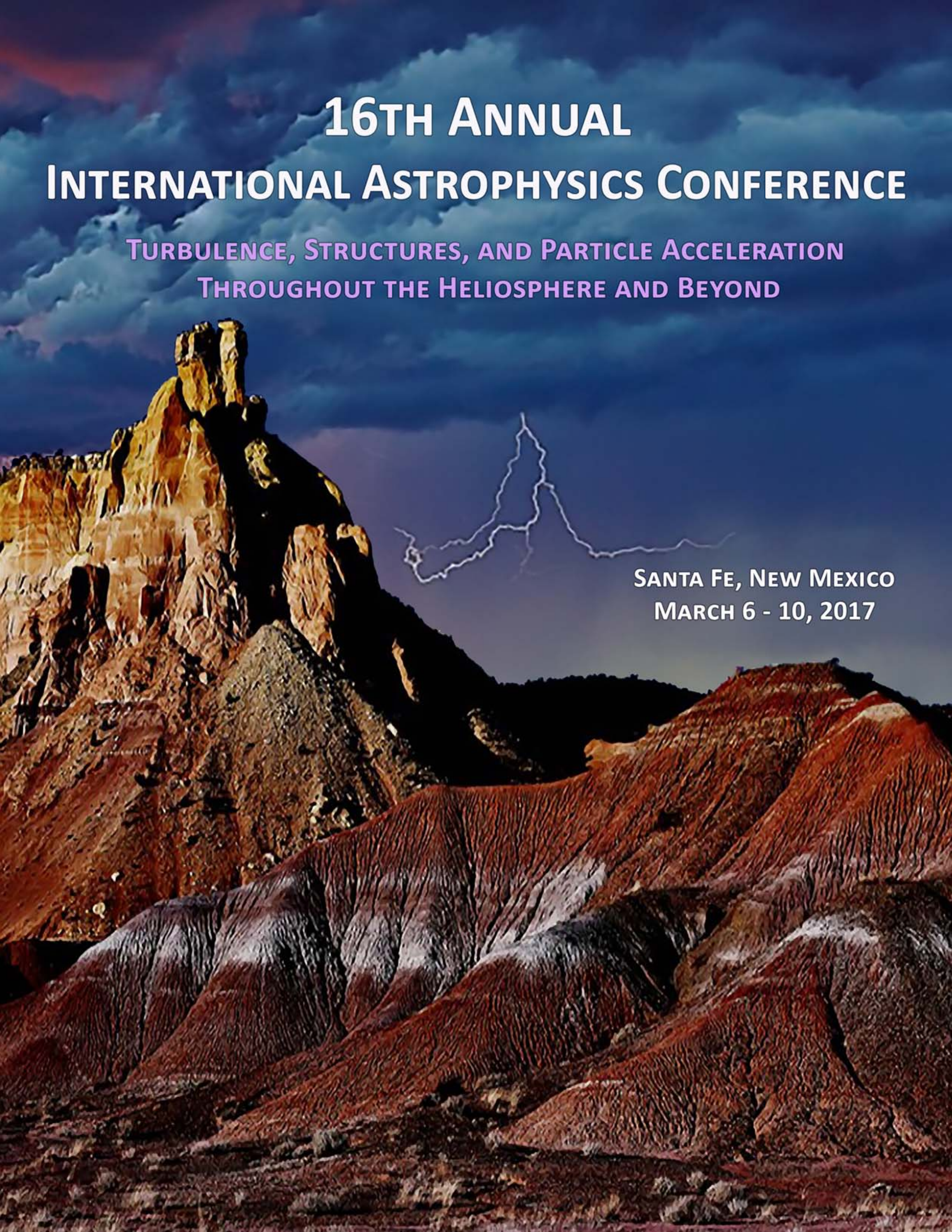
16th Annual International Astrophysics Conference

Turbulence, Structures, and Particle Acceleration Throughout the Heliosphere and Beyond



Santa Fe, New Mexico
March 6 - 10, 2017

16th Annual International Astrophysics Conference
Santa Fe, NM, March 6 – 10, 2017

AGENDA

SUNDAY, MARCH 5		
5:00 PM - 8:00 PM	Registration – Montana Foyer	
6:00 PM – 9:00 PM	Welcome Reception - Montana Ballroom	

MONDAY, MARCH 6		
7:00 AM - 5:00 PM	Registration -Montana Foyer	
8:00 AM - 6:00 PM	GENERAL SESSION – Montana Ballroom	
CHAIR: Zank, G.		
8:00 AM - 8:25 AM	Antiochos, Spiro	Implications of the S-Web Model for Impulsive SEPs
8:25 AM - 8:50 AM	Bucik, Radoslav	Energetic Particles of Anomalous Composition in Helical Jets on the Sun
8:50 AM - 9:15 AM	Jeffrey, Natasha	Non-Gaussian Velocity Distributions in Solar Flares from Extreme Ultraviolet Lines: A Possible Diagnostic of Ion Acceleration
9:15 AM - 9:40 AM	le Roux, Jakobus	Acceleration of Solar Energetic Particles at a Fast Traveling Shock in Nonuniform Coronal Conditions
9:40 AM - 10:05 AM	Kahler, Stephen	A Comparison of Flare Reconnection Fluxes with SEP Events
10:05 AM - 10:30 AM	Morning Break - Ballroom Foyer	
CHAIR: Gopalswamy, N.		
10:30 AM - 10:55 AM	Fisk, Len	The Pump Acceleration Mechanism: One More Try
10:55 AM - 11:20 AM	Gloeckler, George	Implementation of IMAP Science Objectives
11:20 AM - 11:45 AM	Krimigis, Stamatios	Cassini/INCA ENA Solar Cycle Dependence and Voyager Ions in the Heliosheath Suggest a "Bubble" Model of the Heliosphere
11:45 AM - 12:10 PM	Zharkova, Valentina	Particle Dynamics in Reconnecting Current Sheets of the Solar Corona and Heliosphere derived from 3D PIC Simulations
12:10 PM - 12:35 PM	Kong, Xiangliang	Particle Acceleration at Coronal Shocks: the Effect of Large-scale Streamer-like Magnetic Field Structures
12:35 PM - 1:30 PM	Lunch Break – Julia Room	
CHAIR: Zharkova, V.		
1:30 PM - 1:55 PM	Swisdak, Marc	Electron Acceleration During Magnetic Reconnection
1:55 PM - 2:20 PM	Lu, Quanming	The Role of Magnetic Islands in Electron Acceleration during Magnetic Reconnection
2:20 PM - 2:45 PM	Li, Xiaocan	The Role of Fluid Compression in Particle Energization during Magnetic Reconnection
2:45 PM - 3:10 PM	Guo, Fan	Nonthermal Particle Acceleration in Three-dimensional Magnetic Reconnection
3:10 PM - 3:35 PM	Kumar, Rahul	Preferential Heating and Acceleration of Heavy Ions in Alfven Turbulence
3:35 PM - 3:55 PM	Afternoon Break - Ballroom Foyer	
CHAIR: Yoon, P.		
3:55 PM - 4:20 PM	Kucharek, Harald	Sensing the Plasma Flows Around the Heliopause: Consequences for the Shape of the Heliosphere
4:20 PM - 4:45 PM	Livadiotis, George	Statistical Origin and Properties of Kappa Distributions
4:45 PM - 5:10 PM	Reeves, Geoffrey	Energy-Dependent Dynamics and Coupling in the Van Allen Radiation Belts
5:10 PM - 5:35 PM	Tenishev, Valeriy	Local Time Dependence of the Energetic Particle Population in the near Earth Environment
5:35 PM - 6:00 PM	Zheng, Jinlei	A comprehensive Small-scale Magnetic Flux Rope Database via Automated Detecting Algorithm Based on Grad-Shafranov Reconstruction Technique: Database and the Statistical Analysis

