institute of Technology, USA
Ashraf Moradi, University of Alabama in Huntsville, USA
Linghua Wang, Peking University, China

Simultaneous observations of impulsive Solar Energetic Particle (SEP) events by ACE, and STEREO spacecraft have shown that observers with large longitudinal separation can observe the same event. How can energetic particles access such a wide longitudes is a mystery. Of many tangible suggestions, field line meandering offers a possible explanation. In this work, we examine this scenario using electron observations from Wind spacecraft in the past 2 decades. By carefully selecting clean events, we show that interplanetary magnetic field lines do not deviate from Parker field much, implying that the meandering of field line can not account for the large longitudinal separation in these events. A more plausible scenario would be that field line diverges tremendously below the source surface. Other implications of our study will be discussed as well.

Monday, February 18: 1:30 PM - 1:55 PM
Presenter: Rieger, Frank

Energetic Particle Acceleration in Shearing Flows

Frank Rieger, ZAH Univ. & MPIK Heidelberg, Germany

The non-thermal radiation seen from jetted astrophysical objects such as radio-loud AGN bears witness to the presence of energetic charged particles that have experienced continuous acceleration within these sources. Fast shear flows are naturally expected in many of these environments. Combined with new observational results this has given fresh impetus to shear acceleration and emission scenarios. I will review some of the key results concerning the stochastic acceleration of energetic particles in fast, gradual shear flows, highlight expected spectral characteristics, and report on recent developments in the field.

Monday, February 18: 1:55 PM - 2:20 PM
Presenter: Lin, Yu

Generation of Secondary Instabilities in Strong Guide Field Reconnection

Yu Lin, Auburn University, USA
Xueyi Wang, Auburn University, USA
Liu Chen, UC Irvine, USA

Magnetic reconnection under a strong guide field with BG/B0>>1, as in the solar and laboratory plasmas, is investigated using the gyrokinetic electron and fully-kinetic ion (GeFi) particle simulation model, where BG and B0 are the guide and the anti-parallel component of magnetic field, respectively. The simulation is carried out for a force free current sheet. Using the GeFi model, 3D physics of reconnection with a realistically large ion-to-electron mass ratio, mi/me, can be calculated. Secondary instabilities are found to be excited near the separatrix region of the magnetic island associated with the primary reconnection. These secondary instabilities are identified as the ideal MHD surface kink modes.

SCHEDULE OF TALKS

NOTES

Monday, February 18: 2:20 PM - 2:45 PM
Presenter: Du, Senbei

Plasma Energization in Magnetic Flux Rope Coalescence

Senbei Du, University of Alabama in Huntsville, USA
Gary P. Zank, University of Alabama in Huntsville, USA
Fan Guo, Los Alamos National Laboratory, USA
Xiaocan Li, Los Alamos National Laboratory, USA
Adam Stanier, Los Alamos National Laboratory, USA

Magnetic flux ropes are commonly observed throughout the heliosphere, and recent studies suggest that interacting flux ropes are associated with some energetic particle events. In this work, we carry out 2D particle-in-cell (PIC) simulations to study the coalescence of two magnetic flux ropes (or magnetic islands), and the subsequent plasma energization processes. The simulations are initialized with two magnetic islands embedded in a reconnecting current sheet. The two islands collide and eventually merge into a single island. Particles are accelerated during this process as the magnetic energy is released and converted to the plasma energy, including bulk kinetic energy increase by the ideal electric field, and thermal energy increase by the fluid compression and the nonideal electric field. We find that contributions from these different energization mechanisms are all important and comparable with each other. Fluid shear and a nongyrotropic pressure tensor also contribute to the energy conversion process. For simulations with different system sizes and ion-to-electron mass ratios, we find that the general evolution is qualitatively the same, and the energization depends only weakly on either the system size or the mass ratio. Finally, we report new results regarding the particle acceleration mechanisms using a particle tracing technique.

Monday, February 18: 2:45 PM - 3:10 PM
Presenter: Che, Haihong

Solar Coronal Electron Acceleration in Multi-island Magnetic Reconnection

H. Che, UMCP/GSFC, USA
G. P Zank, UAH, USA

In-situ observations of the solar wind and X-ray observations of solar flares show that energetic electrons commonly demonstrate a power-law energy distribution v^{-a} with a ~ 5-7 . These energetic electrons are thought to be produced by magnetic reconnection associated with flares. How magnetic reconnection accelerates electrons to form such a soft power-law energy spectrum is a challenge in solar physics and heliophysics. We report a numerical (particle-in-cell) and theoretical investigation of how multi-island magnetic reconnection accelerate electrons.

SCHEDULE OF TALKS | NOTES

Monday, February 18: 3:10 PM - 3:35 PM
Presenter: Zhao, Lingling

Particle Acceleration Associated with Solar Wind Magnetic Island Dynamics

L.-L. Zhao, University of Alabama in Huntsville, USA
G. P. Zank, University of Alabama in Huntsville, USA
Y. Chen, University of Alabama in Huntsville, USA
Q. Hu, University of Alabama in Huntsville, USA
J. A. le Roux, University of Alabama in Huntsville, USA
S. Du, University of Alabama in Huntsville, USA
L. Adhikari, University of Alabama in Huntsville, USA

The possibility that charged particles are accelerated statistically in a “sea” of small-scale interacting magnetic flux ropes in the supersonic solar wind is gaining credence. We extend the Zank et al. statistical transport theory for a nearly isotopic particle distribution by including an escape term corresponding to particle loss from a finite acceleration region. Steady-state 1D solutions for both the accelerated particle velocity distribution function and differential intensity are derived. We show Ulysses observations of an energetic particle flux enhancement event downstream of a shock near 5 au that is inconsistent with the predictions of classical diffusive shock acceleration (DSA) but may be explained by local acceleration associated with magnetic islands. The generation of these magnetic islands may be related to the interaction of a stream interaction region (SIR) and the heliospheric current sheet (HCS). Particles are accelerated and trapped within the SIR structure characterized by a forward shock-reverse wave (FS-RW) pair. A power spectral density (PSD) analysis suggests that the turbulence level increases in the SIR. This is consistent with the enhanced generation of magnetic flux ropes, which are instrinsic to the quasi-2D MHD turbulence. An automated Grad-Shafranov reconstruction approach is employed to identify small-scale magnetic flux ropes behind the shock. For the first time, the observed energetic particle “time-intensity” profile and spectra are quantitatively compared with theoretical predictions. The results show that stochastic acceleration by interacting magnetic islands accounts successfully for the observed (i) peaking of particle intensities behind the shock instead of at the shock front as standard DSA predicts; (ii) increase in the particle flux amplification factor with increasing particle energy; (ii) increase in distance between the particle intensity peak and the shock front with increasing energy; and (iv) hardening of particle power-law spectra with increasing distance downstream of the shock.

Monday, February 18: 3:55 PM - 4:20 PM
Presenter: Guo, Fan

Compression Acceleration during Magnetic Reconnection

Fan Guo, Los Alamos National Laboratory, USA
Xiaocan Li, Los Alamos National Laboratory, USA
Hui Li, Los Alamos National Laboratory, USA
William Daughton, Los Alamos National Laboratory, USA
Joachim Birn, Space Science Institute, USA

Particle acceleration during magnetic reconnection has been a problem with considerable controversy. While reconnection acceleration has been an active field of research, the dominant acceleration still does not have any consensus. We review and discuss particle acceleration during magnetic reconnection associated with fluid compression. Through a number of numerical simulations and theoretical analysis, we identified a compression acceleration dominated regime featured by low plasma beta and weak guide field. The implications to large-scale magnetic reconnection model will be discussed.

SCHEDULE OF TALKS

NOTES

Monday, February 18: 4:20 PM - 4:45 PM
Presenter: Klein, Kristopher

HelioSwarm: Revealing the Transfer of Energy Across Scales and Boundaries in Plasmas in the Universe

The HelioSwarm Team

Turbulence plays a critical role in the transport of mass, momentum, and energy in magnetized plasmas that comprise heliospheric and astrophysical objects throughout the cosmos. Despite the crucial role of turbulence in governing these systems, there are a number of unanswered questions about the underlying physical processes. The pristine solar wind near Earth offers a natural laboratory for the in situ observation of turbulent fields and particle distributions that are representative of those throughout the universe. To date, all in situ observations of solar wind plasmas have been single point measurements (i.e., ACE, WIND), or have focused on a single scale through the use of carefully controlled clusters of a few spacecraft (i.e., Cluster, MMS). As turbulence is fundamentally a multi-scale, three-dimensional, time-evolving phenomenon, neither single point measurements nor even a cluster of four spacecraft provide insight into the full nature of the turbulent medium. To reveal the full temporal and spatial structure of turbulence requires observations at an array of points that far exceeds the configurations flown to date. With the advent of low resource sensors and small satellites, such arrays of spacecraft are now possible and promise to transform our knowledge of turbulence. Rather than flying in formation, a swarm of small spacecraft will enable direct measurement of a wide range of spatial and temporal scales that span physical ranges of interest. In this presentation, we describe HelioSwarm, a newly-feasible, innovate mission concept employing such a swarm of many small spacecraft. The cost-effective mission will reveal and quantify key unknown aspects of turbulence, allowing us to understand the cascade of energy from longer scale and larger times toward and into smaller scales and shorter times.

Monday, February 18: 4:45 PM - 5:10 PM
Presenter: Fu, Xiangrong

Heating of Heavy Ions in Low-beta Plasma Turbulence

Xiangrong Fu, New Mexico Consortium, USA
Fan Guo, Hui Li, and Xiaocan Li, Los Alamos National Laboratory, USA
Vadim Roytershteyn, Space Science Institute, USA

Solar energetic particles (SEP) are bursts of high-energy (10 keV - GeV) charged particles originated from the Sun during solar activities. A majority of them are protons and electrons, but minor ions such as helium, oxygen, carbon and iron have also been measured routinely. In fact, the information on the relative abundance of different elements and their isotopes provides insights into the mechanism producing SEPs.
In this work, we focus on ion energization by turbulence developed in low-beta plasmas using 3D hybrid simulations. With a 3D model, turbulence can fully develop. With a hybrid model, full kinetics of ions are captured. We show that turbulence with a power-law spectrum is capable of heating minor ions, producing enhancement as a function of q/m. The heating mechanism is cyclotron resonance with localized oblique waves. Our results may explain the observed enhancement of heavy ions in He3-rich SEP events.

SCHEDULE OF TALKS

NOTES

Monday, February 18: 5:10 PM - 5:35 PM
Presenter: Li, Xiaocan

The Formation of Power-law Energy Spectrum in 3D low-beta Magnetic Reconnection

Xiaocan Li, Los Alamos National Lab, USA
Fan Guo, Los Alamos National Lab, USA
Hui Li, Los Alamos National Lab, USA
Senbei Du, University of Alabama in Huntsville, USA
Adam Stanier, Los Alamos National Lab, USA

Magnetic reconnection acceleration has been proposed as a theory for explaining particle acceleration in solar flares and Earth's magnetotail. However, previous kinetic simulations of non-relativistic reconnection have not been able to obtain a power-law energy spectrum, a key observational feature of particle distribution. Here we present results from 3D fully kinetic particle-in-cell simulations of reconnection in the non-relativistic low-beta regime. We show that a clear power-law energy spectrum can form and sustain extensively during the simulation. Comparing with 2D simulations, where high-energy particles are trapped deep in magnetic islands, 3D simulations enable stronger acceleration for high-energy particles due to stochastic magnetic field lines and wave-particle scattering of high-energy particles. These effects lead to a nearly constant acceleration rate for particles at different energies. The power-law index is a balance of particle acceleration and particle escape to the large flux rope. This study clarifies the formation condition of power-law energy spectrum in a reconnection layer and has important implication for understanding particle energization during solar flares.

Monday, February 18: 5:35 PM - 6:00 PM
Presenter: Gurnett, Don

The Systematic Increase of the Electron Density and Other Related Effects as Voyager 1 Moves Outward into Interstellar Space

D. A. Gurnett, University of Iowa
W. S. Kurth, University of Iowa
E. C. Stone, Caltech, USA
A. C. Cummings, Caltech, USA
S. M. Krimigis, Applied Physics Laboratory, Johns Hopkins University, USA
R. B. Decker, Applied Physics Laboratory, Johns Hopkins University, USA
N. F. Ness, University of Delaware, USA
L. F. Burlaga, NASA, GSFC, USA

Voyager 1, which is now at a heliospheric radial distance of 143 AU (Astronomical Units), crossed the heliopause into interstellar space on 25 August 2012 at 121.6 AU. Since then the plasma wave instrument (PWS) has detected seven distinct electron plasma oscillation events, each of which is believed to be associated with a shock wave propagating outward from energetic disturbances at the Sun. The local electron densities in interstellar space are derived from the frequencies of these oscillations. In this paper we also compare these disturbances to effects detected by the galactic cosmic ray (CRS) instrument, the low-energy charged particle (LECP) instrument, and the magnetometer (MAG). Specifically, comparisons are made to bursts of relativistic 5-100 MeV electrons and 5-60 MeV protons that originate from cosmic rays reflected when the shock contacts the tangent magnetic field line through the spacecraft. These precursor effects are analyzed to give an estimate of the velocity of the electron beam involved in exciting the electron plasma oscillations.

SCHEDULE OF TALKS

NOTES

Tuesday, February 19: 8:00 AM - 8:25 AM
Presenter: Moebius, Eberhard

Observation of Suprathermal Tails of He+ Pickup Ions across Solar Wind Compression Regions with STEREO PLASTIC

Eberhard Moebius, University of New Hampshire, USA
Jonathan Bower, University of New Hampshire, USA
Lars Berger, Christian-Albrecht Universität zu Kiel, Germany
Duncan Keilbach, Christian-Albrecht Universität zu Kiel, Germany
Martin A. Lee, University of New Hampshire, USA
Nathan A. Schwadron, University of New Hampshire, USA

The presence of suprathermal tails of solar wind and pickup ions in interplanetary space has been widely observed, even during quiet times with no simultaneous observation of solar energetic particles. One of the general characteristics of these tails are power law spectra with a v^-5 dependence in the solar wind reference frame and exponential fall-off at higher energies, but variations in the spectra of various species have also been observed. Several attempts to explain the formation of suprathermal tails during quiet times have been made, among them continuing acceleration by compressive fluctuations of the solar wind and the superposition of exponential and Gaussian spectra from diffusive shock and stochastic acceleration. While the former may produce tails at all times in the solar wind, the latter may be more or less prominent, depending on spatial or temporal distance from disturbances in the solar wind. In addition, it has been found that acceleration is also effective within compression regions without the formation of shocks. In the context of a superposed epoch analysis of the evolution of He+ pickup ion distributions across compression regions, we report on a related study of He+ tails, using STEREO PLASTIC data from 2007 through 2014. Quiet times have been selected based on limiting energetic He fluxes above the tail energies. We find that the suprathermal tail flux is dependent on the compression strength and varies substantially across the compression region. The strongest tails with spectra close to v^-5 occur in the compressed fast solar wind, and they decrease rapidly with distance from this region. Potential implications of the findings are discussed.

Tuesday, February 19: 8:25 AM - 8:50 AM
Presenter: Livadiotis, George

On the Origin of the Polytropic Behavior in Space Plasmas

G. Livadiotis, Southwest Research Institute, USA

It is shown that the polytropic behavior – the specific power-law relationship among the thermal plasma moments– restricts the functional form of the distribution of particle velocities and energies. Surprisingly, the polytropic behavior requires the statistical mechanics of the plasma particles to turn to the framework of kappa distributions. While it was already known that an interesting property of kappa distributions is that they can lead to the polytropic relationship, the new result shows that the reverse derivation is also true, thus, the polytropic behavior has the role of a mechanism generating kappa distributions. Ultimately, any observation of a polytropic behavior in plasma particle populations constitutes an indirect observation of kappa velocity or energy distributions. Finally, it is discussed how the derived equivalence between the polytropic behavior and the kappa distribution function can be used in further modeling and data analyses of space plasmas.

SCHEDULE OF TALKS

NOTES

Tuesday, February 19: 8:50 AM - 9:15 AM
Presenter: Golla, Thejappa

Observational Evidence for Langmuir Solitons in Solar Type III Bursts

G. Thejappa, University of Maryland, USA
R.J. MacDowall, NASA/GSFC, USA

The source regions of solar type III radio bursts are the regions of very intense Langmuir wave packets excited by the bump-on-tail distributions of energetic electrons accelerated during solar flares. We report the high time resolution observations of some of these wave packets, which provide unambiguous evidence for Langmuir solitons formed as a result of oscillating two stream instability (OTSI). We show that (1) these wave packets occur as intense localized one-dimensional magnetic field aligned wave packets, (2) their measured half-widths and peak amplitudes are inversely correlated to each other, so that the narrower the wave packet, the greater is its amplitude; this inverse correlation is the characteristic feature of Langmuir solitons formed as a result of balance between the non-linearity related self-compression and dispersion related broadening of the wave packets, (3) their FFT spectra contain peaks corresponding to side bands and low frequency enhancements in addition to pump Langmuir waves, whose frequencies and wave numbers satisfy the resonance conditions of the four-wave interaction known as the oscillating two stream instability (OTSI), and (4) they are accompanied by their ponderomotive force induced density cavities. We also report the observations of three dimensional Langmuir wave packets, which satisfy the threshold conditions for the spatial collapse, and whose spectra contain the signatures of the second and third harmonics, excited as a result of three wave interactions involving the daughter products of the OTSI. We will discuss the implication of these observations for theories of solar radio bursts.

Tuesday, February 19: 9:15 AM - 9:40 AM
Presenter: Manchester, Chip

CME-Turbulence Interaction With Temperature Anisotropies

Bart van der Holst, University of Michigan, USA
Kris Klein, University of Arizona, USA

We examine the interaction between Alfven wave turbulence, kinetic instabilities and temperature anisotropies in the environment of a fast coronal mass ejection (CME). The impact of a fast CME on the solar corona causes turbulent energy, thermal energy and dissipative heating to increase by orders of magnitude, and produces conditions suitable for a host of kinetic instabilities. We study these CME-induced effects with the recently developed Alfven Wave Solar Model, with which we are able to self-consistently simulate the turbulent energy transport and dissipation as well as isotropic electron heating and anisotropic proton heating. Furthermore, the model also offers the capability to address the effects of fire hose, mirror mode, and cyclotron instabilities on proton/electron energy partitioning, all in a global-scale numerical simulation. We find the turbulent energy greatly enhanced in the CME sheath with strong wave reflection at the shock, which leads to wave dissipation rates. Finally, we find proton temperature anisotropies are limited by kinetic instabilities to a level consistent with solar wind observations.

SCHEDULE OF TALKS

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Tuesday, February 19: 9:40 AM - 10:05 AM
Presenter: TenBarge, Jason

Energy Dissipation and Phase-Space Dynamics in Eulerian Vlasov-Maxwell Shocks and Reconnection

Jason TenBarge, Princeton University, USA
James Juno, University of Maryland, USA

Shocks and magnetic reconnection are primary mechanisms responsible for converting magnetic and flow energy into thermal and non-thermal particle energy throughout the universe. The magnetospheric multiscale mission (MMS) has given us unprecedented access to high cadence particle and field data for shocks and magnetic reconnection at Earth's magnetopause, including the first detailed in situ views of the particle distribution function in and around the magnetic x-line and across shock ramps. Motivated by these observations, we present a study of zero guide field reconnection in 2x-3v and transverse shocks in 1x-2v using the fully kinetic Eulerian Vlasov-Maxwell component of the Gkeyll simulation framework. In addition to studying the configuration space dynamics, we leverage the recently developed field-particle correlations to identify and diagnose the dominant sources of dissipation and compare the results of the field-particle correlation to other measures of energy transfer.

Tuesday, February 19: 10:30 AM - 10:55 AM
Presenter: McComas, David

Evolution of the Outer Heliosphere

D.J. McComas, On behalf of entire IBEX Science team, Princeton University, USA

The outer heliosphere continues to evolve in response to the large increase in solar wind dynamic pressure, which was observed beginning in late 2014 at 1 au. The response of the outer heliosphere resulted in enhanced energetic neutral atom (ENA) emission late in 2016 and early 2017. The initial ENA brightening was centered on the closest and thinnest region of the inner heliosheath, ~20º south of the upwind direction. From early 2017 to early 2018, ENA emissions rapidly expanded northward to cover nearly the entire upwind direction, as the pressure increase encompassed heliosheath regions located progressively farther from the Sun. This preferential expansion shows that the next closest regions span the upwind side from the north/port to the south/starboard directions. These are consistent with the heliosphere shape being controlled by the combined flow and magnetic pressures of the local interstellar medium as suggested by McComas et al. (2009, Science) and are consistent with the detailed geometry shown by McComas and Schwadron (2014, ApJ); in contrast, they are inconsistent with recent suggestions of a roughly spherical heliosphere. Continuing observation from IBEX will chart the propagation of this enduring pressure enhancement farther out in the heliosphere, around its flanks and over its poles, and then ultimately into the more distant heliotail. The time evolution of enhanced emissions will continue to provide a measure of the distance to the termination shock and across the heliosheath over an ever-expanding range of directions and expose the underlying physics of the global heliospheric interaction.

SCHEDULE OF TALKS

NOTES

Tuesday, February 19: 10:55 AM - 11:20 AM
Presenter: Lembege, Bertrand

Analysis of Energy Spectra Measured by SWAP Experiment on Board of New Horizon Mission: 1D Full Particle Simulation Results versus Recent Experimental Observations

B. Lembege, LATMOS/IPSL/UVSQ/CNRS, France
Z. W. Yang, National Space Science Center, China
G. Zank, University of Alabama in Huntsville, USA

The New Horizon's mission has observed very detailed energy spectra of solar wind and pickup ions (PUIs) at a distance between 25 to 38 AU thanks to the SWAP (Solar Wind Around Pluto) experiment (Mc Comas et al., 2017). Because of the great distance and the need of a large range of viewing directions, SWAP was designed with an extremely high sensitivity and a very large field of view. SWAP was ideally suited to make high quality observations of interstellar PUI H+. Presently, 1D full particle (PIC) simulations have been performed in order to analyze the dynamics of interplanetary shock (and of associated spectra) observed in the nearby environment of Pluto. Herein, we focus on the impact of the shock front nonstationarity, shock obliquity, and on the role of the multi-ion components on these spectra in the context of the SWAP experimental observations. These populations include different solar wind ions (SWIs) and PUIs components, i.e., SWI–H+, SWI-He++, and PUI--H+, and PUI-He+, where H+ and (He+ and He++) note protons and helium ions respectively. The contributions of the different ion components to the global spectra measured in the upstream region of the interplanetary shock are analyzed and compared with recent local SWAP experimental results (Zirnstein et al., 2018).

Tuesday, February 19: 11:20 AM - 11:45 AM
Presenter: Zank, Gary

The Pickup Ion Mediated Solar Wind

G.P. Zank, University of Alabama in Huntsville, USA
L. Adhikari, University of Alabama in Huntsville, USA
L.-L. Zhao, University of Alabama in Huntsville, USA
P. Mostafavi, University of Alabama in Huntsville and Princeton University, USA
E.J. Zirnstein, Princeton University, USA
D.J. McComas, Princeton University, USA

The New Horizons Solar Wind Around Pluto (NH SWAP) instrument [McComas et al 2008] has provided the first direct observations of interstellar hydrogen and helium pickup ions (PUIs) at distances between ~11.26 and 38 AU in the solar wind [McComas et al 2017]. The observations demonstrate that the distant solar wind beyond the hydrogen ionization cavity is indeed mediated by PUIs. The creation of PUIs modifies the underlying low-frequency turbulence field responsible for their own scattering. The dissipation of these low-frequency fluctuations serves to heat the solar wind plasma, and accounts for the observed non-adiabatic solar wind temperature profile and a possible slow temperature increase beyond ~30 AU. We develop a very general theoretical model that incorporates PUIs, solar wind thermal plasma, the interplanetary magnetic field, and low-frequency turbulence to describe the evolution of the large-scale solar wind, PUIs, and turbulence from 1 - 84 AU, the structure of the perpendicular heliospheric termination shock, and the transmission of turbulence into the inner heliosheath, extending the classical models of Holzer, 1972 and Isenberg, 1986. A detailed comparison of the theoretical model solutions and observations derived from the Voyager 2 and NH SWAP data sets shows excellent agreement between the two for reasonable physical parameters.

SCHEDULE OF TALKS

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Tuesday, February 19: 11:45 AM - 12:10 PM
Presenter: Wood, Brian

Searching for Evidence for non-Maxwellian Velocity Distributions in the Local ISM Using Ulysses and IBEX Data

Brian E. Wood, Naval Research Laboratory, USA
Hans-Reinhard Mueller, Dartmouth College, USA
Eberhard Moebius, University of New Hampshire, USA

We provide a progress report on attempts to determine whether fits to Ulysses and IBEX observations of interstellar neutral He can be improved significantly by assuming non-Maxwellian velocity distributions in the source particle population. Traditional analyses of these data involve forward modeling of the He velocity distribution function (VDF) under the effects of solar gravity and photoionization, and assuming a source population with a thermal Maxwellian velocity distribution far from the Sun. However, the ISM VDF could in principle deviate from a single Maxwellian, due to MHD wave-particle interactions, or the effects of MHD turbulence. We experiment with both bi-Maxwellian distributions and Kappa distributions. Fits to Ulysses data suggest improved fits for a bi-Maxwellian distribution with a modest temperature asymmetry of T_perp/T_par=1.11+/-0.11, but a preliminary analysis of IBEX data does not provide support for this result.

Tuesday, February 19: 12:10 PM - 12:35 PM
Presenter: Sokol, Justyna

Modeling the Interstellar Neutral Gas for the Study of the Pick-up ions inside the Heliosphere

M. Bzowski, CBK PAN, Poland
M.A. Kubiak, CBK PAN, Poland

The interstellar neutral gas enters deep inside the heliosphere and is ionized by the solar ionizing factors creating pick-up ions. PUIs propagate outward the heliosphere being a source population for energetic neutral atoms and anomalous cosmic rays, which are source of information about the interaction between the heliosphere with the local interstellar medium. Thus, study of the ISN gas distribution inside the heliosphere has broad implications. We will discuss various approaches to model the ISN gas inside the heliosphere together with consequences for the PUI modeling. We will compare the so-called cold model predictions with the results of the so-called hot model paradigm identifying the limitations for the modeling together with consequences. We will study effects of the ionization rates, radiation pressure, and Mach number of the gas on the resulting ISN gas density distribution in the heliosphere.

SCHEDULE OF TALKS

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Tuesday, February 19: 1:30 PM - 1:55 PM
Presenter: Krimigis, Stamatios

Combined Voyager1&2/LECP ion and Cassini/INCA ENA Measurements: Pressure Balance in the Heliosheath

Stamatios M. Krimigis. JHU/APL, USA,
Kostas Dialynas, Office of Space Research, Academy of Athens, Greece
Robert B. Decker, JHU/APL, USA
Donald G. Mitchell, JHU/APL, USA
Edmond C. Roelof, JHU/APL, USA

Overlapping energy coverage between the Voyagers 1&2 (LECP) while they were within the heliosheath (HS) and the Cassini (INCA) ENA imager at 10 AU enabled a quantitative comparison between in situ-measured energetic ion intensities and remote line-of-site-integrated (LOS) ENA intensities in the image pixels occupied by Voyagers 1&2. Under simplified assumptions, it was thereby possible to deduce the thickness of the HS in the direction of V1 as 27 AU (albeit with large uncertainties), thus predicting the actual heliopause (HP) crossing in August 2012 at 121.6 AU. Under the same assumptions, the partial pressure for protons > 5.2 keV could be calculated. Together with the simulation of Giacalone and Decker (2010) for proton partial pressure of protons E<6 keV, pressure balance at the HP implied a magnitude < 0.64 nT for the hydrostatic pressure of the interstellar magnetic field for an interstellar neutral H-atom density of N=0.10 cm-3. V1 measured ~0.48 nT beyond the HP (Burlaga and Ness, 2016). We have applied the same techniques to estimate the partial proton pressure along the V2 LOS and estimate a HS thickness 35•8 AU implying a crossing at 119•8 AU, using a slightly higher density (N=0.12 cm-3). We conclude that these "ground truth" comparisons with Voyager (LECP) establish that the HS is the source of the energetic protons that produce the Cassini (INCA ENAs) >5.2 keV. When the overlapping energy spectra are combined (5-55 keV from protons inferred from Cassini ENAs, and 28-4000 keV from Voyager 2), they show a clear spectral hardening above 28 keV. To our knowledge, there has been no theoretical prediction of such a marked spectral hardening in the "tail" of the HS proton distribution. Previous assumptions involving the use of a single •-distribution consistent with a •-index of ~1.63 (as measured by Voyager-2) but extrapolated down to 1 keV, underestimate the 5.2-13.5 keV ion pressure by a factor of ~10 and the 13-24 keV ion pressure by a factor of ~2. This underestimate, when invoking pressure balance at the HP results in ISMF magnitude of ~ 0.29 nT compared with the average value of 0.48 nT actually observed by V1. Preliminary maps of the partial pressures of the global heliosphere produced by protons with E >5.2 keV suggest a bubble-like HS as inferred previously by Dialynas et al. (2017).