SESSION ADJORNS

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TUESDAY, MARCH 7		
7:00 AM - 5:00 PM	Registration –Montana Foyer	
8:00 AM – 6:00 PM	GENERAL SESSION – Montana Ballroom	
CHAIR: Coates, A.		
8:00 AM - 8:25 AM	Wang, Linghua	The Injection of Electron/3He-rich SEP Events
8:25 AM - 8:50 AM	Lin, Yu	Transport in the Magnetotail associated with Magnetic Reconnection and Fast Flows
8:50 AM - 9:15 AM	Oka, Mitsuo	Stochastic Electron Acceleration by Whistler Waves within Earth's Bow Shock Layer
9:15 AM - 9:40 AM	Yoon, Peter	Turbulent Equilibria for Charged Particles in Space
9:40 AM - 10:05 AM	Baker, Daniel	New Results Concerning Particle Energization in Earth's Van Allen Radiation Belts
10:05 AM - 10:30 AM	Morning Break - Ballroom Foyer	
CHAIR: Wood, B.		
10:30 AM - 10:55 AM	Coates, Andrew	Pickup Particle Acceleration at Comets, Moons and Magnetospheres
10:55 AM - 11:20 AM	Guo, Xiaocheng	Numerical Simulation of Cosmic Rays Effects on the Structure of the Heliosphere
11:20 AM - 11:45 AM	Cummings, Alan	Cosmic Rays at the Voyagers: Updates of the GCRs in the LISM and Evidence for the Acceleration Site of ACRs
11:45 AM - 12:10 PM	Stone, Edward	The Voyager Interstellar Mission, a Continuing Journey of Exploration
12:10 PM - 12:35 PM	Medvedev, Mikhail	Quasi-collisional Magneto-optic Effects in Turbulent ISM Plasmas. Anomalous Faraday Rotation
12:35 PM - 1:30 PM	Lunch Break – Julia Room	
CHAIR: Golla, T.		
1:30 PM - 1:55 PM	Gedalin, Michael	Probabilistic Shock Crossing and Diffusive Acceleration
1:55 PM - 2:20 PM	Leske, Richard	Improved Understanding of Peculiar Anisotropy Observations in the 23 July 2012 SEP Event
2:20 PM - 2:45 PM	Raymond, John	Ion-Ion Equilibration in a Fast Shock Wave
2:45 PM - 3:10 PM	Roelof, Edmond	Acceleration and Propagation of Anomalous Cosmic Rays and Near-Relativisitic Electrons in the Heliosheath
3:10 PM - 3:35 PM	Hill, Matthew	New Horizons/PEPSSI Measurements of Suprathermal and Pickup Ions, Energetic Particles, and Cosmic Rays in the Heliosphere During Transient Shock Events
3:35 PM - 3:55 PM	Afternoon Break - Ballroom Foyer	
CHAIR: Florinski, V.		
3:55 PM - 4:20 PM	Lario, David	Large Energetic Particle Pressures in Solar Cycles 23 and 24
4:20 PM - 4:45 PM	Mostafavi, Parisa	Structure of Energetic Particle Mediated Shocks Revisited
4:45 PM - 5:10 PM	Li, Gang	Some Issues on Particle Acceleration and Transport in the Inner Heliosphere
5:10 PM - 5:35 PM	Mewaldt, Richard	What Caused the Large Deficit of High-Energy Solar Particles in Solar Cycle 24?
5:35 PM - 6:00 PM	Yan, Huirong	Cross Field Transport of Cosmic Ray in MHD Turbulence
6:00 PM - 6:10 PM	Sokol, Justyna	Polar Conic Current Sheets as Sources of Energetic Particles in the High-latitude Heliosphere during Solar Minima
SESSION ADJOURNS		

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WEDNESDAY, MARCH 8		
7:00 AM - 5:00 PM	Registration –Montana Foyer	
8:00 AM – 6:00 PM	GENERAL SESSION – Montana Ballroom	
CHAIR: Smith, C.		
8:00 AM - 8:25 AM	McKenzie, David	Recent Findings from High-Resolution Observations of Turbulent Motions in Solar Flare Current Sheets
8:25 AM - 8:50 AM	Salem, Chadi	Solar Wind Electron Microphysics and Kinetic-Scale Electromagnetic Fluctuations in the Solar Wind at 1 AU
8:50 AM - 9:15 AM	Consolini, Giuseppe	A Hilbert-Huang Transform Approach to Space Plasma Turbulence at Kinetic Scales
9:15 AM - 9:40 AM	Matthaeus, William	Kinetic Plasma Turbulence: Energy Cascade, Coherent Atructures, and Heating of Protons and Electrons
9:40 AM - 10:05 AM	Boldyrev, Stanislav	Inertial Kinetic-Alfven and Whistler Turbulence in a Non-isothermal Plasma
10:05 AM - 10:30 AM	Morning Break - Ballroom Foyer	
CHAIR: Klein, K.		
10:30 AM - 10:55 AM	Smith, Charles	Observations of Low-Frequency Magnetic Waves due to Newborn Interstellar Pickup Ions Using ACE, Ulysses, and Voyager Data
10:55 AM - 11:20 AM	Usmanov, Arcadi	A Global MHD Simulation of the Solar Corona, Solar Wind and Heliosphere with Turbulence Transport
11:20 AM - 11:45 AM	Zank, Gary	A Nearly Incompressible Description of Low-Frequency Turbulence in the Solar Wind
11:45 AM - 12:10 PM	Adhikari, Laxman	Transport of Nearly Incompressible Magnetohydrodynamic Turbulence from 1 - 75 AU
12:10 PM - 1:30 PM	Lunch Break – Julia Room	
CHAIR: Salem, C.		
1:30 PM - 1:55 PM	Hunana, Peter	On the Parallel and Oblique Firehose Instability in Fluid Models
1:55 PM - 2:20 PM	Giacalone, Joe	The Acceleration of Solar Wind Protons and Minor Ions at a Strong, Quasi-Parallel, Interplanetary Shock
2:20 PM - 2:45 PM	Golla, Thejappa	In Situ Waves Observed in the Vicinity of Interplanetary Shocks
2:45 PM - 3:10 PM	Gary, S. Peter	Electron and Ion Heating by Kinetic Range Turbulence: Three-Dimensional Particle-in-Cell Simulations
3:10 PM - 3:35 PM	Klein, Kristopher	A General Method for Instability Identification in Solar Wind Observations as Illustrated by Particular Application to WIND Observations
3:35 PM - 3:55 PM	Afternoon Break - Ballroom Foyer	
CHAIR: Reisenfeld, D.		
3:55 PM - 4:20 PM	Manchester, Ward	The Evolution of Alfven-wave Turbulence at CME-driven Shocks
4:20 PM - 4:45 PM	Luhmann, Janet	Observer Magnetic Field Mapping to ICME Shocks: Implications of ENLIL Results for Shock Normal Angle Influences
4:45 PM - 5:10 PM	Gopalswamy, Nat	A Hierarchical Relationship between the Fluence Spectra and CME Kinematics in Large Solar Energetic Particle Events
5:10 PM - 5:35 PM	Chapman, Sandra	Quantifying the Variability of the Solar Wind and its Solar Cycle Dependence
5:35 PM - 6:00 PM	Tang, Bofeng	The Transport of Solar Wind Electrons: Preliminary Results
SESSION ADJOURNS		
6:30 PM - 9: 30 PM	Group Dinner - Julia Room	

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AGENDA

THURSDAY, MARCH 9		
7:00 AM - 5:00 PM	Registration -Montana Foyer	
8:00 AM – 6:00 PM	GENERAL SESSION – Montana Ballroom	
CHAIR: Krimigis, S.		
8:00 AM - 8:25 AM	McComas, David	Seven Years of Imaging the Global Heliosphere with IBEX
8:25 AM - 8:50 AM	Bzowski, Maciej	First shot at synthesizing the Warm Breeze from first principles
8:50 AM - 9:15 AM	Sokol, Justyna	Anisotropy of the Distribution Function of Interstellar Neutral Gas in the Inner Heliosphere
9:15 AM - 9:40 AM	Reisenfeld, Daniel	Probing the Boundaries of the Heliosphere Using Observations of the Polar ENA Flux from IBEX and Cassini/INCA
9:40 AM - 10:05 AM	Gladstone, Randy	New Horizons Observations of Interplanetary Lyman alpha
10:05 AM - 10:30 AM	Morning Break - Ballroom Foyer	
CHAIR: Frisch, P.		
10:30 AM - 10:55 AM	Jokipii, Jack	Pressure Balance at the Heliopause
10:55 AM - 11:20 AM	Richardson, John	The Heliosheath at Solar Maximum
11:20 AM - 11:45 AM	Pogorelov, Nikolai	Physical Phenomena at the Heliospheric Interface
11:45 AM - 12:10 PM	Li, Hui	Plasma heating inside ICMEs by Alfvenic Fluctuations Dissipation
12:10 PM - 1:30 PM	Lunch Break – Julia Room	
CHAIR: Jokipii, R.		
1:30 PM - 1:55 PM	Washimi, Haruichi	Time-Varying Heliospheric Size due to Long- and Short-Time Variations in Solar Activity
1:55 PM - 2:20 PM	Swaczyna, Pawel	Imaging Heliosphere with Energetic Neutral Atoms of Heavy Elements - Perspectives for ENA Detectors on IMAP
2:20 PM - 2:45 PM	Opher, Merav	The Twist of the Draped Interstellar Magnetic Field Ahead of the Heliopause
2:45 PM - 3:10 PM	Fuselier, Stephen	Reconnection at the Heliopause: Predictions for Voyager 2
3:10 PM - 3:35 PM	Frisch, Priscilla	Interstellar Magnetic Field Direction Near the Heliosphere
3:35 PM - 3:55 PM	Afternoon Break - Ballroom Foyer	
CHAIR: Pogorelov, N.		
3:55 PM - 4:20 PM	Qin, Gang	Time-dependent Modulation of Glactic Cosmic Rays in the Inner Heliosphere
4:20 PM - 4:45 PM	Czechowski, Andrzej	Heliosphere in a Strong Interstellar Magnetic Field
4:45 PM - 5:10 PM	Florinski, Vladimir	Large-scale Magnetic Fluctuations in the Outer Heliosheath and Galactic Cosmic-ray Depletions at the 90 Degree Pitch Angle
5:10 PM - 5:35 PM	Zirnstein, Eric	Structure of the Heliotail from Interstellar Boundary Explorer Observations: Implications for the 11 Year Solar Cycle and Pickup Ions in the Heliosheath
5:35 PM - 6:00 PM	Wood, Brian	A Search for Secondary He in Ulysses/GAS Data
SESSION ADJOURNS		