References

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SCHEDULE OF TALKS

NOTES

Tuesday, February 19: 1:55 PM - 2:20 PM
Presenter: Zirnstein, Eric

Strong Scattering of keV Pickup Ions in the Local Interstellar Magnetic Field Draped Around Our Heliosphere: Implications for the IBEX Ribbon's Source and IMAP

E. J. Zirnstein, Princeton University, USA
D. J. McComas, Princeton University, USA
N. A. Schwadron, University of New Hampshire, USA
M. A. Dayeh, Southwest Research Institute, USA
J. Heerikhuisen, University of Alabama in Huntsville, USA
P. Swaczyna, Princeton University, USA

The leading hypothesis for the origin of the Interstellar Boundary Explorer (IBEX) "ribbon" of enhanced energetic neutral atoms (ENAs) from the outer heliosphere is the secondary ENA mechanism, whereby neutralized solar wind ions escape the heliosphere and, after several charge-exchange processes, may propagate back toward Earth primarily in directions perpendicular to the local interstellar magnetic field (ISMF). However, the physical processes governing the parent protons outside of the heliopause are still unconstrained. One of the proposed mechanisms for creating the ribbon is the so-called "spatial retention" mechanism proposed by Schwadron & McComas (2013), whereby pickup ions outside the heliopause that originate from the neutral solar wind are spatially-retained in a region of space via strong pitch angle scattering before becoming ENAs. We present results from modeling the spatial retention mechanism in a 3D simulated heliosphere, where we include the effects from the ISMF draped around the heliosphere as well as the latitudinal solar wind structure. We demonstrate how the pitch angle scattering rate inside and outside the retention region can change the ribbon's structure. Finally, we show how the ribbon's structure observed at 1 au is affected by different instrument measurement capabilities, and how the Interstellar Mapping and Acceleration Probe (IMAP) may observe the ribbon's shape.

Tuesday, February 19: 2:20 PM - 2:45 PM
Presenter: Pogorelov, Nikolai

Energetic Ions in the Heliosphere and Beyond

Michael Gedalin, Ben-Gurion University, Israel
Jacob Heerikhuisen, University of Alabama in Huntsville, USA
Tae Kim, University of Alabama in Huntsville, USA
Kyle Renfroe, University of Alabama in Huntsville, USA
Vadim Roytershteyn, Space Science Institute, USA
Ming Zhang, Florida Institute of Technology, USA

This presentation addresses the effect of pickup ions (PUIs) on the solar wind (SW) flow and on the energetic neutral atom creation in the local interstellar medium. We also derive the PUI bulk properties from the recently revisited analysis of Ulysses data. The behavior of non-Maxwellian plasma crossing a collisionless shock is discussed from the viewpoint of test-particle, hybrid, and full-PIC simulations. We also discuss the effect of the heliosphere on the anisotropy of 1-10 TeV Galactic cosmic rays.

SCHEDULE OF TALKS

NOTES

Tuesday, February 19: 2:45 PM - 3:10 PM
Presenter: Bzowski, Maciej

Distribution Function Of Interstellar Neutral He After Processing In The Outer Heliosheath

Maciej Bzowski, CBK PAN, Poland
Marzena A. Kubiak, CBK PAN, Poland
Jacob Heerikhuisen, University of Alabama in Huntsville, USA
Eric Zirnstein, Princeton University, USA

Interstellar He atoms penetrate the outer heliosheath and charge exchange with ions from the perturbed plasma flow, mostly He+ ions. As a result, the so-called secondary population of interstellar He appears. The He atoms, both the original interstellar ones and those being products of charge exchange collisions, move ballistically within the outer heliosheath. Since the mean free path length against collisions is comparable to the outer heliosheath size, they travel to significant distances before further charge-exchange collisions with the ambient plasma. This results in both losses and production of the secondary atoms on one hand and of the atoms with velocity vectors characteristic for the primary population on the other hand. Ultimately, neutral He atoms leave the outer heliosheath region, some of them reentering the interstellar medium, and some penetrating the heliopause. Some of these latter ones reach 1 au, where they may be observed. Because of the highly kinetic character of the production and loss of He atoms in the OHS, the overall distribution function is not expected to be a superposition of two Maxwell-Boltzmann distributions, representing the primary and secondary components of He. However, adopting a bi-Maxwellian approximation for the distribution function of He atoms at the heliopause appears to be a good approach to reproduce the interstellar neutral He signal observed by IBEX. Here, we simulate the distribution function of He in the OHS and investigate their distribution function adopting the outer heliosheath plasma conditions obtained from MHD-kinetic global heliosphere model and charge-exchange collisions responsible for the production and losses of He atoms. We analyze the symmetries and asymmetries of these simulated distributions, both inside the OHS and inside the heliopause, as a function of location relative to the inflow axis and the B-V plane (the plane defined by the vectors of interstellar magnetic field and Sun's velocity through the Local Interstellar Medium). We illustrate how the local distribution function inside the heliopause gradually evolves to resemble the bi-Maxwellian distribution. Finally, we demonstrate that the bi-Maxwellian approximation can be used to calculate the density of neutral He inside the termination shock down to 1 au because it is able to reproduce the densities obtained from the full kinetic simulation of the production and losses of He atoms.

Tuesday, February 19: 3:10 PM - 3:35 PM
Presenter: Swaczyna, Pawel

Temperature and Non-equilibrium Distributions of Interstellar Neutrals

Pawel Swaczyna, Princeton University, USA
David J. McComas, Princeton University, USA
Nathan A. Schwadron, University of New Hampshire, USA

Observations of interstellar neutral (ISN) atoms in the inner heliosphere are the main source of information about the temperature of the Local Interstellar Medium (LISM) around the heliosphere. Recent studies of the observations of ISN helium atoms from the IBEX-Lo detector found that the temperature of the LISM is ≈7500 K. These studies assumed that the primary population of ISN helium is fully equilibrated and follows the Maxwell-Boltzmann distribution function. The main processes leading to thermalization of the neutral populations in the LISM are charge-exchange reactions with ionized components and elastic collisions. However, these processes may not be sufficient to fully thermalize the ISN helium population at scales comparable with the distance to the edge of the Local Interstellar Cloud. In this study, we test a possibility that ISN helium is not fully thermalized. We use kappa distributions as a model of a possible out-of-equilibrium state of ISN helium atoms. We compare these distributions with the Maxwell-Boltzmann distribution accounting for the part of distribution observed by IBEX. We identify the relationship between the κ index and temperature of the kappa distribution and show that there is a fundamental degeneracy between the two for the limited observations available. We find that a simple consistency with the IBEX data indicates that $\kappa > 3.8$, which likely limits the equivalent range of temperatures to 7,500 K -- 11,000 K. These findings show that the physical state of the LISM ahead of the heliosphere may be substantially different than currently thought. Consequently, the result significantly impacts our understanding and future analyses of the interaction between the heliosphere and the LISM.

SCHEDULE OF TALKS | NOTES

Tuesday, February 19: 3:55 PM - 4:20 PM
Presenter: Medvedev, Mikhail

Plasma Constraints on the Cosmological Abundance of Magnetic Monopoles and the Origin of Cosmic Magnetic Fields

Mikhail V. Medvedev, KU and MIT, USA
Abraham Loeb, Harvard, USA

Existing theoretical and observational constraints on the abundance of magnetic monopoles are limited. Here we demonstrate that an ensemble of monopoles forms a plasma whose properties are well determined and whose collective effects place new tight constraints on the cosmological abundance of monopoles. In particular, the existence of micro-Gauss magnetic fields in galaxy clusters and radio relics implies that the scales of these structures are below the Debye screening length, thus setting an upper limit on the cosmological density parameter of monopoles, Omega_M < 3e-4, which precludes them from being the dark matter. Future detection of Gpc-scale coherent magnetic fields could improve this limit by a few orders of magnitude. In addition, we predict the existence of magnetic Langmuir waves and turbulence which may appear on the sky as "zebra patterns" of an alternating magnetic field with nonvanishing dot-product (k.B). We also show that magnetic monopole Langmuir turbulence excited near the accretion shock of galaxy clusters may be an efficient mechanism for generating the observed intracluster magnetic fields. [Partially supported by DOE grant DE-SC0016368 and DOE EPSCOR grant DE-SC0019474]

Tuesday, February 19: 4:20 PM - 4:45 PM
Presenter: Rahmanifard, Fatemeh

Radiation Pressure from IBEX Observations of the Interstellar Hydrogen Trough Solar Cycle 24

Fatemeh Rahmanifard, University of New Hampshire, USA
Eberhard Möbius, University of New Hampshire, USA
Nathan A. Schwadron, University of New Hampshire, USA
André Galli, University of Bern, Switzerland
Nicholas Richards, University of New Hampshire, USA
Harald Kucharek, University of New Hampshire, USA
Justyna M. Sokół, Polish Academy of Sciences, Poland
David Heirtzler, UNH, USA
Martin A. Lee, UNH, USA
Maciej Bzowski, Polish Academy of Sciences, Poland
P. Wurz, University of Bern, Switzerland
I. Kowalska-Leszczynska, Polish Academy of Sciences, Poland
Marzena A. Kubiak, Polish Academy of Sciences, Poland
Stephen A. Fuselier, Southwest Research Institute and University of Texas, USA
David J. McComas, Princeton University, USA

As the Sun moves through the Local Interstellar Medium (LISM), neutral atoms including but not limited to H, He, O, and Ne travel through the heliosphere and can be detected by the Interstellar Boundary Explorer (IBEX). Interstellar neutral (ISN) hydrogen atoms, with an assumed drifting Maxwellian distribution function in the LISM, are subject to solar gravity and radiation pressure as well as ionization processes inside the heliosphere. They travel to the inner heliosphere on almost hyperbolic trajectories. For ISN H, the radiation pressure roughly compensates for solar gravity. This compensation prevents significant gravitational focusing of ISN H atoms and shifts the longitude of the observed peak of the ISN H flow relative to that of ISN He. We have studied the effect of the solar activity level on the peak longitude of the ISN H, measured between 10 and 21 eV by IBEX-Lo instrument. We applied a chi-square analysis to find the peak of the observed flux and use these flux peaks to investigate the effect of radiation pressure on ISN hydrogen over the course of almost one complete solar cycle (from 2009 to 2018). We found that the effective solar radiation pressure acting on ISN H atoms increases and decreases with solar activity, as expected. The observed effect of the radiation pressure on the ISN H flow appears to agree with simulations based on a recent analysis using Ly-alpha profile and total irradiance observations (Kowalska-leszczynska et al., 2018). Further study of IBEX ISN H response functions and future Interstellar Mapping and Acceleration Probe (IMAP) data should provide significant improvements in our understanding of the effects of radiation pressure on interstellar neutral atoms.

SCHEDULE OF TALKS | NOTES

Tuesday, February 19: 4:45 PM - 5:10 PM
Presenter: Xu, Siyao

On the Broadband Synchrotron Spectra of Pulsar Wind Nebulae

Siyao Xu, University of Wisconsin-Madison, USA
Noel Klingler, The George Washington University, USA
Oleg Kargaltsev, The George Washington University, USA
Bing Zhang, University of Nevada Las Vegas, USA

As shown by broadband observations, pulsar wind nebulae (PWNe) are characterized by a broken power-law spectrum of synchrotron emission. Based on the modern magnetohydrodynamic (MHD) turbulence theories, we investigate the reacceleration of electrons in the PWN through the adiabatic stochastic acceleration (ASA), which arises from fundamental dynamics of MHD turbulence. The ASA acts to flatten the injected energy spectrum of electrons at low energies, while synchrotron cooling results in a steep spectrum of electrons at high energies. Their dominance in different energy ranges leads to a flat radio spectrum and a steep X-ray spectrum. Our analytical spectral shapes generally agree well with the observed synchrotron spectra of radio- and X-ray-bright PWNe. The spectral break corresponding to the balance between the ASA and synchrotron losses provides a constraint on the acceleration timescale of the ASA and the magnetic field strength in the PWN.

Tuesday, February 19: 5:10 PM - 5:35 PM
Presenter: Mostafavi, Parisa

The Effect of Inner Heliosheath Shocks on Energetic Neutral Atom Observations by IBEX

P. Mostafavi, University of Alabama in Huntsville and Princeton University, USA
G.P. Zank, University of Alabama in Huntsville, USA
E.J. Zirnstein, Princeton University, USA
D.J. McComas, Princeton University, USA

A collision between an interplanetary disturbance and the heliospheric termination shock (HTS) leads to the generation and propagation of plasma structures in the inner heliosheath (IHS). If the interplanetary disturbance has an increased density or pressure, the interaction with the HTS can lead to one or more shocks propagating in the IHS until they collide with the heliopause. IHS shocks are partially reflected at the HP and propagate back into the subsonic IHS and are partially transmitted into the very local interstellar medium. The IHS is dominated by the pressure of energetic particles as was observed by Voyager 2, making the plasma beta, when the energetic particle pressure is included, much greater than one. We model IHS shocks using a pickup ion (PUI)-mediated plasma model and show that they are mediated by PUIs. The dissipation mechanism at quasi-perpendicular IHS shocks results primarily in PUIs being heated. Only a very small percentage of the upstream solar wind flow energy is converted to thermal gas heating downstream of the shock. IHS shocks are broad since the diffusion coefficient associated with PUIs is large. The presence of IHS shocks results in greater heating of the PUI component in the IHS. The increased temperature enhances the production of energetic neutral atoms (ENAs) due to charge exchange between IHS PUIs and interstellar neutral gas. When IHS shocks are included in the model, we find that the predicted enhancement of the ENA flux leads to better consistency with corresponding IBEX observations.

Tuesday, February 19: 5:35 PM - 6:00 PM
Presenter: Raymond, John

Development of Turbulence behind a Radiative Shock

J. Raymond, CfA, USA
W.P. Blair, JHU, USA
J. Slavin, CfA, USA
B. Burkhart, Flatiron Center, USA
R. Sankrit, STScI, USA

The cooling zone behind a shock in the ISM is subject to several instabilities. We use narrow band images from HST of a portion of the Cygnus Loop, along with a set of ground-based spectra that cover part of the same region, to investigate the properties of the gas as it evolves from a smoothly rippled structure in [O III] to a clumpy, irregular structure in cooler ions.

SCHEDULE OF TALKS

NOTES

Wednesday, February 20: 8:00 AM - 8:25 AM
Presenter: Intriligator, Devrie

Implications of the Voyager 1 and 2 Particle and Field Observations around their Respective Heliopause Crossings

Devrie Intriligator, Carmel Research Center, USA
David Miller, Carmel Research Center, USA
James Intriligator, Tufts University and Carmel Research Center, USA
William Webber*, New Mexico State University, USA
*Deceased

We examined the similarities and differences between Voyager 1 particle and field observations around its heliopause crossing in 2012 and the corresponding observations by Voyager 2 in late 2018 and early 2019. It appears that the heliopause itself as being the dynamic boundary between the solar system magnetic field and the interstellar medium magnetic field. The location of the heliopause varies in response to both short-term effects of plasma instabilities and longer-term bulk motions of the heliosheath. Plasma flows in the respective regions provide a framework for explaining observed decreases in count rates with heliopause distance. This decrease is seen for both solar system solar and anomalous cosmic rays diffusing outward from the heliopause and galactic cosmic rays diffusing inward. We will discuss our overall conclusions for the Voyager 1 and 2 heliopause crossings, their significance, and their relationship to underlying fundamental physical phenomena.

Wednesday, February 20: 8:25 AM - 8:50 AM
Presenter: Isenberg, Phil

New Results from an Empirically-Based Model of the Upstream Heliopause and Outer Heliosheath

Philip A. Isenberg, UNH, USA
Harald Kucharek, UNH,USA

The heliopause is the three-dimensional surface that defines the boundary separating the magnetized plasma of the interstellar medium from that originating at the Sun. The flowing interstellar plasma encounters the heliopause as an obstacle, which deflects the flow. Charge exchange between this deflected plasma and the undeflected neutral atoms in the outer heliosheath create secondary interstellar neutrals with the properties of the deflected flow. Thus, secondary neutrals measured at 1 AU carry information about the deflected interstellar plasma and the shape of the heliopause that causes the deflection. We have developed a simplified semi-analytical model for the plasma deflected around an almost arbitrarily deformed obstacle, using the concept of superposed potential flows. We then obtain model fluxes of neutral Helium created by charge exchange through this deflected plasma that would be incident on the IBEX-Lo detectors at 1 AU. By comparing model results with the Helium sky maps measured by IBEX, we can infer the global shape of the upstream heliopause. We will report on the current state of our investigation.These empirically-based results can be used to guide and validate the much more complicated global simulation efforts being undertaken by other groups.

SCHEDULE OF TALKS

NOTES

Wednesday, February 20: 8:50 AM - 9:15 AM
Presenter: Zieger, Bertalan

Particle Acceleration by Dispersive Magnetosonic Waves in the Inner Heliosheath

Bertalan Zieger, Boston University, USA

The solar wind in the inner heliosheath beyond the termination shock (TS) is a non-equilibrium collisionless plasma consisting of thermal solar wind ions, suprathermal pickup ions (PUI) and electrons. Since the thermalization time scale is much larger than the convection time scale, and the convection time scale is much larger than the isotropization time scale of PUI, the three-fluid description of the solar wind plasma is a reasonable approximation. In this presentation, we briefly review the theory of dispersive shock waves in multi-ion non-equilibrium plasma. In such plasma, two fast magnetosonic wave modes exist: the high-frequency fast mode that propagates mainly in the PUI and the low-frequency fast mode that propagates in the thermal solar wind ions [Zieger et al., 2015]. Both of these wave modes are dispersive on fluid scale. Recently we have shown that the TS crossing observed by Voyager 2 is a subcritical quasi-stationary dispersive shock wave or oscilliton, which appears as a trailing wave train downstream the TS [Zieger et al., 2015]. Here we present high-resolution three-fluid MHD simulations of nonlinear magnetosonic waves at the TS and in the inner heliosheath up to 8 AU downstream of the TS. Downstream propagating nonlinear PUI waves grow until they steepen into PUI shocklets (thin current sheets). We show that upstream-to-downstream transmissions across a number of forward PUI shocklets can efficiently accelerate both ions and electrons through the shock drift acceleration mechanism deep in the inner heliosheath, which is a potential mechanism of anomalous cosmic ray (ACR) acceleration as well. The relative energy gain of accelerated particles depends only on the compression ratio of the shocklets, which results in a power law velocity distribution. Our theoretical results are also applicable to particle acceleration downstream of low-Mach-number subcritical interplanetary shocks at 1 AU.

Wednesday, February 20: 9:15 AM - 9:40 AM
Presenter: Leske, Richard

Has the Source Intensity of Anomalous Cosmic Rays Decreased?

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

Long-term measurements have shown that modulated anomalous cosmic rays (ACRs) and galactic cosmic rays (GCRs) at 1 AU have differences in their peak relative intensities that depend on the solar polarity cycle. After more than 21 years in orbit, the Advanced Composition Explorer (ACE) has observed both ACRs and GCRs at two solar minima with the same polarity using the same set of instruments. During the present A>0 period, the ACR oxygen intensity at energies above ~8 MeV/nucleon remains ~25% below the level reached at the last A>0 minimum in 1997; conversely, the GCR iron intensity at ~300 MeV/nucleon exceeds the 1997 value by ~18%. In fact, neutron monitor GCR intensities are higher now than ever seen during any previous A>0 epoch. Similarly, in the 2009 A<0 minimum, the peak ACR intensities measured by ACE were similar to those in the 1987 A<0 cycle observed by other spacecraft, while GCR intensities reached the highest levels recorded during the last 50 years. These observations suggest that 1-AU ACR intensities have been suppressed relative to GCRs in recent solar minima, despite an overall reduction in heliospheric modulation.
ACR intensities depend not only on solar modulation, but also on their source strength, which could vary with changes in the heliosphere. Contributing factors might include a reduction in the acceleration efficiency of ACRs due to decreases in the strength or turbulence levels of the interplanetary magnetic field, or a drop in the abundance of ACR seed material (interstellar pick-up ions) due to less ionization in this epoch of weaker solar activity.
We present more than 20 years of ACR and GCR intensity data acquired by ACE throughout two complete solar cycles and discuss possible reasons for the differences in the relative behavior of ACRs and GCRs. In particular, we suggest that the ACR source strength has probably decreased over this period.

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Wednesday, February 20: 9:40 AM - 10:05 AM
Presenter: Roelof, Edmond

Low Intensity "Basins" in Cassini/INCA ENA Images (5-55 keV) of the Heliosheath

E. C. Roelof, JHU/APL, USA
S. M. Krimigis, JHU/APL, USA
D. G. Mitchell, JHU/APL, USA
K. Dialynas, Off. Space Research and Technology, Academy of Athens, GR

Well prior to Cassini launch, it was noted that the INCA camera could respond at a low level to ENAs generated by energetic proton populations associated with shocks (CIRs, CMEs) when also imaging the heliosphere and heliosheath (HS) beyond it (Roelof, COSPAR Proc. Solar Wind Seven, 1992). With this possibility in mind, we have newly analyzed our mission-long Cassini/INCA database of already carefully validated ENA images that consists of occasional individual exposures (varying from a few hours to a few days) when the camera field-of-view was as clear as possible of contamination from Saturn's magnetosphere. We searched all the intervals in this database (2003-2016) for the minimum intensity measured in each INCA sky pixel (7deg x •deg) aggregated them into a sky-map (one for each of the four energy channels 5-55 keV). We did not accept a minimum intensity unless >16 counts had been accumulated in the pixel, so that any minimum intensity (j) in our skymaps had a guaranteed Poisson uncertainty sigma(j)/j<25%. In order to reveal any CIR contributions, we constructed one set of skymaps in Sun-referenced ecliptic coordinates in which the Sun is always at (long.=0 and lat.=0) as viewed from Saturn. A pattern of enhanced intensities did appear in the skymaps; its latitude/longitude morphology was consistent with computer simulations of ENA intensities for a rotation-averaged CIR (based on data from the Ulysses/EPAM latitude and Voyager/LECP radial dependences of energetic protons 30-60 keV). Outside of that pattern lay extensive low-to-mid-latitude "basins" of low intensity at longitudes away from the Sun. We interpreted these basins as providing glimpses of actual heliosheath (HS) ENA intensities that are minimally affected by intervening CIRs. Consequently, another set of skymaps was made in inertial Solar-ecliptic (J2000) coordinates, in which the intervals in inertial pixel directions were searched for their minimum mission-long intensities. Basins also appeared at low-to-mid latitudes in these inertial skymaps for all 4 energy channels, and they occupied over 40% of the sky. Their variations in intensity (over the sky) were consistent with our Poisson selection criterion of sigma(j)/j<25%, and their mean intensities (in any of the 4 energy channels) were well above our estimates for instrumental background rates. Therefore (within Poisson statistics), the inertial basins are remarkably uniform in intensity in both space and time over samples drawn from the years 2003 to 2016. The largest basin extends continuously over inertial longitudes 60•-240• at low latitudes. Since this basin includes the "tail" direction of the heliosheath, it therefore provides strong observational evidence supporting the quasi-spherical shape for the heliopause (as advocated by Dialynas et al., Nature Astronomy, 2017). Recently further evidence for quasi-sphericity (independent of ENA imaging) has been deduced from Voyager 1/2 observations of 2-3kHz radio emissions from 1983 onward (viz., Kurth and Gurnett, J. Geophys. Res., 108, 2003) by Roelof (AGU, SH33C-3655, 2018, and poster at this conference).

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Wednesday, February 20: 10:30 AM - 10:55 AM
Presenter: Cummings, Alan

The Anisotropy of Anomalous Cosmic Rays Observed by Voyager 2 in the Inner Heliosheath and Beyond

A. C. Cummings, Caltech, USA
E. C. Stone, Caltech, USA
N. Lal, GSFC, USA
B. C. Heikkila, GSFC, USA
J. D. Richardson, MIT, USA

In Stone et al., 35th ICRC, Busan, 2017, we reported on the analysis of Voyager 2 (V2) data that was collected during rolls of the spacecraft about the axis pointed towards Earth, which are carried out periodically to help calibrate the magnetometer instrument (MAG). In that work, we studied proton data from ~0.5 to 35 MeV from three Low-Energy Telescopes on the Cosmic Ray Subsystem experiment, which point in different directions, and concluded that there must be an anisotropy of anomalous cosmic rays (ACRs) such that the flow is from the tail or flank of the heliosphere towards the nose. That study used 21 rolls from late 2011 through late 2015 when V2 was in the inner heliosheath. There were no rolls in 2016, but starting in 2017, there have been 9 additional rolls, two of which occurred after the heliopause crossing on 5 November 2018. Although these new rolls consist of only one or two revolutions, compared to the 10 revolutions per roll maneuver in the previous study, a preliminary assessment of the data indicates that the anisotropies observed are large enough that useful results should be obtained. This is particularly true for the first roll in the local interstellar medium (LISM), where a very large anisotropy is observed. We will present the results of this extended study, which will provide new information about the ACR flows as V2 approached the heliopause and important information about the transition region from the inner heliosheath into the LISM.

Wednesday, February 20: 10:55 AM - 11:35 AM
Presenter: Giacalone, Joe

The Role of the Magnetic Field in Cosmic-Ray Transport and Interaction with Shocks

Joe Giacalone, University of Arizona, USA

I will review the physics of cosmic ray transport and acceleration at shocks, emphasizing the critical role of the magnetic field, and highlighting the important contributions to this discipline made by Randy Jokipii.

Wednesday, February 20: 11:35 AM - 12:15 PM
Presenter: Jokipii, J. R.

Thoughts on Nearly 60 years of Attempting to Understand Energetic Particles in Space.

J. R. Jokipii, University of Arizona, USA

I will reflect on the major influences on my scientific work beginning with my studies at Caltech,, my work at Chicago and Arizona.

Wednesday, February 20: 1:30 PM - 1:55 PM
Presenter: Stone, Ed

Voyager 2 Joins Voyager 1 in Exploring Different Heliopause Regions

Ed Stone, Caltech, USA

Voyager 2 entered the very local interstellar medium (VLISM) on November 5, 2018, joining Voyager 1 in exploring the very local interstellar medium at a radial distance of 119 AU. Although the radial distance to the heliopause is similar to that observed by Voyager 1 (122 AU), the two spacecraft entered the VLISM in different places at different times; Voyager 2 was toward the flank in the southern hemisphere during declining solar activity, while Voyager 1 was near the nose in the northern hemisphere during increasing solar activity. Significant differences between the Voyager 1 and 2 observations will be discussed, as will the Voyager 2 plasma observations that were not available on Voyager 1.