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AGENDA

FRIDAY, MARCH 10		
7:00 AM - 5:00 PM	Registration –Montana Foyer	
8:00 AM – 6:00 PM	GENERAL SESSION – Montana Ballroom	
CHAIR: Kahler, S.		
8:00 AM - 8:25 AM	Cooper, John	Outer Heliospheric and Local Interstellar Environments of Extreme Kuiper Belt Objects and Planets
8:25 AM - 8:50 AM	Li, Hui	Parametric Decay Instability of Alfven Waves and Particle Heating in Low-Beta Plasmas
8:50 AM - 9:15 AM	Le, Ari	Enhanced Electron Heating and Mixing in a 3D Kinetic Simulation for MMS Magnetopause Crossings with Weak Guide Fields
9:15 AM - 9:40 AM	Malkov, Mikhail	Transport of Energetic Particles in Astrophysical Plasmas: from Rectilinear to Diffusive Propagation
9:40 AM - 10:05 AM	Lembege, Bertrand	Microturbulence within the Front of a Quasi-perpendicular Supercritical Shock
10:05 AM - 10:30 AM	Morning Break - Ballroom Foyer	
CHAIR: Zank, G.		
10:30 AM - 10:55 AM	Mazelle, Christian	Martian Electron Foreshock: New Results from MAVEN and Comparison with Terrestrial Electron Foreshock
10:55 AM - 11:20 AM	Parks, George	Mass, Charge and Energy Dependence of Solar Wind Interaction with Earth's Bow Shock
11:20 AM - 11:45 AM	Weidl, Martin	Parallel Collisionless Shocks Forming in Simulations of the LAPD Experiment
END OF CONFERENCE		

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TALKS BY PARTICIPANT

Adhikari, Laxman	Wed, March 8	11:45 AM - 12:10 PM	Transport of Nearly Incompressible Magnetohydrodynamic Turbulence from 1 - 75 AU
Antiochos, Spiro	Mon, March 6	8:00 AM - 8:25 AM	Implications of the S-Web Model for Impulsive SEPs
Baker, Daniel	Tue, March 7	9:40 AM - 10:05 AM	New Results Concerning Particle Energization in Earth's Van Allen Radiation Belts
Boldyrev, Stanislav	Wed, March 8	9:40 AM - 10:05 AM	Inertial Kinetic-Alfven and Whistler Turbulence in a Non-isothermal Plasma
Bucik, Radoslav	Mon, March 6	8:25 AM - 8:50 AM	Energetic Particles of Anomalous Composition in Helical Jets on the Sun
Bzowski, Maciej	Thu, March 9	8:25 AM - 8:50 AM	First shot at synthesizing the Warm Breeze from first principles
Chapman, Sandra	Wed, March 8	5:10 PM - 5:35 PM	Quantifying the Variability of the Solar Wind and its Solar Cycle Dependence
Coates, Andrew	Tue, March 7	10:30 AM - 10:55 AM	Pickup Particle Acceleration at Comets, Moons and Magnetospheres
Consolini, Giuseppe	Wed, March 8	8:50 AM - 9:15 AM	A Hilbert-Huang Transform Approach to Space Plasma Turbulence at Kinetic Scales
Cooper, John	Fri, March 10	8:00 AM - 8:25 AM	Outer Heliospheric and Local Interstellar Environments of Extreme Kuiper Belt Objects and Planets
Cummings, Alan	Tue, March 7	11:20 AM - 11:45 AM	Cosmic Rays at the Voyagers: Updates of the GCRs in the LISM and Evidence for the Acceleration Site of ACRs
Czechowski, Andrzej	Thu, March 9	4:20 PM - 4:45 PM	Heliosphere in a Strong Interstellar Magnetic Field
Fisk, Len	Mon, March 6	10:30 AM - 10:55 AM	The Pump Acceleration Mechanism: One More Try
Florinski, Vladimir	Thu, March 9	4:45 PM - 5:10 PM	Large-scale Magnetic Fluctuations in the Outer Heliosheath and Galactic Cosmic-ray Depletions at the 90 Degree Pitch Angle
Frisch, Priscilla	Thu, March 9	3:10 PM - 3:35 PM	Interstellar Magnetic Field Direction Near the Heliosphere
Fuselier, Stephen	Thu, March 9	2:45 PM - 3:10 PM	Reconnection at the Heliopause: Predictions for Voyager 2
Gary, S. Peter	Wed, March 8	2:45 PM - 3:10 PM	Electron and Ion Heating by Kinetic Range Turbulence: Three-Dimensional Particle-in-Cell Simulations
Gedalin, Michael	Tue, March 7	1:30 PM - 1:55 PM	Probabilistic Shock Crossing and Diffusive Acceleration
Giacalone, Joe	Wed, March 8	1:55 PM - 2:20 PM	The Acceleration of Solar Wind Protons and Minor Ions at a Strong, Quasi-Parallel, Interplanetary Shock
Gladstone, Randy	Thu, March 9	9:40 AM - 10:05 AM	New Horizons Observations of Interplanetary Lyman alpha
Gloeckler, George	Mon, March 6	10:55 AM - 11:20 AM	Implementation of IMAP Science Objectives
Golla, Thejappa	Wed, March 8	2:20 PM - 2:45 PM	In Situ Waves Observed in the Vicinity of Interplanetary Shocks
Gopalswamy, Nat	Wed, March 8	4:45 PM - 5:10 PM	A Hierarchical Relationship between the Fluence Spectra and CME Kinematics in Large Solar Energetic Particle Events
Guo, Xiaocheng	Tue, March 7	10:55 AM - 11:20 AM	Numerical Simulation of Cosmic Rays Effects on the Structure of the Heliosphere
Guo, Fan	Mon, March 6	2:45 PM - 3:10 PM	Nonthermal Particle Acceleration in Three-dimensional Magnetic Reconnection
Hill, Matthew	Tue, March 7	3:10 PM - 3:35 PM	New Horizons/PEPSSI Measurements of Suprathermal and Pickup Ions, Energetic Particles, and Cosmic Rays in the Heliosphere During Transient Shock Events
Hunana, Peter	Wed, March 8	1:30 PM - 1:55 PM	On the Parallel and Oblique Firehose Instability in Fluid Models

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Intriligator, Devrie	Mon, March 6	11:20 AM - 11:45 AM	Multispacecraft Observations of Large-Scale Propagation and Dynamic Effects in the Heliosphere and Interactions with the Local Interstellar Medium
Jeffrey, Natasha	Mon, March 6	8:50 AM - 9:15 AM	Non-Gaussian Velocity Distributions in Solar Flares from Extreme Ultraviolet Lines: A Possible Diagnostic of Ion Acceleration
Jokipii, Jack	Thu, March 9	10:30 AM - 10:55 AM	Pressure Balance at the Heliopause
Kahler, Stephen	Mon, March 6	9:40 AM - 10:05 AM	A Comparison of Flare Reconnection Fluxes with SEP Events
Klein, Kristopher	Wed, March 8	3:10 PM - 3:35 PM	A General Method for Instability Identification in Solar Wind Observations as Illustrated by Particular Application to WIND Observations
Kong, Xiangliang	Mon, March 6	12:10 PM - 12:35 PM	Particle Acceleration at Coronal Shocks: the Effect of Large-scale Streamer-like Magnetic Field Structures
Krimigis, Stamatios	Mon, March 6	11:20 AM - 11:45 AM	Cassini/INCA ENA Solar Cycle Dependence and Voyager Ions in the Heliosheath Suggest a "Bubble" Model of the Heliosphere
Kucharek, Harald	Mon, March 6	3:55 PM - 4:20 PM	Sensing the Plasma Flows Around the Heliopause: Consequences for the Shape of the Heliosphere
Kumar, Rahul	Mon, March 6	3:10 PM - 3:35 PM	Preferential Heating and Acceleration of Heavy Ions in Alfven Turbulence
Lario, David	Tue, March 7	3:55 PM - 4:20 PM	Large Energetic Particle Pressures in Solar Cycles 23 and 24
Le, Ari	Fri, March 10	8:50 AM - 9:15 AM	Enhanced Electron Heating and Mixing in a 3D Kinetic Simulation for MMS Magnetopause Crossings with Weak Guide Fields
le Roux, Jakobus	Mon, March 6	9:15 AM - 9:40 AM	Acceleration of Solar Energetic Particles at a Fast Traveling Shock in Nonuniform Coronal Conditions
Lembege, Bertrand	Fri, March 10	9:40 AM - 10:05 AM	Microturbulence within the Front of a Quasi-perpendicular Supercritical Shock
Leske, Richard	Tue, March 7	1:55 PM - 2:20 PM	Improved Understanding of Peculiar Anisotropy Observations in the 23 July 2012 SEP Event
Li, Hui	Fri, March 10	8:25 AM - 8:50 AM	Parametric Decay Instability of Alfven Waves and Particle Heating in Low-Beta Plasmas
Li, Hui	Thu, March 9	11:45 AM - 12:10 PM	Plasma heating inside ICMEs by Alfvenic Fluctuations Dissipation
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Li, Gang	Tue, March 7	4:45 PM - 5:10 PM	Some Issues on Particle Acceleration and Transport in the Inner Heliosphere
Lin, Yu	Tue, March 7	8:25 AM - 8:50 AM	Transport in the Magnetotail associated with Magnetic Reconnection and Fast Flows
Livadiotis, George	Mon, March 6	4:20 PM - 4:45 PM	Statistical Origin and Properties of Kappa Distributions
Lu, Quanming	Mon, March 6	1:55 PM - 2:20 PM	The Role of Magnetic Islands in Electron Acceleration during Magnetic Reconnection
Luhmann, Janet	Wed, March 8	4:20 PM - 4:45 PM	Observer Magnetic Field Mapping to ICME Shocks: Implications of ENLIL Results for Shock Normal Angle Influences
Malkov, Mikhail	Fri, March 10	9:15 AM - 9:40 AM	Transport of Energetic Particles in Astrophysical Plasmas: from Rectilinear to Diffusive Propagation
Manchester, Ward	Wed, March 8	3:55 PM - 4:20 PM	The Evolution of Alfven-wave Turbulence at CME-driven Shocks
Matthaeus, William	Wed, March 8	9:15 AM - 9:40 AM	Kinetic Plasma Turbulence: Energy Cascade, Coherent Atructures, and Heating of Protons and Electrons
Mazelle, Christian	Fri, March 10	10:30 AM - 10:55 AM	Martian Electron Foreshock: New Results from MAVEN and Comparison with Terrestrial Electron Foreshock

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McComas, David	Thu, March 9	8:00 AM - 8:25 AM	Seven Years of Imaging the Global Heliosphere with IBEX
McKenzie, David	Wed, March 8	8:00 AM - 8:25 AM	Recent Findings from High-Resolution Observations of Turbulent Motions in Solar Flare Current Sheets
Medvedev, Mikhail	Tue, March 7	12:10 PM - 12:35 PM	Quasi-collisional Magneto-optic Effects in Turbulent ISM Plasmas. Anomalous Faraday Rotation
Mewaldt, Richard	Tue, March 7	5:10 PM - 5:35 PM	What Caused the Large Deficit of High-Energy Solar Particles in Solar Cycle 24?
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Oka, Mitsuo	Tue, March 7	8:50 AM - 9:15 AM	Stochastic Electron Acceleration by Whistler Waves within Earth's Bow Shock Layer
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Parks, George	Fri, March 10	10:55 AM - 11:20 AM	Mass, Charge and Energy Dependence of Solar Wind Interaction with Earth's Bow Shock
Pogorelov, Nikolai	Thu, March 9	11:20 AM - 11:45 AM	Physical Phenomena at the Heliospheric Interface
Qin, Gang	Thu, March 9	3:55 PM - 4:20 PM	Time-dependent Modulation of Glactic Cosmic Rays in the Inner Heliosphere
Raymond, John	Tue, March 7	2:20 PM - 2:45 PM	Ion-Ion Equilibration in a Fast Shock Wave
Reeves, Geoffrey	Mon, March 6	4:45 PM - 5:10 PM	Energy-Dependent Dynamics and Coupling in the Van Allen Radiation Belts
Reisenfeld, Daniel	Thu, March 9	9:15 AM - 9:40 AM	Probing the Boundaries of the Heliosphere Using Observations of the Polar ENA Flux from IBEX and Cassini/INCA
Richardson, John	Thu, March 9	10:55 AM - 11:20 AM	The Heliosheath at Solar Maximum
Roelof, Edmond	Tue, March 7	2:45 PM - 3:10 PM	Acceleration and Propagation of Anomalous Cosmic Rays and Near-Relativisitic Electrons in the Heliosheath
Salem, Chadi	Wed, March 8	8:25 AM - 8:50 AM	Solar Wind Electron Microphysics and Kinetic-Scale Electromagnetic Fluctuations in the Solar Wind at 1 AU
Smith, Charles	Wed, March 8	10:30 AM - 10:55 AM	Observations of Low-Frequency Magnetic Waves due to Newborn Interstellar Pickup Ions Using ACE, Ulysses, and Voyager Data
Sokol, Justyna	Tue, March 7	6:00 PM - 6:10 PM	Polar Conic Current Sheets as Sources of Energetic Particles in the High-latitude Heliosphere during Solar Minima
Sokol, Justyna	Thu, March 9	8:50 AM - 9:15 AM	Anisotropy of the Distribution Function of Interstellar Neutral Gas in the Inner Heliosphere
Stone, Edward	Tue, March 7	11:45 AM - 12:10 PM	The Voyager Interstellar Mission, a Continuing Journey of Exploration
Swaczyna, Pawel	Thu, March 9	1:55 PM - 2:20 PM	Imaging Heliosphere with Energetic Neutral Atoms of Heavy Elements - Perspectives for ENA Detectors on IMAP
Swisdak, Marc	Mon, March 6	1:30 PM - 1:55 PM	Electron Acceleration During Magnetic Reconnection
Tang, Bofeng	Wed, March 8	5:35 PM - 6:00 PM	The Transport of Solar Wind Electrons: Preliminary Results
Tenishev, Valeriy	Mon, March 6	5:10 PM - 5:35 PM	Local Time Dependence of the Energetic Particle Population in the near Earth Environment
Usmanov, Arcadi	Wed, March 8	10:55 AM - 11:20 AM	A Global MHD Simulation of the Solar Corona, Solar Wind and Heliosphere with Turbulence Transport
Wang, Linghua	Tue, March 7	8:00 AM - 8:25 AM	The Injection of Electron/3He-rich SEP Events
Washimi, Haruichi	Thu, March 9	1:30 PM - 1:55 PM	Time-Varying Heliospheric Size due to Long- and Short-Time Variations in Solar Activity
Weidl, Martin	Fri, March 10	11:20 AM - 11:45 AM	Parallel Collisionless Shocks Forming in Simulations of the LAPD Experiment

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Wood, Brian	Thu, March 9	5:35 PM - 6:00 PM	A Search for Secondary He in Ulysses/GAS Data
Yan, Huirong	Tue, March 7	5:35 PM - 6:00 PM	Cross Field Transport of Cosmic Ray in MHD Turbulence
Yoon, Peter	Tue, March 7	9:15 AM - 9:40 AM	Turbulent Equilibria for Charged Particles in Space
Zank, Gary	Wed, March 8	11:20 AM - 11:45 AM	A Nearly Incompressible Description of Low-Frequency Turbulence in the Solar Wind
Zharkova, Valentina	Mon, March 6	11:45 AM - 12:10 PM	Particle Dynamics in Reconnecting Current Sheets of the Solar Corona and Heliosphere derived from 3D PIC Simulations
Zheng, Jinlei	Mon, March 6	5:35 PM - 6:00 PM	A comprehensive Small-scale Magnetic Flux Rope Database via Automated Detecting Algorithm Based on Grad-Shafranov Reconstruction Technique: Database and the Statistical Analysis
Zirnstein, Eric	Thu, March 9	5:10 PM - 5:35 PM	Structure of the Heliotail from Interstellar Boundary Explorer Observations: Implications for the 11 Year Solar Cycle and Pickup Ions in the Heliosheath

SCHEDULE OF TALKS

NOTES

Monday, March 6: 8:00 AM - 8:25 AM
Presenter: Antiochos, Spiro

Implications of the S-Web Model for Impulsive SEPs

S. K. Antiochos, NASA/GSFC, USA
A. K. Higginson, NASA/GSFC, USA
C. R. DeVore, NASA/GSFC, USA
B. J. Lynch, UC Berkeley, USA

One of the most important discoveries of the STEREO mission is that impulsive Solar Energetic Particle (SEP) events frequently exhibit large longitudinal spread in the heliosphere, up to 100 degrees or more. This result is especially puzzling given the long-standing observations that impulsive SEPs originate in highly localized regions in the corona, angular extent less than one degree, and that the SEPs generally show so-called drop-outs, effectively ruling out diffusion as a mechanism for the observed spread. We discuss the implications of the S-Web slow solar wind model for the propagation of SEPs and their distribution in the heliosphere. We present recent 3D MHD simulations demonstrating that for commonly-observed coronal magnetic topologies, the connectivity of the corona to heliosphere will be quasi-singular, with small regions near the Sun connecting to giant arcs in the heliosphere that span tens of degrees in both latitude and longitude. We also discuss the implications of the simulations for the particle acceleration process itself, in particular, via the formation of numerous magnetic islands in the inner heliosphere. Finally, we discuss the implications for observations from the upcoming Solar Orbiter and Solar Probe Plus missions, which will measure impulsive SEPs near the Sun, thereby, mitigating propagation effects.
This research was supported, in part, by the NASA SR and LWS Programs.

Monday, March 6: 8:25 AM - 8:50 AM
Presenter: Bucik, Radoslav

Energetic Particles of Anomalous Composition in Helical Jets on the Sun

R. Bucik, University of Göttingen & Max Planck Institute for Solar System Research, Germany
D. E. Innes, Max Planck Institute for Solar System Research, Germany
G. M. Mason, Applied Physics Laboratory, Johns Hopkins University, USA
M. E. Wiedenbeck, Jet Propulsion Laboratory, California Institute of Technology, USA
R. Gomez-Herrero, Space Research Group, University of Alcala, Spain
N. V. Nitta, Lockheed Martin Advances Technology Center, USA

Particle acceleration in stellar flares is ubiquitous in the Universe, though, our Sun is the only astrophysical object where the energetic particles and their source flares can be jointly observed. Acceleration mechanism in solar flares, tremendously enhancing (up to factors of ten thousand) rare elements like 3He and ultra-heavy nuclei, has been puzzling for almost 50 years. Here we present the most intense 3He- and Fe-rich solar energetic particle events so far reported. The high-resolution extreme-ultraviolet imaging observations revealed for the first time a helical structure in the source flare with jet-like shape. The events were observed with two Solar Terrestrial Relations Observatories STEREO on backside of the Sun, and hidden from the Earth view, during the period of increased solar activity in 2014. The new observations suggest that swirling motion in solar flares appears to be related to production of energetic particles with anomalous composition.