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Wednesday, February 20: 1:55 PM - 2:20 PM
Presenter: Decker, Robert

Charged Particles Measured during the Voyager 2 Heliopause Crossing

Robert B. Decker, JHU/APL, USA
Stamatios M. Krimigis. JHU/APL, USA
Matthew E. Hill, JHU/APL, USA
Edmond C. Roelof, JHU/APL, USA

We report on variations in the intensities and angular distributions of 28 keV - 30 MeV ions, 22 keV - 1.5 MeV electrons, and > 213 MeV galactic cosmic ray protons, all measured during the passage of Voyager 2 from the heliosheath into the local interstellar medium. Intensity drops of low-energy heliosheath ions are consistent with the heliopause crossing occurring on or about 5 Nov. (DOY 309) of 2018, at a helioradius of 119.0 AU, heliographic latitude of -32 deg., and longitude of about 45 deg. from that of Voyager 1, which is near the heliopause nose. We compare these Voyager 2 data with those taken during the Voyager 1 heliopause crossing in Aug. of 2012 at 121.6 AU. Compared to the Voyager 1 observations made during its heliosheath to interstellar medium transition, those at Voyager 2 show lower levels of interstellar magnetic field and galactic cosmic ray intrusion into the pre-heliopause heliosheath, and longer decay times and markedly different angular distributions of heliosheath ions that penetrate into the post-heliopause local interstellar medium. One interesting similarity is that at both Voyagers the intensities of ~ 50 keV heliosheath electrons began decreasing rapidly roughly 150 days prior the heliopause, dropping to background levels before the crossings. Also, angular distributions of >213 MeV galactic cosmic ray protons measured at Voyager 2 show extended periods of small and varying anisotropy, with intensity depletions evidently occurring within a narrow range of pitch angles near 90 deg., that are remarkably similar to periods of anisotropy in >211 MeV protons that have been measured in the interstellar medium at Voyager 1 since mid-2012.

Wednesday, February 20: 2:20 PM - 2:45 PM
Presenter: Richardson, John

Plasma Observations Across the Heliopause

John Richardson MIT, USA
John Belcher MIT, USA

Voyager 2 crossed the heliopause on November 9 2018. The plasma density increased several months prior to the crossing at roughly the same time the galactic cosmic rays began to increase. At the boundary the solar wind fluxes in the sunward looking detectors dropped to background levels. Signal is observed in the D-cup which is oriented toward the T direction. We will show plasma data leading up, at, and across the heliopause in the interstellar medium and discuss what we have learned about this plasma.

Wednesday, February 20: 2:45 PM - 3:10 PM
Presenter: Burlaga, Leonard

Magnetic Field Observations Indicate That Voyager 2 Crossed the Heliopause

L. F. Burlaga, NASA Goddard Space Flight Center, USA
N. F. Ness, University of Maryland UMBC, USA
D. Berdichevsky, Trinnovum, LLC, through contract with NASA/GSFC, USA
L. Jian, NASA Goddard Space Flight Center, USA
J. Park, NASA Goddard Space Flight Center, USA
A. Szabo, NASA Goddard Space Flight Center, USA

The magnetic field observations made by Voyager 2 indicate that the spacecraft crossed the heliopause on ≈day 309, 2018, although there are indications that the magnetic field intensity began to increase ≈ 7 days earlier. The magnetic field intensity B increased to ≈ 0.65 nT, which is comparable to that observed by Voyager 1 after it crossed the heliopause and began observing the draped interstellar magnetic fields. Voyager 2 observed only a single crossing of the heliopause during an interval of at least 60 days, in contrast to Voyager 1, which observed three such increases and two decreases in B during an interval of interval of ≈ 27 days. Preliminary Voyager 2 observations suggest that there was a change in the magnetic field direction across the heliopause

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Wednesday, February 20: 3:10 PM - 3:35 PM
Presenter: Lee, Lou-Chuang

Solar Coronal Heating by Fast Shocks and Voyager 1 Observations of Interstellar Electron Turbulence Spectrum

L. C. Lee, Institute of Earth Sciences, Academia Sinica,Taiwan

The interaction between network magnetic fields and emerging intranetwork fields may lead to magnetic reconnection and flares, microflares and nanoflares, which generate fast shocks with an Alfvén Mach number MA < 4 R⊙. The results can explain SOHO observations of the heating and acceleration of protons and minor ions in the solar corona.• 240 km/s for protons at r = 3 •(H+) • vth• 360 km/s for He++ ions, and u(H+) •(He++) • vth• 460 km/s for O5+ ions, u(He++) •(O5+) • vth• 1.5 can lead to u(O5+) • MA • 1.2 for protons; (c) the large perpendicular thermal velocity of He++ and O5+ ions can be converted to the radial outflow velocity (u) in the divergent coronal field lines; and (d) the heating and acceleration by shocks with 1.1 •/T|| • 50 for O5+ ions and a mild anisotropy with T•/T|| • 1.5 leads to a large temperature anisotropy with T• MA •), which is an increasing function of the mass/charge ratio; (b) the heating by subcritical shocks with 1.1 •2. Protons and minor ions in the solar corona are then heated and accelerated by fast shocks. A study of shock heating shows that (a) the nearly nondeflection of ion motion across the shock ramp leads to a large perpendicular thermal velocity (vth On the other hand, interstellar scintillation of radio waves from pulsars reveals that the interstellar turbulence spectrum of electron density approximates the Kolmogorov power law from wavenumber to . In our resent study, the interstellar turbulence spectrum of electron density is obtained from in situ observations of Voyager 1. The observed spectrum extends from ( ) to =50m ( ), close to the Debye length. The measured spectrum covers part ( ) of the Kolmogorov inertial range (q = 10-18-10-6m-1) as well as ion and electron kinetic scales ( ). The observed Kolmogorov inertial range shows a good agreement with earlier studies by Lee and Jokipii and Armstrong et al.. Around the kinetic scales, a bulge of spectral intensity higher than the Kolmogorov spectrum is found.

Wednesday, February 20: 3:55 PM - 4:20 PM
Presenter: Matsukiyo, Shuichi

Kinetic Scale Radial Structure of the Heliopause

Shuichi Matsukiyo, Kyushu Univ., Japan
Gary P. Zank, UAH, USA
Haruichi Washimi, UAH, USA
Tohru Hada, Kyushu Univ., Japan

The kinetic structure of the heliospheric boundaries is investigated using one-dimensional full PIC (Particle-In-Cell) simulations. Both the termination shock and the heliopause are simultaneously reproduced in the simulation. The spatial scale of the heliopause increases as the angle between the heliopause normal and local magnetic field (referred to as the normal angle, hereafter) becomes increasingly oblique. The total pressure, including the plasma pressure and magnetic pressure, at the heliopause is not constant when the normal angle is oblique in contrast to predictions based on MHD theory. In the oblique case, the solar wind plasma and interstellar plasma are able to inter-penetrate by moving along the local magnetic field. Since their bulk velocities along the magnetic field differ from each other, the distributions overlap in phase space so that the effective local plasma pressure parallel to the magnetic field is enhanced. This results in an increase that resembles a hump in the density and parallel pressure of the local plasma, which is not seen in magnetic field.

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Wednesday, February 20: 4:20 PM - 4:45 PM
Presenter: Florinski, Vladimir

Some Properties of the Heliopause during Voyager 1 and 2 Crossings

V. Florinski, University of Alamama in Huntsville, USA
X. Guo, National Space Science Center, China

We discuss two large scale properties of the magnetic boundary of the solar system known as the heliopause. The first is the distance to the interface, which is thought to be too small, for both Voyager 1 and Voyager 2 crossings, compared with the computer models of the heliosphere based on our best knowledge of the properties of the local interstellar medium. It is shown that heat can be removed from the heliosphere by a diffusing component, such as anomalous cosmic rays, leading to a decrease in the width of the inner heliosheath. This requires an efficient transport of energetic particles across the boundary and their subsequent rapid escape into the ISM. The process can partially account for a disparity between the plasma pressures on the two sides of the heliopause as reported in the literature. We also compare the stability of the heliopause transition with respect to magnetic interchange for the magnetic field conditions at Voyager 1 (small angle between the solar wind and interstellar fields) and Voyager 2 (large angle between the two directions). The instability could operate for small angles between the fields leading to a field alignment in the region affected by the instability. However, we find that interchange instability is inefficient for Voyager 2 conditions, which is consistent with the absence to magnetic flux tube crossings within the heliopause transition region.

Wednesday, February 20: 4:45 PM - 5:10 PM
Presenter: Rankin, Jamie

Galactic Cosmic-Ray Anisotropies: Voyager 1 in the Local Interstellar Medium

Jamie S. Rankin, Princeton University, USA
Edward C. Stone, California Institute of Technology, USA
Alan C. Cummings, California Institute of Technology, USA
David J. McComas, Princeton University, USA
Nand Lal, Goddard Spaceflight Center, USA
Bryant Heikkila, Goddard Spaceflight Center, USA

Since crossing the heliopause on August 25, 2012, Voyager 1 observed reductions in galactic cosmic ray count rates caused by a time-varying depletion of particles with pitch angles near 90-deg, while intensities of particles with other pitch angles remain unchanged. Between late 2012 and mid-2017, three large-scale events occurred, lasting from ~100 to ~630 days. Omnidirectional and directional high-energy data from Voyager 1's Cosmic Ray Subsystem are used to report cosmic ray intensity variations. Omnidirectional (>20 MeV) proton-dominated measurements show up to a 3.8% intensity reduction. Bi-directional (>70 MeV) proton-dominated measurements taken from various spacecraft orientations provide insight about the depletion region's spatial properties. We characterize the anisotropy as a "notch" in an otherwise uniform pitch-angle distribution of varying depth and width centered about 90-deg in pitch angle space. The notch averages 22-deg wide and 15% deep – signifying a depletion region that is broad and shallow. There are indications that the anisotropy is formed by a combination of magnetic trapping and cooling downstream of solar-induced transient disturbances in a region that is also likely influenced by the highly compressed fields near the heliopause.

SCHEDULE OF TALKS

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Wednesday, February 20: 5:10 PM - 5:35 PM
Presenter: Opher, Merav

A Predicted Small and Round Heliosphere

Merav Opher , Boston University, USA
Abraham Loeb, Harvard University, USA
James Drake, University of Maryland, USA
Gabor Toth, University of Michigan, USA

The shape of the solar wind bubble within the interstellar medium, the so-called heliosphere, has been explored over six decades (Davis 55; Parker ’61; Axford ’72; Baranov & Malama ‘93). As the Sun moves through the surrounding partially-ionized medium, neutral hydrogen atoms penetrate the heliosphere, and through charge-exchange with the supersonic solar wind, create a population of hot pick-up ions (PUIs). The Voyager 2 (V2) data demonstrated that the heliosheath pressure is dominated by PUIs. Here we use a novel magnetohydrodynamic model that treats the PUIs as a separate fluid from the thermal component of the solar wind. Unlike previous models, the new model reproduces the properties of the PUIs and solar wind ions based on the New Horizon (McComas et al. 2017) and V2 (Richardson et al. 2008) spacecraft observations. The inclusion of PUIs as a separate component from the thermal component captures the loss of PUIs due to charge exchange with neutrals (Malama et al. 2006). The loss of PUIs modifies the overall thermodynamics of the HS, deflating the heliosphere, leading to a smaller and rounder shape than previously predicted. We will discuss the consequences of this new shape for draping of the interstellar magnetic field and conditions at Voyager 1 and 2 in the local interstellar medium.

Wednesday, February 20: 5:35 PM - 6:00 PM
Presenter: Ratkiewicz, Romana

Heliosphere Under Influence of Sun-originating vs. LISM-originating Fluctuations

Romana Ratkiewicz, Space Research Center PAS, Institute of Aviation, Poland
Marek Strumik, Space Research Centre PAS,Poland

We investigate response of the heliospheric interface to different kinds of fluctuations. Time-dependent simulations and a parametric study of stationary solutions are used to shed light on the effects of Sun-originating fluctuations as contrasted with the influence of fluctuations in the Local Interstellar Medium (LISM). Positions of the heliopause and the termination shock are discussed in this context. We make an attempt of clarifying differences between simulation results obtained for fully time-dependent cases and those inferred from quasi-stationary approach.

Thursday, February 21: 8:00 AM - 8:25 AM
Presenter: Spence, Harlan

Acceleration of Charged Particles in Earth's Radiation Belts: Transformative Understanding from the Van Allen Probes Mission

Harlan E. Spence, University of New Hampshire, USA

The NASA Van Allen Probes mission, launched in August 2012, continues to transform our understanding of particle acceleration processes (and more) in Earth' radiation belts. The functionally identical twin probes orbit through Earth's radiation belts with a full complement of instrumentation that measures both charged particles and electromagnetic fields. One instrument suite on both probes is called the Radiation Belt Storm Probes (RBSP) - Energetic Particle, Composition, and Thermal Plasma (ECT) suite. Together, the two-point RBSP-ECT particle measurements, when analyzed with two-point electromagnetic fields and waves observations provide new understanding on the acceleration, global distribution, and variability of radiation belt electrons. RBSP-ECT consists of three instruments: the Helium Oxygen Proton Electron (HOPE) spectrometer, the Magnetic Electron Ion Spectrometer (MagEIS), and the Relativistic Electron Proton Telescope (REPT), which cover comprehensively the full electron and ion spectra from one eV to 10's of MeV with high energy and pitch angle coverage and resolution. In this presentation, I summarize key scientific results on particle acceleration derived from the RBSP-ECT suite and the Van Allen Probes mission including the relative role of localized acceleration versus transport-generated particle acceleration as well as the importance of source and seed populations required to accelerate electrons to relativistic or even ultra-relativistic energies.

SCHEDULE OF TALKS

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Thursday, February 21: 8:25 AM - 8:50 AM
Presenter: Dayeh, Maher A.

Forecasting the Physical Properties of Energetic Storm Particle (ESP) Events at 1 AU

M. A. Dayeh, Southwest Research Institute, USA
J. Nickell, Southwest Research Institute, USA
M. I. Desai, Southwest Research Institute, USA
R. W. Ebert, Southwest Research Institute, USA

Energetic storm particle (ESP) events are ion enhancements observed in association with the passage of interplanetary shocks. ESPs are sometime extreme and could bring sudden and significant increases in the near-Earth particulate radiation. This poses severe hazards to astronauts and hardware in space. Understanding the source material and acceleration processes of ESPs is critical to improve the capabilities of forecasting the physical properties of these events, such as their time-of-arrival, peak intensities, and heavy-ion composition.
Using solar wind plasma, magnetic field, and energetic particle measurements from ACE and Wind during solar cycles 23 and 24, we identify ~200 ESP events at 1 AU and for each event, we infer a set of parameters thought to affect the production of ESPs. These include IP shock properties (e.g., speed, strength, obliquity), upstream conditions (e.g., seed populations, solar wind and interplanetary magnetic field conditions), in addition to the ESP properties (e.g., peak intensities, spectra and heavy-ion abundances). We then apply machine-learning algorithms to examine the feasibility of forecasting ESP properties. We present preliminary promising results and identify the challenges associated with forecasting ESPs at 1 AU.

Thursday, February 21: 8:50 AM - 9:15 AM
Presenter: Mewaldt, Richard

The Large Energetic Storm Particle Event of September 18, 2017 Observed by STEREO-A

R.A. Mewaldt, Caltech, USA
C.M.S Cohen, Caltech, USA
G. Li, University of Alabama in Huntsville, USA
J. Hu (University of Alabama in Huntsville, USA
D. Lario, Johns Hopkins University/Applied Physics Laboratory, USA
M.I. Desai, Southwest Research Institute, USA
N. Dresing, University of Kiel, Germany

Much like a Fourth of July fireworks display, Cycle 24 solar activity ended with a series of bangs during September 2017, including four X-Class flares, a record breaking 3000 km/s CME, and a large ground-level enhancement event (GLE), all recorded by Earth-based observers. Less well known is a backside CME from the same active region on September 17, which resulted in a spectacular “energetic storm particle” (ESP) event observed at STEREO-A on September 18 in association with a strong quasi-perpendicular shock. This talk will describe measurements of the time history, energy spectra, and composition of energetic ions from ~0.1 to 100 MeV/nucleon measured by the SEPT, SIT, LET and HET instruments on STEREO-A as well as ESP electron spectra. Comparison will be made with the intense July 23, 2012 ESP event also observed by STEREO-A. The composition of ESP ions observed by STEREO-A will be compared with that of possible seed-particle sources.

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Thursday, February 21: 9:15 AM - 9:40 AM
Presenter: Hu, Junxiang

Modeling of Energetic Storm Particle (ESP) Events and their Effects on SEP Energy Spectra

Junxiang Hu, UAH, USA
Gang Li, UAH, USA
Richard Mewaldt, Caltech, USA
Christina Cohen, Caltech, USA
Gary Zank, UAH, USA

Energetic Storm Particles (ESPs) are often observed locally during SEP (Solar Energetic Particles) events when the CME-driven shocks pass by the observer. In this work, we apply the improve Particle Acceleration and Transport in Heliosphere (iPATH) model to simulate a major ESP event observed by STEREO-A on September 18, 2017. We also exploit the simulation results to understand the acceleration process of ESPs and their longitudinal variations. Furthermore, we study how the energetic storm particles affect the key features of SEP energy spectra, with an emphasis on the spectral break energies.

Thursday, February 21: 9:40 AM - 10:05 AM
Presenter: Kota, Jozsef

Solar Cycle Variations in the Acceleration of Anomalous Cosmic Rays

Jozsef Kota, University of Arizona, USA

The last unusually long and weak solar minimum had unique features. The solar wind density was low and the magnetic field was weak. Galactic cosmic rays (GCRs) reached record high levels, while anomalous cosmic ray (ACR) fluxes, remained below their level at two solar cycles earlier (Leske et al., 2013, Space Sci. Res.) suggesting that the acceleration of ACRs may have been less efficient. This could occur for several reasons. Moraal and Stoker (2012, JGR) pointed out that the larger diffusion co-efficent should reduce the breakdown energy of the ACR spectrum. We present time-dependent simulations adopting a simple axially symmetric hoop-model where the heliospheric magnetic field, together with the wavy current sheet are kinematically carried out by the uniform radial solar wind. The variation of the relevant transport parameters at the Sun are similarly convected by the wind. The model includes radial and latitudinal variations and acceleration at a spherical termination shock (TS). Dynamical variations of the heliocentric distance and strength of the shock will also be briefly discussed.

Thursday, February 21: 10:30 AM - 10:55 AM
Presenter: Ho, George

3He-rich Solar Energetic Particle Events with no Measurable 4He Intensity Increases

George Ho, JHU/APL
Glenn Mason, JHU/APL
Robert Allen, JHU/APL

We investigated 3He-rich solar energetic particle (SEP) events in the current solar cycle starting in 2009 through 2017. Both “impulsive” (flare-related) 3He-rich and CME-related “gradual” events are included. In the last solar cycle, we found the number of observed 3He-rich events correlated with solar activity. The same correlation is seen again in Cycle 24. Because of the comparatively weak activity, both the occurrence of 3He-rich events and their intensities are significantly less than those from Cycle 23. Interestingly, we found in several of the 3He-rich events, there is no measurable 4He intensity increase above the instrument background. Previously, we found that there is a limit on the number of 3He ions can be released from the Sun in an impulsive SEP event, while there is no such limit on the 4He ions (Ho et al., 2005). In this paper, we examine several of these 3He-rich events in detail and discuss the lack of observable 4He intensity increases and the implications for the enhancement and acceleration mechanism of this special type of SEP events.

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Thursday, February 21: 10:55 AM - 11:20 AM
Presenter: Wang, Linghua

The in situ Electron Acceleration at ICME-driven Shocks

Linghua Wang, Peking University, China

We present a comprehensive study of the in-situ electron acceleration at 74 ICME-driven shocks observed by the WIND 3DP instrument at 1 AU from 1995 through 2014. For all these shock cases, both the suprathermal electron fluxes in the ambient solar wind and downstream, J_A and J_D, generally fit well to a double-power-law spectrum with an upward break around 2 keV. For the shock cases with significant electron flux enhancements across the shock, the downstream electron spectral index appears similar to (mostly larger than) the ambient electron spectral index, ranging from ~2 to ~6 with a sharp peak between 3 and 4 (semi-uniformly distributed between ~2 to ~3.2), at energies below (above) the break. Among the shock parameters, JD correlates the most with the magnetosonic Mach number, while the electron flux enhancement across the shock, J_D /J_A, correlates the most with the magnetic compression ratio. On the other hand, J_D /J_A peaks mainly in the in the directions perpendicular to the interplanetary magnetic field. Also note that quasi-perpendicular shock cases behave similarly to quasi-parallel shocks, but with stronger electron flux intensities and enhancements. These results suggest that the shock electron acceleration at 1 AU could favor the shock drift acceleration. The interplanetary shocks could accelerate solar wind strahl/halo electrons at energies below ~2 keV, while they could contribute to the production of solar wind superhalo electrons at energies above ~2 keV.

Thursday, February 21: 11:20 AM - 11:45 AM
Presenter: Wiedenbeck, Mark

Isotopic Fractionation in 3He-rich SEP Events

M. E. Wiedenbeck, JPL/Caltech, USA

Heavy-element abundances in 3He-rich solar energetic particle (SEP) events commonly exhibit a pattern in which enhancements relative to coronal abundances increase approximately monotonically with atomic number, Z. The Fe/O ratio is typically enhanced by a factor ~10 whereas elements with Z>40 can be enhanced relative to O by factors >100. Mason and Klecker (ApJ 862, 7, 2018) discussed a possible fractionation mechanism in which propagation of energetic particles through a hydrogen gas or plasma can cause large enhancements of heavy elements relative to lighter elements by virtue of the fact that the specific ionization of heavier elements is more affected by the attachment of atomic electrons. Studies of isotopic composition in 3He-rich SEP events have also shown that abundance ratios of heavy isotopes relative to lighter isotopes of the same element (such as 22Ne/20Ne) can exhibit significant enhancements. We are investigating the question of whether the Mason-Klecker mechanism could also be responsible for these effects. We will review the observational status of isotopic fractionation in 3He-rich events, discuss a new calculation of the effects proposed by Mason and Klecker, and compare the expected effects on isotopic abundance ratios with measured values.

SCHEDULE OF TALKS

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Thursday, February 21: 11:45 AM - 12:10 PM
Presenter: Wijsen, Nicolas

Modelling Solar Energetic Protons Near and Within a Corotating Interaction Region

Nicolas Wijsen, KU Leuven, Belgium
Angels Aran, University of Barcelona, Spain
Jens Pomoell, University of Helsinki, Finland
Stefaan Poedts, KU Leuven, Belgium

When solar energetic particles (SEPs) escape their acceleration site, they propagate through our solar system, guided by the interplanetary magnetic field (IMF). In this work we focus on how the interplanetary transport of SEPs is affected by the presence of a high-speed solar wind stream embedded in a slow solar wind. Due to the presence of such a high-speed stream, the solar wind configuration deviates from nominal conditions, which affects the SEP propagation. We study these effects by using a three-dimensional SEP transport model together with the data-driven heliospheric model, EUHFORIA. The latter model solves the ideal magnetohydrodynamic (MHD) equations, providing realistic solar wind configuration in the heliosphere. This solar wind is then used by our particle transport model to solve the focused transport equation in a stochastic manner, thereby providing SEP distributions in the entire heliosphere.We find that the presence of a fast solar wind stream, which evolves into a corotating interaction region (CIR), affects strongly the energetics and spatial characteristics of SEP events. In particular, particles gain energy at the two shock waves bounding the CIR. Also, the non-nominal IMF structure induces a strong dependency of the width of the SEP event on the location of the particle source region. Finally, we look at how the SEP peak-intensity varies along a set of pre-selected magnetic field lines that are residing in varying solar wind conditions.

Thursday, February 21: 12:10 PM - 12:35 PM
Presenter: Aschwanden, Markus

Global Energetics of Solar Flares and Coronal Mass Ejections

Markus Aschwanden, LMSAL, USA,
Amir Caspi, Southwest Institute, USA
Christina Cohen, Caltech, USA
Gordon Holman, GSFC, USA
Ju Jing,NJIT, USA
Matthieu Kretschame, Univ. Orleans, France
Eduard Kontar, Univ. Glasgow, UK
James McTiernan, Univ. Berkeley, USA
Richard Mewaldt, Caltech, USA
Aidan O'Flannagain, Trinity College Dublin, UK
Ian Richardson, Caltech, USA
Daniel Ryan, GSFC, USA
Harry Warren, NRL, USA
Yan Xu, NJIT, USA

We investigate the global energetics and energy closure of various physical processes that are energetically important in solar flares and coronal mass ejections (CMEs), which includes: magnetic energies, thermal energies, nonthermal energies (particle acceleration), direct and indirect heating processes, kinetic CME energies, gravitational CME energies, aerodynamic drag of CMEs, solar energetic particle events, EUV and soft X-ray radiation, white-light, and bolometric energies. Statistics on these forms of energies is obtained from 400 GOES M- and X-class events during the first 3.5 years of the Solar Dynamics Observatory (SDO) mission. A primary test addressed in this study is the closure of the various energies, such as the equivalence of the dissipated magnetic energies and the primary flare energies (accelerated particles, direct heating, CME acceleration), which faciliate the energy of secondary processes (plasma heating, shock acceleration, aerodynamic drag). Our study demonstrates energy closure in the statistical average, while individual events may have considerable uncertainties, requiring improved nonlinear force-free field models and particle acceleration models with observationally constrained low-energy cutoffs.

SCHEDULE OF TALKS

NOTES

Thursday, February 21: 1:30 PM - 1:55 PM
Presenter: Bellan, Paul

Experimental Observations of a Cascade from the MHD Scale to the Non-MHD Scale

Paul Bellan, Caltech, USA

An astrophysically relevant time-dependent, three-dimensional, multi-scale cascade of distinctive and disparate plasma phenomena is observed in considerable detail in a laboratory experiment at Caltech. The analysis and modeling of these observations have produced many new insights into plasma behavior. In brief, the observed multi-scale cascade sequence is: MHD jet propagation, MHD kink instability, MHD Rayleigh-Taylor instability, and then non-MHD energetic particle creation and whistler wave emission. Simple initial/boundary conditions lead to this complex, yet well-resolved reproducible sequence. The initial/boundary conditions provide magnetic helicity and mass injection in axisymmetric geometry. Helicity injection occurs via an electrostatic potential difference imposed across two electrodes linked by the same magnetic flux. The electrodes are a disk and a coaxial concentric annulus; these are linked by the magnetic flux from a coil producing a dipole magnetic field. An electrostatic potential drop applied across the linked electrodes drives an electric current along the linking magnetic field. This current produces magnetic forces that form a long collimated MHD-driven jet which is essentially a scale model of an astrophysical jet. The injected mass feeds the lengthening jet. On attaining the critical length at which the Kruskal-Shafranov kink instability criterion is satisfied, the jet kinks. The kink lateral acceleration creates an effective gravity that provides the environment for spontaneous development of a Rayleigh-Taylor instability. The Rayleigh-Taylor ripples choke the jet cross-section; this choking amplifies the jet axial electric current density to the point that ideal MHD fails and various phenomena beyond the scope of MHD are abruptly instigated. These non-MHD phenomena include EUV radiation, X-ray emission, and whistler wave radiation. The X-rays are surprising because the jet plasma is so cold and collisional that one would not expect electrons to be accelerated to the high energy required for X-ray production. This observation has motivated a model showing how a small cohort of electrons in a highly collisional plasma can be accelerated to extreme energies by a sub-Dreicer inductive electric field; this cohort has a much greater population than the very tiny set of electrons that are initially moving so fast as to runaway in the electric field.