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Monday, March 6: 8:50 AM - 9:15 AM
Presenter: Jeffrey, Natasha

Non-Gaussian Velocity Distributions in Solar Flares from Extreme Ultraviolet Lines: A Possible Diagnostic of Ion Acceleration

Natasha L. S. Jeffrey, School of Physics & Astronomy, University of Glasgow, UK.
Lyndsay Fletcher, School of Physics & Astronomy, University of Glasgow, UK.
Nicolas Labrosse, School of Physics & Astronomy, University of Glasgow, UK.

In a solar flare, a large fraction of the magnetic energy released is converted rapidly to the kinetic energy of non-thermal particles and bulk plasma motion. This will likely result in non-equilibrium particle distributions and turbulent plasma conditions. We investigate this by analysing the profiles of high-temperature extreme ultraviolet emission lines from a major flare (SOL2014-03-29T17:44) observed by the EUV Imaging Spectrometer (EIS) on Hinode. We find that in many locations the line profiles are non-Gaussian, consistent with a kappa-distribution of emitting ions with properties that vary in space and time. At the flare footpoints, close to sites of hard X-ray emission from non-thermal electrons, the kappa-index for the Fe XVI 262.976 angstrom line at 3 MK takes values of 3-5. In the corona, close to a low-energy HXR source, the Fe XXIII 263.760 angstrom line at 15 MK shows kappa values of typically 4-7. The observed trends in the kappa parameter show that we are most likely detecting the properties of the ion population rather than any instrumental effects. We calculate that a non-thermal ion population could exist if locally accelerated on timescales < 0.1 s. However, observations of net redshifts in the lines also imply the presence of plasma downflows which could lead to bulk turbulence, with increased non-Gaussianity in cooler regions. Both interpretations have important implications for theories of solar flare particle acceleration.

Monday, March 6: 9:15 AM - 9:40 AM
Presenter: le Roux, Jakobus

Acceleration of Solar Energetic Particles at a Fast Traveling Shock in Nonuniform Coronal Conditions

Jakobus A. le Roux, University of Alabama in Huntsville, USA
Aaron D. Arthur, University of Alabama in Huntsville, USA

We used a time-dependent focused transport model to simulate the diffusive shock acceleration (DSA) of SEPs at a fast traveling quasi-parallel shock driven by a coronal mass ejection (CME) in the highly non-uniform plasma conditions in the corona. Results will be presented to illustrate that the DSA process becomes highly time-dependent because of the rapid variation of these coronal properties with heliocentric distance, thus producing SEP spectra that differ substantially from the predictions of standard steady-state DSA theory. Additionally, the model includes SEP interaction with MHD wave turbulence in terms of gyro-resonant interactions with parallel propagating Alfven waves to simulate self-consistent time-dependent amplification of Alfven waves by the shock accelerated SEPs streaming ahead of the shock. It will be shown and discussed how the initial strong SEP pitch-angle anisotropy at lower energies and associated strong upstream wave growth both weaken in a highly time-dependent fashion, but still generate significantly more efficient DSA of SEPs compared to when wave growth is neglected. Interestingly, the simulations of Alfven wave transport predict the development of a large peak in the Alfven wave energy density downstream that might have interesting potential implications for additional SEP energization by 2nd order Fermi acceleration and SEP trapping to potentially benefit SEP injection and DSA at a trailing CME shock that needs further exploration.

SCHEDULE OF TALKS

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Monday, March 6: 9:40 AM - 10:05 AM
Presenter: Kahler, Stephen

A Comparison of Flare Reconnection Fluxes with SEP Events

Stephen Kahler, AFRL, USA
Maria Kazachenko, UC Berkeley, USA
Ben Lynch, UC Berkeley, USA
Brian Welsch, U Wisconsin G.B., USA

The primary solar sources of energetic (E > 20 MeV) particles are flares and CME-driven shocks. Some studies claim that even up to GeV energies solar flares are major contributors to SEP events. There are several candidate flare processes for producing SEPs, but acceleration in magnetic reconnection regions is probably the most efficient. Previous studies have relied on flare radiation signatures to determine the times and locations of SEP injections. An alternative approach is to use the amount of magnetic flux that gets reconnected during solar flares. The photospheric magnetic flux swept out by flare ribbons is thought to be directly related to the amount of magnetic reconnection in the corona and is therefore a key diagnostic tool for understanding the physical processes in flares and CMEs. We use the database of flare magnetic reconnection fluxes and peak reconnection rates to compare these parameters with SEP properties. We find that while sizes of ~ 25 MeV SEP events in the western hemisphere correlate with both CME speeds and reconnection fluxes, there are many cases of large reconnection fluxes with no observed SEP events. The occurrence of large reconnection fluxes accompanied by slow CMEs but no SEP events suggests that the CME shocks are the primary, if not the only, sources of high energy (E > 100 MeV) SEP events.

Monday, March 6: 10:30 AM - 10:55 AM
Presenter: Fisk, Len

The Pump Acceleration Mechanism: One More Try

L.A. Fisk, Department of Climate & Space, University of Michigan, USA

Starting in the early 2000s, I developed a theory for a pump acceleration mechanism to account in detail for the ubiquitously observed so-called -5 spectra, a distribution function that is a power law in particle speed with spectral index of -5. Of all the theories I have developed in my career, this one has seen no general use in explaining data and relatively little constructive discussion. With this talk, I will make another attempt to interest experimentalists and theorists in using and expanding on the pump acceleration mechanism. The inevitability of the pump acceleration occurring in conditions that are common in space plasmas will be discussed, along with supporting numerical studies and observations.

Monday, March 6: 10:55 AM - 11:20 AM
Presenter: Gloeckler, George

Implementation of IMAP Science Objectives

G. Gloeckler, Department of Climate and Space, University of Michigan, USA
L.A. Fisk, Department of Climate and Space, University of Michigan, USA

The Interstellar Mapping and Acceleration Probe (IMAP) mission provides an unprecedented opportunity to explore in detail the spatial and temporal variations of charged particle velocity distribution functions in the global heliosheath and, for the first time, the ionized particle spectra in nearby interstellar space. Equally important, IMAP will finally allow us to determine the most common mechanisms for efficient particle acceleration. Here we list which measurements are required to achieve these science objectives, and the type of advanced instruments—which are now possible to build based on flight proven technology—that will provide these measurements. In particular, we will describe the capabilities and requirements for a Solar wind and Pickup Ion Composition and Energy spectrometer (SPICES) that will provide high sensitivity, fine time resolution measurements of full 3-D distribution functions of ions, which will enable us to rigorously test predictions of the pump acceleration mechanism discussed by Fisk elsewhere in this conference. We will briefly mention how it should be possible to configure SPICES to also measure ENAs with high sensitivity, especially the lowest energy (below 1 eV) ENAs, and to measure the composition of the neutral gas.

Monday, March 6: 11:20 AM - 11:45 AM
Presenter: Krimigis, Stamatios

Cassini/INCA ENA Solar Cycle Dependence and Voyager Ions in the Heliosheath Suggest a "Bubble" Model of the Heliosphere

S. M. Krimigis, JHU/APL, USA
K. Dialynas, Academy of Athens, Greece
D. G. Mitchell, JHU/APL, USA
R. B. Decker, JHU/APL, USA
E. C. Roelof, JHU/APL, USA

Using the Cassini/INCA (Ion and Neutral Camera), we have produced all-sky ENA-hydrogen maps over a 13-year time period (2003-2016) in four discrete energy passbands within the energy range of 5.2-55 keV. We compare the solar cycle variation of the > 5.2 keV ENAs in both the heliospheric “nose” (upstream) and “anti-nose” (downstream) directions and find that the ENA intensities not only follow the solar cycle (SC) variation to a minimum and then a recovery, but also exhibit a very similar time profile in both the nose and anti-nose directions. By comparing the time profile of V1, V2 ion measurements in the Heliosheath (HS) with the ENA in overlapping energy bands we are able to show that the source of the observed ENAs is in the HS. Further, using the V1, V2 ions we predict the in situ ENA intensities using observed neutrals density and the HS width seen by V1 (~29 AU) and estimated (~ 70 AU) for V2, thus strengthening the case for the HS source of the ENA. The similarity between > 5.2 keV anti-nose ENAs, > 24 keV nose ions and the 5.2 <E< 24 keV ENA present a compelling case that the modulation of super-thermal ions over the SC is global throughout the HS. Taken together, the ~3-year time delay between ENA recovery from minimum in the anti-nose direction and solar activity, (as manifested by the solar sunspot number used as proxy for the solar wind), the coherence of the time profile between the nose and anti-nose ENAs, for standard solar wind speed about 400-800 km/s and ion speed inside the HS (~100 km/s), enable us to estimate that the HP towards the tail could perhaps extend up to < 200AU. These observations, together with the recent V1 measurement of a BISM about 0.5 nT (a strong ISMF, per Parker's 1961 model), strongly suggest that the heliosphere resembles a diamagnetic bubble with no significant tail-like feature, also consistent with some recent MHD simulations and models.