SCHEDULE OF TALKS

NOTES

Thursday, February 21: 1:55 PM - 2:20 PM
Presenter: Adhikari, Laxman

Theory and Transport of Nearly Incompressible Magnetohydrodynamic Turbulence. V. A Coupled Solar Corona and Turbulence Model

Laxman Adhikari, CSPAR/UAH, USA
Gary P. Zank, Space Science Department/UAH, CSPAR/UAH, USA
Lingling Zhao, CSPAR/UAH, USA

We couple a recently developed model for the transport and dissipation of nearly incompressible magnetohydrodynamic turbulence (NI MHD) to a hydrodynamic description of quiet solar coronal plasma to "redo" the Parker problem of solar wind acceleration. Our self-consistent NI MHD turbulence model is appropriate to the small plasma beta \beta_p <<1 regime, and the turbulence is coupled superposition of quasi-2D and slab fluctuations. The role of dissipative heating by low-frequency turbulence is investigated for three sets of boundary conditions at the base of the solar corona. Although the energy in turbulent fluctuations is assumed to be the same, the correlation function/correlation length at the base of the solar corona is varied from small, moderate to large values, implying that the heating rate will vary similarly. We find that i) for all three choices of correlation length at the coronal base, the coronal temperature increases to >10^6 K within a few solar radii. The heating rate is determined by choice of correlation length with the smallest value leading to the fastest heating rate and the largest, the slowest; ii) similarly, the location of the sonic surface depends on the heating rate and the choice of correlation length at the inner boundary, yielding typically a supersonic solar wind within the ~4 R0; iii) the rate of decay of the quasi-2D and slab turbulence energies depends on the size of the assumed correlation length/correlation function (small implies rapid decay and vice versa); iv) balanced quasi-2D turbulence at the base of the corona evolves to an imbalanced state with height above the coronal base, with the rate being determined by the assumed correlation length value at the boundary; v) An imbalanced slab turbulence state at the base of the corona evolves towards less imbalanced state with increasing height, with a similar dependence on correlation length assumptions, and vi) although the normalized residual energy for both quasi-2D and slab turbulence is positive very close to the coronal base, the residual energy for both become negative with increasing height at a rate determined by the boundary value of the correlation length. The quasi-2D normalized residual energy is always less than that of the slab turbulence and tends to -1, with the energy thus being in magnetic fluctuations exclusively rather than in velocity fluctuations.

Thursday, February 21: 2:20 PM - 2:45 PM
Presenter: Tasnim, Samira

Mapping Magnetic Field Lines for an Accelerating Solar Wind

S. Tasnim, UAH, USA
Iver H. Cairns, B. Li, M. S. Wheatland, USYD, Australia
G. P. Zank, UAH, USA

Mapping of magnetic field lines is important for studies of the solar wind and the sources and propagation of energetic particles between the Sun and observers. A recently developed mapping approach is generalised to use a more advanced solar wind model that includes the effects of solar wind acceleration, non-radial intrinsic magnetic fields and flows at the source surface/inner boundary, and conservation of angular momentum. The field lines are mapped by stepping along $\mathbf{B}$ and via a Runge-Kutta algorithm, leading to essentially identical maps. The new model's maps for Carrington rotation CR 1895 near solar minimum (19 April to 15 May 1995) and a solar rotation between CR 2145 and CR 2146 near solar maximum (14 January to 9 February 2014) are compared with the published maps for a constant solar wind model. The two maps are very similar on a large scale near both solar minimum and solar maximum, meaning that the field line orientations, winding angles, and connectivity generally agree very well. However, close inspection shows that the field lines have notable small-scale structural differences. An interpretation is that inclusion of the acceleration and intrinsic azimuthal velocity has significant effects on the local structure of the magnetic field lines. Interestingly, the field lines are more azimuthal for the accelerating solar wind model for both intervals. In addition, predictions for the pitch angle distributions (PADs) for suprathermal electrons agree at the 90 -- 95 % level with observations for both solar wind models for both intervals.

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Thursday, February 21: 2:45 PM - 3:10 PM
Presenter: Klein, Kristopher

A Preferential Ion Heating Zone Near The Sun: What is it, Where is it, and What Drives it?

Kristopher Klein, University of Arizona, USA
Justin Kasper, University of Michigan, USA
Mihailo Martinovic, University of Arizona, USA
Daniel Vech, University of Michigan, USA

Characterizing the thermodynamics of the Sun's corona and outer atmosphere is essential to understanding its expansion and the acceleration of the solar wind. Driven by observations at 1 AU, we construct a model for a region near the Sun's surface where minor ions are preferentially heated compared to protons by some unspecified mechanism. Beyond this region, the relative temperatures of the ions are only affected by collisional relaxation. Using decades of measurements from 1 AU, we determine that the outer boundary of this surface is tens of solar radii from the Sun's surface, and we study its dynamic behavior as a function of solar cycle. Many mechanisms have been proposed which may drive preferential ion heating. We consider one mechanism, the breaking of ion magnetic moments via stochastic heating by low frequency Alfvenic turbulence, and determine using observations from the Wind and Helios missions if such heating is consistent with this preferential heating zone. Our work indicates that Parker Solar Probe will be the first mission to enter this zone and directly measure, and thereby identify, the mechanisms controlling the young solar wind.

Thursday, February 21: 3:10 PM - 3:35 PM
Presenter: Hu, Qiang

Radial Evolution of the Properties of Small-Scale Magnetic Flux Ropes in the Solar Wind

Qiang Hu, Yu Chen, and J. le Roux, Department of Space Science, UAH, USA

Small-scale magnetic flux ropes, most with duration <= 1 hour at 1 AU, are found to be ubiquitous in the solar wind from in-situ spacecraft measurements. We have built an event database (fluxrope.info) for these structures identified and summarized their main physical properties. Further analysis provided strong evidence in support of the view of their generation through turbulence cascade processes in space plasmas. We extend such analysis to spacecraft measurements at larger radial distances, mainly those from the Ulysses mission. We perform comparison of relevant properties of these structures and reveal their radial evolution near ecliptic plane. Meanwhile we also try to derive, quantitatively, the parameters important for the underlying process such as magnetic reconnection, intrinsic to turbulence cascade, in order to aid in theoretical investigations. We will also supplement the largely statistical analysis results by individual case studies to illustrate the process of flux rope merging and associated particle energization signatures through an observational approach.

Thursday, February 21: 3:55 PM - 4:20 PM
Presenter: Qin, Gang

Energetic Particles Accelerated by an Interplanetary Coronal Mass Ejection Shock with Magnetic Cloud

Gang Qin, School of Science, Harbin Institute of Technology, China
Zhenning Shen, School of Science, Harbin Institute of Technology, China

Ground-level enhancement events (GLEs) generally accompanies with fast interplanetary coronal mass ejections (ICMEs), and the shock driven by the ICME is an effective source of energetic particles. In GLE59, observations show that a magnetic cloud (MC) is behind the ICME shock and it is assumed to affect the proton intensity-time profiles observed near the Earth. Based on the observation of GLE59, we study the effect of MC on SEPs accelerated by an ICME shock by numerically solving the focused transport equation in the three-dimensional Parker magnetic field. The shock is regarded as a moving source of energetic particles with an assumed particle distribution function. The mirror effect is considered to simulate the behavior of particles when they encounter the boundary of the MC. It is found that the simulation results of proton intensity-time profiles agree well with the observations in energy ranging from $\sim$1 MeV to $\sim$100 MeV. Comparing with the simulation results without MC, it is found that the MC affects the intensity-time profiles significantly when the observer encounters the MC.

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Thursday, February 21: 4:20 PM - 4:45 PM
Presenter: Mazelle, Christian

A Fast-Fermi Acceleration at Mars Bow Shock

Christian Mazelle, IRAP CNRS-University of Toulouse - UPS - CNES, France
Karim Meziane, University of New Brunswick, Canada
David L. Mitchell, Space Sciences Laboratory, University of California, Berkeley, USA
Jared R. Espley, NASA Goddard Space Flight Center, USA

We have recently reported for the first time strong quantitative evidence that a fast-Fermi mechanism is taking place at the Martian bow shock. MAVEN spacecraft observations from SWEA instrument show electron flux spikes with energy up to ~ 1.5 keV. These spikes are associated with sunward propagating electrons and appear when the interplanetary magnetic field line threading the spacecraft is connected near the Martian bow shock tangency point. The loss cone distribution is a salient feature of these backstreaming electrons as the phase space density peaks on a ring centered along the magnetic field direction above an energy cut-off. Moreover, the data show no evidence of any effect due to a hypothetical cross-shock potential on the observed angular distributions since peak pitch-angles increase with energy. Although similar distributions are seen at the terrestrial bow shock, the quantitative analysis of the measurements strongly indicates that the electrons are produced at the shock foot and escape upstream before exploring the entire nearly perpendicular shock structure. This somehow seems to contrast with the backstreaming electrons observed at the terrestrial foreshock.

Thursday, February 21: 4:45 PM - 5:10 PM
Presenter: Cohen, Christina

Solar Energetic Particles Associated with Filament Eruptions

C.M.S. Cohen, California Institute of Technology, USA
R.A. Mewaldt, California Institute of Technology, USA
G.C. Ho, Johns Hopkins Applied Physics Laboratory, USA
N. Thakur, Catholic University of America, USA

It is well known that solar energetic particles (SEPs) can be accelerated near the Sun both by flare-related reconnection processes and by shocks driven by coronal mass ejections (CMEs), with the latter typically dominating in large SEP events. It is critical for accurate space weather prediction and our understanding of the variability of SEP events to understand the details of shock acceleration, yet it is often difficult to identify which SEP event characteristics are controlled by shock acceleration and which are a result of related flare processes as large flares and fast CMEs frequently occur together. Filament eruptions typically have weak soft X-ray flares but can result in fast CMEs and type II radio bursts indicating the presence of a strong and long-lasting shock able to accelerate particles. Thus the SEPs associated with these events provide the best opportunity to study shock acceleration near the Sun without the added complication of flare-associated acceleration. We present the results of a study of filament eruptions, both with and without associated SEP events. We detail the SEP characteristics of these events and compare them to more 'typical' SEP events; additionally we compare the CME properties of eruptions with SEP events to those without.

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Thursday, February 21: 5:10 PM - 5:35 PM
Presenter: Verkhoglyadova, Olga

Characterization of Solar Wind Driving of the Earth's Ionosphere With Total Electron Content

Olga P. Verkhoglyadova, Anthony J. Mannucci, Attila Komjathy and Xiaoqing Pi, Jet Propulsion Laboratory, California Institute of Technology, USA

Understanding solar wind coupling to the Earth's ionosphere can aid space weather forecasting efforts. Characterization of ionosphere driving by different structures in the solar wind is often a challenging problem. We present examples of ionospheric response to the November 2003 and 2004 superstorms resulting from complex solar wind drivers. We quantify ionospheric dynamics with the most widely used and readily available ionospheric parameter, total electron content (TEC) obtained from Global Navigation Satellite System (GNSS) measurements.
The coupling function approach has often been applied to characterize solar wind coupling to the magnetosphere. We will discuss extensions of this approach to include coupling to the ionosphere. The JPL Global Ionosphere Map (GIM) dataset produced every 15 minutes during 2000-2015 provides global coverage. We explore the novel four-plasma-state solar wind categorization scheme of Xu and Borovsky (2015) to associate solar wind plasma regimes with statistical properties of the global maximum TEC and measures of global electron content (GEC).

Thursday, February 21: 5:35 PM - 6:00 PM
Presenter: Kim, Tae

A Time-dependent Model of the Ambient Solar Wind Driven by Boundary Conditions from Observations of Interplanetary Scintillation

T. K. Kim, UAH, USA
C. N. Arge, NASA/GSFC, USA
N. V. Pogorelov, UAH, USA

The ambient solar wind has important effects on energetic particles. For example, corotating interaction regions formed at the interface between fast and slow streams often drive interplanetary shocks that modulate the intensity of galactic cosmic rays and accelerate ions to high energies. Thus, a realistic model of the ambient solar wind may help to explain observations of energetic particles in interplanetary space. We describe a time-dependent MHD model driven by solar wind velocities estimated from observations of interplanetary scintillation (IPS), which are ground-based remote observations of the fluctuating intensity of distant, compact radio sources. We present the simulation results for a quiet period dominated by stream interactions. We compare the IPS-based model with solar wind data both in the ecliptic plane and at high heliographic latitudes, as well as with a conventional heliospheric MHD model driven by the Wang-Sheeley-Arge coronal model output.

Friday, February 22: 8:00 AM - 8:25 AM
Presenter: Yoon, Peter

Weakly Turbulent Nonlinear Wave-Particle Interactions in Space and Astrophysical Plasmas

Peter H. Yoon, KASI, Korea/UMD, USA/KHU, Korea

Weakly nonlinear and incoherent interactions among waves and plasma particles can be described by perturbative nonlinear kinetic theory known in the plasma physics literature as the weak turbulence theory. In the context of space physics, the weak turbulence analysis of electron beam-plasma interaction pertains to two prominent examples. One is the physical origin of non-thermal electron distribution function observed in space. It is well known that the solar wind electron distribution function can be empirically fitted with the celebrated kappa distribution function (Vasyliunas 1968), but its origin was not understood. The weak turbulence theory of electron beam-plasma interaction and ensuing Langmuir turbulence can naturally explain the generation of electron kappa distribution function (Yoon 2014). The stationary kappa distribution function for the electrons that forms as a result of interaction with saturated Langmuir turbulence spectrum may be equivalent to the non-extensive statistical equilibrium state (Tsallis 2009, Livadiotis 2017). Another application is on the radiation generation during the course of electron beam-plasma interaction process. The emission of electromagnetic radiation at the plasma frequency and/or its harmonic(s) is known in the literature as the plasma emission, and it is the fundamental process responsible for the solar type II and type III radio bursts (McLean and Labrum 1985). Many theories have been developed in the literature since the decade of 1950s (Melrose 1980), but complete theoretical/numerical demonstration of plasma emission starting from the electron beam-plasma instability process has not been done until recently (Ziebell 2015). The plasma emission result when Langmuir turbulence energy is partially converted to electromagnetic radiation via nonlinear processes. This talk will overview the latest development on this research topic.