Monday, March 6: 11:45 AM - 12:10 PM
Presenter: Zharkova, Valentina

Particle Dynamics in Reconnecting Current Sheets of the Solar Corona and Heliosphere derived from 3D PIC Simulations

Zharkova V.V., Northumbria University, UK
Khabarova O.V., IZMIRAN, Russia

We discuss specifics of particle acceleration in reconnecting current sheets with different magnetic field topologies in the solar corona and heliosphere. Particles of fast solar wind in solar flares, or in a vicinity of the heliospheric current sheet (HCS) or in a front of Interplanetary Coronal Mass Ejections (ICMEs) often reveal very peculiar energy/velocity profiles, density distributions with double or triple peaks and well defined streams of electrons occurring about or far away from these events. While in flares the signature of energetic particles can be strongly obscured by transport effects and thus difficult to directly compare with models without some additional assumptions, the parameters of solar wind particles can be measured from in-situ observations. In order to interpret the parameters of energetic particles (both ions and electrons) measured by the WIND payload during the HCS crossings a comparison of the data was carried with the 3D Particle-In-Cell (PIC) simulations for the scaled magnetic topology (Zharkova & Khabarova, 2012, 2015). The simulations showed very close fit to the observed particle energy distributions, densities, ion peak velocities, electron pitch-angles and directivities measured the heliospheric current sheet. The measured particle characteristics (ion velocity, electron pitch angles and the distance at which electrons are turned from the HCS) are in agreement with the simulations of additional particle acceleration in a reconnecting HCS with strong guiding field as measured by WIND. There is also additional acceleration occurring at the front ICME current sheets, which can explain anti-correlation of ion and electron fluxes and their appearance on the opposite sides from the ICME front (”strahls”), which cannot be produced by shock acceleration often assumed for particles near ICMEs. We also explain the conditions for generation of different types of turbulence by accelerated particles in different magnetic field topologies relevant to the solar corona and heliosphere.

Monday, March 6: 12:10 PM - 12:35 PM
Presenter: Kong, Xiangliang

Particle Acceleration at Coronal Shocks: the Effect of Large-scale Streamer-like Magnetic Field Structures

Xiangliang Kong, Shandong University, China
Fan Guo, Los Alamos National Laboratory, USA
Joe Giacalone, University of Arizona, USA
Hui Li, Los Alamos National Laboratory, USA
Yao Chen, Shandong University, China

Large gradual solar energetic particle (SEP) events are of particular importance because of their hazardous threats to astronauts and equipment in space. Although there are compelling observational evidence supporting the scenario of particle acceleration at strong shocks driven by coronal mass ejections, it is not clear how those high-energy particles are accelerated and what the determining factors are in producing extremely large events. Recent observations have shown that in extreme large SEP events the CME-shocks develop and accelerate particles at heights very close to the Sun (<3 solar radii). Motivated by this, we present an SEP acceleration study including the process that a strong shock propagates through a streamer-like magnetic field in the low corona region. Particle acceleration is modeled by numerically solving the Parker transport equation with both spatial diffusion along and across the magnetic field. We show that particles can be sufficiently accelerated to up to a few hundred MeV within a few solar radii. In the streamer-like field case, particles are more efficiently accelerated compared to the case with a simple radial magnetic field. This suggests that the coronal magnetic field configuration is an important factor for producing large SEP events. We also discuss the distribution of particles as they propagate in the shock region with changing magnetic field geometry at the shock front, which may offer predictions of energetic particles that Solar Probe Plus can test.

Monday, March 6: 1:30 PM - 1:55 PM
Presenter: Swisdak, Marc

Electron Acceleration During Magnetic Reconnection

Marc Swisdak, University of Maryland, USA
Joel Dahlin, NASA GSFC, USA
Jim Drake, University of Maryland, USA

Magnetic reconnection is an important source of energetic particles in many astrophysical phenomena including solar flares and magnetospheric storms. Kinetic PIC simulations reveal that the efficiency of electron acceleration is highly sensitive to the magnitude of the guide field (the field component perpendicular to the reconnection plane).
When the guide field is smaller than the reconnecting component, the dominant electron accelerator is a Fermi-type mechanism that preferentially energizes the most energetic particles. In strong guide field reconnection, the field-line contraction that drives the Fermi mechanism becomes weak. Instead, parallel electric fields are primarily responsible for driving electron heating but are ineffective in driving the energetic component of the spectrum. Three-dimensional simulations reveal that the stochastic magnetic field that develops during 3D guide field reconnection plays a vital role in particle acceleration and transport. In 2D systems, electrons are trapped within stagnant magnetic island cores so that acceleration is suppressed, whereas in 3D the stochastic magnetic field enables energetic electrons to freely sample regions where energy release is taking place. In 3D systems with a weak guide field, however, transport is diminished and electron acceleration is suppressed as in the 2D case.
These results suggest that the most efficient electron acceleration occurs in reconnection with a moderate guide field so that both the Fermi mechanism is an efficient driver and energetic electrons may freely access acceleration sites. This has important implications for electron acceleration in solar flares and reconnection-driven turbulent dissipation.

Monday, March 6: 1:55 PM - 2:20 PM
Presenter: Lu, Quanming

The Role of Magnetic Islands in Electron Acceleration during Magnetic Reconnection

Quanming Lu, School of Earth and Space Sciences, University of Science and Technology of China, Hefei, China
Can Huang, School of Earth and Space Sciences, University of Science and Technology of China, Hefei, China
Shui Wang, School of Earth and Space Sciences, University of Science and Technology of China, Hefei, China

Magnetic reconnection converts magnetic energy rapidly into plasma kinetic energy, at the same time, the topology of magnetic field lines also changes. During such a process, magnetic islands can be generally generated due to the tearing mode instability, and they are considered to play an important role in electron acceleration. With particle-in-cell simulations combined with satellite observations, we investigate mechanisms of electron acceleration during the evolution of magnetic islands, including the contract and coalescence of magnetic islands, and evaluate the roles of the mechanism of parallel electric field, betatron and Fermi acceleration.

Monday, March 6: 2:20 PM - 2:45 PM
Presenter: Li, Xiaocan

The Role of Fluid Compression in Particle Energization during Magnetic Reconnection

Xiaocan Li, Los Alamos National Lab, USA
Fan Guo, Los Alamos National Lab, USA
Hui Li, Los Alamos National Lab, USA
Gang Li, Department of Space Science and CSPAR, The University of Alabama in Huntsville, USA

Theories of particle transport and acceleration have shown that fluid compression is the leading mechanism for particle energization. However, the role of compression in particle energization during magnetic reconnection is unclear. We address this issue using two approaches. First, using fully kinetic simulations, we quantitatively calculate the effect of compression in particle energization during reconnection. We show that compression has an important contribution to the high energy particle energization. Based on this result, we then study the large-scale reconnection acceleration by solving the Parker's transport equation in a background reconnecting flow provided by MHD simulations. Due to the compressional effect, particles are accelerated to high energies and develop power-law energy distributions. This study clarifies the nature of particle acceleration in reconnection layer, and may be important to understand particle energization during solar flares.

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Monday, March 6: 2:45 PM - 3:10 PM
Presenter: Guo, Fan

Nonthermal Particle Acceleration in Three-dimensional Magnetic Reconnection

Fan Guo, LANL,
Xiaocan Li, LANL
Yi-Hsin Liu, NASA GSFC
Hui Li, LANL
William Daughton, LANL

Magnetic reconnection is a commonly known multi-scale plasma process that quickly converts magnetic energy into kinetic energy in bulk plasma flow, thermal and nonthermal particle distributions. An important problem that remains unsolved is the acceleration of nonthermal charged particles in the reconnection region. In particular, the large-scale theory and 3D extension of this problem are poorly known. To shed more lights to this problem, we utilize a number of tools to resolve this problem. Using LANL's VPIC code, we study particle acceleration in magnetic reconnection via large-scale 3D kinetic simulations to examine several effects that may be important, including pre-existing fluctuations, kink and secondary tearing instabilities, and open boundary conditions. The results show that particle acceleration in reconnection layers is surprisingly robust despite the development of 3D turbulence and instabilities. Furthermore, the observed particle acceleration in the 3D simulations is sometimes more efficient than the corresponding 2D case, indicating viable new acceleration mechanisms. This study clarifies the nature of particle acceleration in reconnection layer, and may be important to understand particle acceleration during astrophysical high-energy flares.

Monday, March 6: 3:10 PM - 3:35 PM
Presenter: Kumar, Rahul

Preferential Heating and Acceleration of Heavy Ions in Alfven Turbulence

David Eichler, Ben Gurion University, Israel
Massimo Gaspari, Princeton University, USA
Anatoly Spitkovsky, Princeton University, USA

We simulate decaying turbulence in a homogeneous pair plasma using a three-dimensional electromagnetic particle-in-cell method. A uniform background magnetic field permeates the plasma such that the magnetic pressure is three times larger than the thermal pressure and the turbulence is generated by counter-propagating shear Alfvén waves. The energy predominately cascades transverse to the background magnetic field, rendering the turbulence anisotropic at smaller scales. We simultaneously move several ion species of varying charge to mass ratios in our simulation and show that the particles of smaller charge to mass ratios are heated and accelerated to non-thermal energies at a faster rate. This is in accordance with the enhancement of heavy ions and a non-thermal tail in their energy spectrum observed in the impulsive solar flares. We further show that the heavy ions are energized mostly in the direction perpendicular to the background magnetic field, with a rate consistent with our analytical estimate of the rate of heating due to cyclotron resonance with the Alfvén waves, of which a large fraction is due to obliquely propagating waves

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Monday, March 6: 3:55 PM - 4:20 PM
Presenter: Kucharek, Harald

Sensing the Plasma Flows Around the Heliopause: Consequences for the Shape of the Heliosphere

H. Kucharek, University of New Hampshire, USA
J. Park, NASA Goddard Space Flight Center, USA
P. Isenberg, University of New Hampshire, USA
E. Moebius, University of New Hampshire, USA
N. Schwadron University of New Hampshire, USA

Remote sensing IBEX observations of the interstellar gas flow in the inner heliosphere provide the most detailed information about the physical conditions of the surrounding interstellar medium and the interaction of this flow with the heliosheath. An excellent diagnostic tool to probe this interaction is the secondary component of the interstellar neutral gas flow that originates from charge exchange between primary interstellar neutrals and the plasma outside the heliopause. The interstellar plasma is diverted around the heliosphere, and the neutrals that are emitted from this flow through charge exchange carry information on the diverted flow. Therefore, IBEX-lo sky maps of secondary neutral He, O, and H fluxes contain information on the interstellar plasma flow patterns and thus the shape of the heliosphere. With a theoretical model based on Hydro-Dynamic (HD) considerations we are able to determine the global shape of the heliosphere by estimating the local curvature of the diverting boundary. With this approach, current model predictions that are solely based on theories can likely be confirmed or disproved.

Monday, March 6: 4:20 PM - 4:45 PM
Presenter: Livadiotis, George

Statistical Origin and Properties of Kappa Distributions

George Livadiotis,
Southwest Research Institute, USA

Classical particle systems reside at thermal equilibrium with their velocity distribution function stabilized into a Maxwell distribution. On the contrary, collisionless and correlated particle systems, such as space and astrophysical plasmas, are characterized by a non-Maxwellian behavior, typically described by so-kappa distributions, or combinations thereof. Empirical kappa distributions have become increasingly widespread across space and plasma physics. A breakthrough in the field came with the connection of kappa distributions to non-extensive statistical mechanics. Understanding the statistical origin of kappa distributions was the cornerstone of further theoretical developments and applications, some of which will be presented in this talk: (i) The physical meaning of thermal parameters, e.g., temperature and kappa index; (ii) the N-particle description of kappa distributions; (iii) the generalization to phase-space kappa distribution of a Hamiltonian with non-zero potential; and (iv) the Sackur-Tetrode entropy for kappa distributions.

SCHEDULE OF TALKS

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Monday, March 6: 4:45 PM - 5:10 PM
Presenter: Reeves, Geoffrey

Energy-Dependent Dynamics and Coupling in the Van Allen Radiation Belts

Geoffrey D. Reeves

Radiation belt electrons in the inner magnetosphere are commonly described by an inner belt population close to the Earth, inside the plasmasphere, and an outer belt population outside the plasmasphere, separated by a “slot region”. This picture has influenced much of our interpretation of radiation belt events and has informed much of our understanding of the processes that control radiation belt structure and dynamics. Recent studies with Van Allen Probes, MMS, THEMIS, and other HSO data sets have added much nuance and richness to that simplistic picture.

One of the first results from the Van Allen Probes mission [Baker et al., 2013] showed that the outer zone can, at times, consist of two distinct belts (two spatial domains) at some energies while different energies still populate a single belt. Fennell et al., [2015] and Li et al., [2015] showed that, during the Van Allen Probes era there were no inner zone electrons with energies >1 MeV. In addition, Reeves et al., [2016] showed that the spatial extent of the inner zone was strongly energy-dependent with low energies (e.g. 50 keV) extending from L = 1 to 4 but high energies (e.g. 800 keV) extending L = 1 to only L ~ 1.2.

At high energies (e.g. >3 MeV) Baker et al., [2014] described an “impenetrable barrier” that restricted outer zone electrons to L >2.8 while Reeves et al., [2016] showed that electrons at lower energies commonly penetrated through the slot region and into the inner zone. Additionally, even when electrons did not penetrate through the slot, lower energies penetrated more deeply with a strikingly linear relationship between log(Energy) and L of the inner edge of the outer belt. Therefore, although the inner edge of the radiation belts may be at the plasmapause for one energy they cannot be co- located at other energies.

We will discuss how and why electrons at different energies occupy different spatial domains as well as how and why those domains change in time. Among the features to be investigated are the location, extent, or existence of the inner electron belt as a function of energy and time; the energy dependence of the inner edge of the outer belt and relationship to the plasmapause in both active and recovery times; and the location of the peak in outer belt fluxes as a function of geomagnetic activity (the Tverskaya relationship).

Monday, March 6: 5:10 PM - 5:35 PM
Presenter: Tenishev, Valeriy

Local Time Dependence of the Energetic Particle Population in the near Earth Environment

Valeriy Tenishev, University of Michigan, USA
Dmitry Borovikov, University of Michigan, USA
Michael R. Combi, University of Michigan, USA
Natalia Ganushkina, University of Michigan, USA
Tamas Gombosi, University of Michigan, USA

The Earth's energetic particle environment consists of several components of the ionizing radiation: galactic cosmic rays (GCRs), solar energetic particles (SEP), and particles populating two radiation belts. Of those, it is SEPs and GCRs that are critical for evaluating of the safety of the space operations performed in the LEO altitude range.
According to the current paradigm, GCRs are produced by diffusive shock acceleration in supernova remnants (e.g., Blandford & Eichler 1987) from which they diffuse to fill the whole galaxy. The composition of GCRs is dominated by H+ and He2+ (e.g., Simpson 1983; Mewaldt 1994). In order to be observed at the Earth, these charged particles have to penetrate the electromagnetic fields of the heliosphere, which is a region around the Sun extended further than 100 AU, and dominated by the solar-wind plasma and by the interplanetary magnetic field (IMF). SEPs are energetic particles ejected by the Sun in events that are correlated with coronal mass ejections (CMEs) and solar flares (e.g., Reames 1999).
In this presentation we will address fundamental questions of the local time dependence of GCRs and SEPs in the near Earth environment. That will be done by modeling of propagation of SEPs and GCRs in the magnetosphere using our Adaptive Mesh Particle Simulator (AMPS), which is a global Monte Carlo particle code describing dynamics of the relativistic particles affected by the geomagnetic field. We will discuss the spatial magnetospheric distribution of the energetic particles that span in the energy range from tens of MeV, and up to 10 GeV in the region starting from the Earth's magnetopause down to the LEO altitudes.

Monday, March 6: 5:35 PM - 6:00 PM
Presenter: Zheng, Jinlei

A comprehensive Small-scale Magnetic Flux Rope Database via Automated Detecting Algorithm Based on Grad-Shafranov Reconstruction Technique: Database and the Statistical Analysis

Jinlei Zheng, Department of Space Science, University of Alabama in Huntsville, USA
Qiang Hu, The Center for Space Plasma and Aeronomic Research, Department of Space Science, University of Alabama in Huntsville, USA

In this study, we built a comprehensive small-scale magnetic flux rope database based on the Grad-Shafranov (GS) reconstruction method. The GS reconstruction model [Hu and Sonnerup, 2001, 2002] is able to recover the non-symmetric geometry of the small-scale flux rope with a more general non-force-free configuration. Using our latest developed automated flux rope detection algorithm, we detected a large number of small-scale flux ropes with 10 ~ 180 minutes durations in the period ranging from 1996 to 2015 (covering two solar cycles). Besides rediscovering most of the events listed in other databases, we also discovered much more small-scale flux rope events which were not reported before. The detection result shows that the small-scale flux ropes are occurring more frequently than that of large-scale flux ropes, and the occurrence of small-scale magnetic flux ropes has strong solar cycle dependency. The statistical analysis on occurrence, plasma profile, solar wind speed, and axial orientation preferences of the small-scale flux ropes are presented and discussed. Results shows that besides the widely known aspects, such as proton temperature and plasma beta value, the small-scale flux ropes are more likely to occur in low-speed stream, and have orientation preferences along parker spiral. The relations between particle energization, shock, and small scale flux ropes are also discussed.

SCHEDULE OF TALKS

NOTES

Tuesday, March 7: 8:00 AM - 8:25 AM
Presenter: Wang, Linghua

The Injection of Electron/3He-rich SEP Events

Linghua Wang, Institute of Space Physics and Applied Technology, Peking University, China
Säm Krucker, Space Sciences Laboratory, University of California, Berkeley, USA
Glenn M. Mason, Applied Physics Laboratory, Johns Hopkins University, USA
Gang Li, Department of Space Science and CSPAR, University of Alabama in Huntsville, USA

We have derived the particle injections at the Sun for ten good electron/3He-rich solar energetic particle (SEP) events, using a 1.2 AU particle path length (suggested by analysis of the velocity dispersion). The inferred solar injections of high-energy (~10 to 300 keV) electrons and of ~MeV/nucleon ions (carbon and heavier) start with a delay of 17 ± 3 min and 75 ± 14 min, respectively, after the injection of low-energy (~0.4 to 9 keV) electrons. The injection duration (averaged over energy) ranges from ~200 to 550 min for ions, from ~90 to 160 min for low-energy electrons, and from ~10 to 30 min for high-energy electrons. Most of the selected events have no reported Hα flares or GOES SXR bursts, but all have type III radio bursts that typically start after the onset of a low-energy electron injection. All nine events with SOHO/LASCO coverage have a relatively fast (>570 km/s), mostly narrow (<30 deg), west-limb coronal mass ejection (CME) that launches near the start of the low-energy electron injection, and reaches an average altitude of ~1.0 and 4.7 Rs, respectively, at the start of the high-energy electron injection and of the ion injection. The electron energy spectra show a continuous power law extending across the transition from low to high energies, suggesting that the low-energy electron injection may provide seed electrons for the delayed high-energy electron acceleration. The delayed ion injections and high ionization states may suggest an ion acceleration along the lower-altitude flanks, rather than at the nose of the CMEs.