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Friday, February 22: 8:25 AM - 8:50 AM
Presenter: Alonso Guzman, Juan

Theoretical Model of Ion-Acoustic Shock Wave Structure in Dusty Plasma

Juan G Alonso Guzman, UAH, USA
Dr Gary P Zank, UAH CSPAR, USA

Dust is an important component of plasma in multiple environments throughout the solar system, including dust created as comets melt in the vicinity of the Sun or the dust rings that surround massive planets such as Saturn. The effects of dust particles in the structure and propagation of ion-acoustic waves through plasma have been empirically recorded and studied for nearly two decades (see Nakamura et al., 1999, Physical Review Letters). A Korteweg-de Vries-Burgers (KdVB) PDE involving the electrostatic potential governs the process, and numerical solutions agree well with the overall shock structure. However, the exact form and nature of the dissipation term within this equation is hitherto unknown. Inspired by comments in Nakamura et al. (1999), this research seeks to incorporate ion-dust collisions into the plasma framework in order to obtain an exact form for the dissipation coefficient in terms of experimental quantities. In order to achieve this goal, we assume a simplified shielded potential to derive appropriate scattering quantities for the Fokker- Plank equation, and then proceed with a Chapman-Enskog expansion, leading to an explicit form of the desired term, among others. With our contribution, we hope to provide a complete and rigorous theoretical foundation for the use of a KdVB equation to describe ion-acoustic shockwave structure, and obtain a formula for the dissipation coefficient based on measurable quantities. This will further our understanding of this phenomena, as well as pinpoint certain key parameters that could be adjusted to control the wave structure.

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Friday, February 22: 8:50 AM - 9:15 AM
Presenter: Hill, Matthew

A New Cosmic Ray Monitor in the Outer Heliosphere: The PEPSSI Experiment on New Horizons

P. Kollmann, JHU/APL, USA
L.E. Brown, JHU/APL, USA
R.L. McNutt, Jr., JHU/APL, USA
R.C. Allen, JHU/APL, USA
R.B. Decker, JHU/APL, USA

We use a nominal background signal in the New Horizons (NH) spacecraft's Pluto Energetic Particle Spectrometer Science Investigation (PEPSSI) solid state detector (SSD) measurements to determine the time and energy-dependent intensities of $\gtrsim$ 65 MeV particles. The unique location of NH—as the only active spacecraft in the heliosphere beyond the orbit of Jupiter and the only outer-heliospheric, ecliptic spacecraft ever, except Pioneer 10 in the heliotail—makes this high-energy capability, which corresponds predominantly to galactic cosmic rays (GCRs), a substantial enhancement to the network of ground and space-based cosmic ray monitors, observations from which have been gaining insight into space activity even before the space age. We report seven years of cosmic ray data from 2012-2018 while NH and Voyager 2 (V2) spacecraft range from 22.0 to 43.3 AU and 97.3 to 119.5 AU from the Sun, respectively. The energy absorption characteristics of the active and inactive elements of the PEPSSI sensor and the spacecraft body have been accounted for to extract the penetrating particle measurements. By comparing these new observations with similar cosmic ray data from ACE/CRIS at 1 AU and V2/LECP in the heliosheath, we see the cosmic rays transport conditions (e.g., arising from the spectrum of magnetic turbulence) propagate into the outer heliosphere, with the cosmic ray minimum (solar maximum) conditions occurring at 2014.86 at the Sun, 2015.48 at 31 AU, and 2018.02 at 113 AU. Forbush decreases are observed in the data coincident with the passage of apparent interplanetary shocks at NH, evidenced by intensity enhancement of pickup ion, suprathermal ion, and energetic particle populations, but recurrent events after solar maximum with similar particle enhancements are much less likely to be associated with Forbush decreases, probably due to the eroded magnetic field observed the Voyagers during recurrent events when they were at similar distances from the Sun as NH currently is.

Friday, February 22: 9:15 AM - 9:40 AM
Presenter: Jian, Lan

Long-Term Observations of Large-Scale Solar Wind Structures and Their Relationship with Energetic Storm Particle Events in the STEREO Era

L. K. Jian, NASA Goddard Space Flight Center, USA
J. G. Luhmann, University of California, Berkeley, USA
C. T. Russell, University of California, Los Angeles, USA
R. W. Ebert, Southwest Research Institute, USA
M. A. Dayeh, Southwest Research Institute, USA
X. Blanco-Cano, Universidad Nacional Autónoma de México, Mexico

Since the launch in 2006, the STEREO mission has operated for more than 12 years, covering from the late declining phase of solar cycle 23 to the late declining phase of cycle 24. We have conducted long-term observations of interplanetary coronal mass ejections (ICMEs), stream interaction regions (SIRs), shocks, and solar energetic particle events using STEREO A/B spacecraft data, and provided the event lists to the public. Here we report some of the main statistical results from these surveys, such as the comparison of ICME-driven shocks and SIR-driven shocks, the solar cycle variations of these structures. In addition, we have selected several multi-spacecraft energetic storm particle (ESP) events at 1 AU in the STEREO era. They are primarily associated with low Mach number, quasi-perpendicular shocks. We have studied the longitude distribution of the shock properties and energetic ions during these events, and the relationship between them.

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Friday, February 22: 9:40 AM - 10:05 AM
Presenter: Cooper, John

Energy-Dependent Hysteresis in Long-Distance Propagation of Solar Energetic Particles

John Cooper, NASA Goddard Space Flight Center, USA
Lynn Wilson, NASA Goddard Space Flight Center, USA
Robert Coleman, Howard University, USA

Most solar energetic particle events show little time dependence in the arrival at 1 AU of lower and higher energy particles. This is expected and frequently observed for well-connected prompt electron events at relativistic MeV energies. Survey of solar electron data from multiple spacecraft reveals a small class of events with significant difference in arrival times of peak fluxes versus energy. In scatter plots of low vs. high energy electron fluxes such events show a "hysteresis" curve in which arrival of higher energy electrons initially leads that of lower energy electrons and then lags after peak flux. This effect was very pronounced for the event of June 4, 2011 as detected at both Stereo A and B by the High Energy Telescope of the IMPACT instrument suite. The two spacecraft were separated by 2 AU on opposite sides of the Sun, Stereo A apparently being better connected for a prompt event from the electron source and showing no hysteresis time-lag. At Stereo B the lag time in peak flux for electrons below and above 1 MeV electrons was 18 hours, suggestive of much longer propagation path length over many AU from the source to this spacecraft. The data sources of the full survey also include Helios 1 and 2, and IMP-8. The survey was supported by the Virtual Energetic Particle Observatory (VEPO) and the Space Physics Data Facility (SPDF) at NASA Goddard Space Flight Center.

Friday, February 22: 10:30 AM - 10:55 AM
Presenter: Ip, Wing

Nanodust and ENAs in the Near-Solar Region

Wing-Huen Ip, National Central University, Taiwan
Ian-Lin Lai, National Central University, Taiwan
Fang Shen, National Space Science Center, Chinese Academy of Sciences, China

With the anticipation that the Parker Solar Probe will move into the source region of the charged nano-grains (CNGs) and inner-souce ENAs, we study the transport and acceleration effects of small dust particles released from circumsolar particulate matter or sun-grazing comets. A 3D solar wind model from NHD simulation is used for the numerical calculations. Depending on the locations of the initial ejection and surface electrostatic potential, the orbital motions of the CNGs could have different characteristics. These include temporary traping and fast escape. The preliminary statistical results and their implications on the inner-source ENAs will be discussd.

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Friday, February 22: 10:55 AM - 11:20 AM
Presenter: Lazarian, Alex

Turbulent Reconnection: Generic type of 3D Astrophysical Reconnection

Alex Lazarian, University of Wisconsin, Madison, USA

Turbulent reconnection is an idea from the previous century, namely, from the time when the entire reconnection community was facsinated by the "final solution" of the reconnection problem, namely, Hall collisionless reconnection. The difference between the aforementioned schemes of reconnection were striking. The turbulent reconnection used the Y-type configuration generalizing the Sweet-Parker setup, while the Hall reconnection was an incarnation of the Petschek X-type reconnection, but with the restriction to the collisionless media. Many models were developed explaining the onset of reconnection by the transfer from the slow collisional reconnection to the fast collisionless Hall reconnection. As the time passed and 2D simulations became more sophisticated the Hall reconnection gradually got out of favor and was substituted by another "final solution", which is ideologically closer to the turbulent reconnection, namely, the tearing reconnection. The latter adopted Y-type reconnection layer configuration and introduced the stochasticity into the current sheet. The requirement of being collisionless as the watershed between the fast, i.e. resistivity independent, and slow, i.e. resistivity dependent reconnection, reconnection was also lifted. As in the key ingradient of turbulent reconnection model, i.e. Alfvenic component of turbulence, was not present 2D simulatios it was not surprising that these studies provided results different from the turbulent reconnection predictions. I shall discuss the third stage of the "reconnection saga" that started with the advent of 3D reconnection simulations. These simulations both in non-relativistic and relativistic setups demonstrate the features of turbulent reconnection. I shall briefly discuss the astrophysical consequences of these important findings.

POSTER PRESENTATIONS

Che, Haihong	***The Solar Wind Electron Halo as Produced by Electron Beams Originating in Nanoflares: Beam Density Dependence*** Haihong Che, UMCP/GSFC, USA M. L. Goldstein, SSI, USA C. S. Salem, SSL, UC Berkeley, USA A. F. Vinas, GSFC, USA It has been suggested recently \citep{che14apjl} that the nearly isotropic electron halo seen in the electron velocity distribution function of the solar wind may originate from nanoflares, where accelerated electron beams are unstable to electron two-stream instability (ETSI) and the beams are heated and generate whistler and kinetic Alfv\'en waves. The kinetic waves then scatter the hot electron tail into an isotropic halo. This model can explain various observations of the solar wind. However, since the density and the drift of the electron beams in the source region in the corona cannot be directly measured, understanding how beam density and drift affect the electron velocity function is essential to establish the link between the solar wind observables and the electron dynamics in nanoflares. In this paper Using particle-in-cell simulations and kinetic theory, we show that a necessary condition for an isotropic halo to develop is that the beam density be lower than a critical density $N_c \sim 0.3$. Heating of the core electrons becomes weaker with decreasing beam density, while the heating of halo electrons becomes stronger. As a result, the temperature ratio of the halo and core electrons increases with the decrease of the beam density. We also apply these results to the current observations and discuss the possible optimal electron beam density produced in the nanoflares.
Guo, Fan	***The Acceleration of Energetic Particles at Coronal Shocks and Emergence of a Double Power Law Feature in Particle Energy Spectra*** Xiangliang Kong, Shandong University at Weihai, China Fan Guo, Los Alamos National Laboratory, USA Yao Chen, Shandong University at Weihai, China Joe Giacalone, University of Arizona, USA We present numerical modelling of particle acceleration at coronal shocks propagating through a streamer-like magnetic field by solving the Parker transport equation with spatial diffusion both along and across the magnetic field.. We show that the location on the shock where the high-energy particle intensity is the largest, depends on the energy of the particles and on time. The acceleration of particles to more than 100 MeV mainly occurs in the shock-streamer interaction region, due to perpendicular shock geometry and the trapping effect of closed magnetic fields. A comparison of the particle spectra to that in a radial magnetic field shows that the particle intensity at 100 MeV (200 MeV) is enhanced by more than one order (two orders) of magnitude. This indicates that the streamer-like magnetic field can be an important factor in producing large SEP events. We also show that the energy spectrum integrated over the simulation domain consists of two different power laws. Further analysis suggests that it may be a mixture of two distinct populations accelerated in the streamer and open field regions, where the acceleration rate differs substantially. Our calculations also show that the particle spectra are affected considerably by a number of parameters, such as the streamer tilt angle, particle spatial diffusion coefficient, and shock compression ratio. While the low-energy spectra agree well with standard diffusive shock acceleration theory, the break energy ranges from a few MeV to ~90 MeV and the high-energy spectra can extends to ~1 GeV with a slope of ~2-3.
Guo, Fan	***Determining the Dominant Acceleration Mechanism during Relativistic Magnetic Reconnection in Large-scale Systems*** Fan Guo, Los Alamos National Laboratory, USA While a growing body of research indicates that relativistic magnetic reconnection is a prodigious source of particle acceleration in high-energy astrophysical systems, the dominant acceleration mechanism remains controversial. Using a combination of fully kinetic simulations and theoretical analysis, we demonstrate that Fermi-type acceleration within the large-scale motional electric fields dominates over direct acceleration from non-ideal electric fields within small-scale diffusion regions. This result has profound implications for modeling particle acceleration in large-scale astrophysical problems, since it opens up the possiblity of modeling the energetic spectra without resolving microscopic diffusion regions.

POSTER PRESENTATIONS

Roelof, Edmond	***The Plasma Heliopause was like a Sphere: Evidence from Voyager 2-3 kHz radio emission (1992-1994)*** Edmond C. Roelof, JHU/APL, USA Knowledge of the shape of the plasma heliopause (HP) boundary between the heliosheath plasma (Ne~0.001/cc) and the adjacent interstellar plasma (Ne~0.1/cc) will be essential for the design of the Interstellar Probe mission. For decades, the choices have seemed to lie between shapes whose draped local interstellar magnetic field is comet-like (with a long “tail” in the direction downwind from the interstellar plasma flow), or more bubble-like. New evidence favoring the plasma “bubble” comes from the 2-3 kHz radio emission detected by the Voyager 1/2 PWS experiment during the intense long-lasting events 1992-1994, commencing with a cluster of “fast-drift” bursts from 1.8-3.6 kHz that lasted about 70d, combined with >180d “cavity” emission between 1.8-2.3 kHz that exhibited a very slow upward frequency drift. Intensities of the fast-drift bursts 2.5-3.6 kHz maximized in the “upwind” hemisphere, but the cavity radiation was essentially isotropic. D. A. Gurnett, W. S. Kurth, and their collaborators have identified the 1.8-2.3 kHz radio emission with electron-beam-generated electron plasma oscillations in the plasma density gradient at the HP and the 2.5-3.6 kHz with density gradients beyond the HP in the upstream interstellar medium. Since light velocity is 172 AU/d, the photons in the 1.8-2.3 kHz cavity radiation must have travelled >200 times the radius of the HP during their confinement within a very high-Q cavity (whose topology must therefore be nearly “closed” and topologically equivalent to a sphere). The 70 d spread in the onsets of the cluster of anisotropic fast-drift bursts confines the HP shape to be quasi-spherical to within a few tens of per cent. The so-far-unexplained very slow drift of the isotropic 1.8-2.3 kHz emission can be produced by an inward radial motion of the HP at about 16 km/s. Although these inferences hold strictly only for the large 1992-1994 events, they may also be consistent with the Voyager 1/2 in situ observations during 2010-2018.

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