Tuesday, March 7: 8:25 AM - 8:50 AM
Presenter: Lin, Yu

Transport in the Magnetotail associated with Magnetic Reconnection and Fast Flows

Yu Lin, Auburn University, USA
Xueyi Wang, Auburn University, USA
San Lu, UCLA, USA
Joe Perez, Auburn University, USA
Jay Johnson, Andrews Unversity, USA
Simon Wing, JHU/APL, USA
Quanming Lu, USTC, China

A three-dimensional (3-D) global hybrid code (i.e., the Auburn global hybrid code) that solves the fully kinetic ion physics has been developed and utilized to simulate the dynamics of the Earth's magnetotail. The focus of this talk will be on the structure and wave dynamics associated with fast flows generated by magnetic reconnection in the near- to mid-tail plasma sheet. 3-D flux ropes are shown in the structure of reconnection, with a width of 1-5 earth radii in the dawn-dusk direction. The earthward accelerated flux ropes then merge and form low entropy bubbles as the flux tubes shorten. Alfven/kinetic Alfven waves (KAWs) and compressional waves are generated from the reconnection and near the global dipolarization front, with strong turbulence at the flow braking. Ion particle distributions reveal multiple populations/accelerated beams in the tail and strong perpendicular heating in the ring current region. The wave/turbulence spectrum, ion acceleration, and plasma global transport to the inner magnetosphere associated with the reconnected flux tubes are presented.

SCHEDULE OF TALKS

NOTES

Tuesday, March 7: 8:50 AM - 9:15 AM
Presenter: Oka, Mitsuo

Stochastic Electron Acceleration by Whistler Waves within Earth's Bow Shock Layer

M. Oka, UC Berkeley, USA
A. J. Hull, UC Berkeley, USA
M. Hoshino, Univ. Tokyo, Japan
T.-D. Phan, UC Berkeley, USA
T. Amano, Univ. Tokyo, Japan
and the MMS team

High-energy electrons with relativistic velocities are produced at high Mach number astrophysical shocks, as have been indicated by emissions such as synchrotron X-rays and radio waves. In the standard 'diffusive shock acceleration' scenario, electrons are accelerated stochastically by receiving energization 'kicks' multiple times while being scattered back and forth across the shock front. A challenge is that electrons need to be sufficiently energetic before being injected into the standard process for further energization. The lack of such a seed population is termed "injection problem" and has been a subject of theoretical debate. In interplanetary space where in-situ measurements are available, non-thermal electrons have been detected, but the precise location and mechanism of electron acceleration have remained unclear. Here we show that electrons are energized through bursts of whistler waves within the transition layer of Earth's bow shock. We further found evidence of the diffusive shock acceleration although, unlike the standard scenario, electrons were accelerated even in a low energy range (>0.1 keV) and were confined within the shock transition layer. The new observation at Earth suggests a need for revisiting current models of electron injection and subsequent acceleration to high energies at astrophysical shocks.

Tuesday, March 7: 9:15 AM - 9:40 AM
Presenter: Yoon, Peter

Turbulent Equilibria for Charged Particles in Space

Peter H Yoon, University of Maryland, USA

It is well known that the solar wind electron distribution function is apparently composed of several components, but the energetic tail population is well fitted with kappa distribution function. It is also well established that the solar wind protons possess quasi power-law tail distribution function that is well fitted with an inverse power law model. In the recent past, the present author developed a theory of a system of electrons and Langmuir turbulence that are in dynamical steady-state. In such a model, the kappa distribution function for the electrons emerges as a unique solution of the steady-state weak turbulence plasma kinetic equation. For the proton inverse power-law tail problem Fisk and Gloeckler's theory of compressional turbulence received much attention in the literature. In the present talk, their model is revisited in the light of plasma kinetic theory that involves low-frequency dispersive Alfven wave and fast magnetosonic wave turbulence. The steady-state solution of the self-consistent particle kinetic equation and wave kinetic equation for these waves, we seek to obtain an alternative and complementary solution of the Fisk and Gloeckler's model.

Tuesday, March 7: 9:40 AM - 10:05 AM
Presenter: Baker, Daniel

New Results Concerning Particle Energization in Earth's Van Allen Radiation Belts

Daniel N. Baker, Laboratory for Atmospheric and Space Physics, University of Colorado Boulder, USA

The first great scientific discovery of the Space Age was that the Earth is enshrouded in toroids, or "belts", of very high-energy magnetically trapped charged particles. Early observations of the radiation environment clearly indicated that the Van Allen belts could be delineated into an inner zone dominated by high-energy protons and an outer zone dominated by high-energy electrons. The energy distribution, spatial extent and particle species makeup of the Van Allen belts has been subsequently explored by several space missions. However, recent observations by the NASA dual-spacecraft Van Allen Probes mission have revealed wholly unexpected properties of the radiation belts, especially for electrons at highly relativistic (E > 2 MeV) and ultra-relativistic (E > 5 MeV) kinetic energies. In this presentation we show using high spatial and temporal resolution data from the Relativistic Electron-Proton Telescope (REPT) experiment on board the Van Allen Probes that multiple belts can exist concurrently and that an exceedingly sharp inner boundary exists for ultra-relativistic electrons. Using additionally available Van Allen Probes data, we demonstrate that these remarkable features of energetic electrons are driven by strong solar and solar wind forcings. The comprehensive Van Allen Probes data show more broadly and in many ways how extremely high energy particles are accelerated, transported, and lost in the magnetosphere due to interplanetary shock wave interactions, coronal mass ejection impacts, and high-speed solar wind streams. The new data have in many ways rewritten the textbooks about the radiation belts as a key space weather threat to human technological systems.

Tuesday, March 7: 10:30 AM - 10:55 AM
Presenter: Coates, Andrew

Pickup Particle Acceleration at Comets, Moons and Magnetospheres

Andrew Coates, Mullard Space Science Laboratory, University College London
Rosetta RPC team
Cassini CAPS team

Ionisation of neutrals plays a key role in the plasma interactions of comets and moons, and in magnetospheres. Following ionisation, ions and electrons are 'picked up' in the plasma flow, initially accelerating along the electric field and then gyrating around the magnetic field. For an ion with mass m (amu) this leads to an acceleration of up to 4m times the energy of the flowing plasma. Further scattering in pitch angle and energy may increase the acceleration further. Here, we illustrate the process at work with relevant plasma measurements from comets including Rosetta's comet 67P, from Titan and near Enceladus and Rhea.

Tuesday, March 7: 10:55 AM - 11:20 AM
Presenter: Guo, Xiaocheng

Numerical Simulation of Cosmic Rays Effects on the Structure of the Heliosphere

Xiaocheng Guo, NSSC, CHINA
Chi Wang, NSSC, CHINA
Vladimir Florinski, USA

The heliopause is a pressure balanced structure that separates the inner and outer heliosheaths. The total pressure of the solar wind particles, including pickup ions and anomalous cosmic rays (ACRs), is approximately equal to the pressure of the interstellar gas and its magnetic field on the outer side. Should one of the pressures change, the heliosphere will shrink or expand in response, to compensate for the imbalance and reach a new equilibrium state. Based on Voyager 1 observations, some ACRs may have crossed the heliopause and escaped into the interstellar medium, providing a mechanism of energy transfer between the inner and outer heliosheaths that is not included in conventional MHD models. Here we evaluate the effect of ACR escape on the size and shape of the heliosphere using a simple model that includes the additional momentum and energy flux terms across the heliopause. We show that this effect significantly changes the size and shape of the helioshere, and should be considered in the MHD modelling of the heliosphere.

SCHEDULE OF TALKS

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Tuesday, March 7: 11:20 AM - 11:45 AM
Presenter: Cummings, Alan

Cosmic Rays at the Voyagers: Updates of the GCRs in the LISM and Evidence for the Acceleration Site of ACRs

A.C. Cummings, Caltech, USA
E.C. Stone, Caltech, USA
B.C. Heikkila, Goddard Space Flight Center, USA
N. Lal, Goddard Space Flight Center, USA
W. R. Webber, New Mexico State University, USA

Voyager 1 (V1) is now at 137.7 AU, more than 15 AU past the heliopause, recording galactic cosmic rays (GCRs) from the local interstellar medium. We will present an update of the gradient of GCRs, which so far is consistent with zero. Voyager 2 (V2) is now at 113.7 AU, and has traveled further in the heliosheath, 30 AU, than V1 did before it crossed the heliopause (28 AU). We will update the V2 data and look for signs that a crossing of the heliopause is in its near future. In addition, we will examine high-time resolution data from V2 taken during spacecraft rolls to infer the anisotropy of anomalous cosmic rays and comment on possible acceleration sites of these particles.
This work was supported by NASA Grant NNN12AA01C

Tuesday, March 7: 11:45 AM - 12:10 PM
Presenter: Stone, Edward

The Voyager Interstellar Mission, a Continuing Journey of Exploration

Edward C. Stone, Caltech, USA

Voyager 1 is now more than 16 AU beyond the heliopause, observing the transient disturbance of the local interstellar plasma, the intensity and anisotropy of galactic cosmic rays, and the turbulence and draping of the local interstellar magnetic field around the heliosphere. Voyager 2, now at nearly 114 AU, has continued to observe the turning of the subsonic solar plasma as it approaches the heliopause and the solar modulation of galactic cosmic rays in the inner heliosheath. An overview and update of these and other observations will be presented.

Tuesday, March 7: 12:10 PM - 12:35 PM
Presenter: Medvedev, Mikhail

Quasi-collisional Magneto-optic Effects in Turbulent ISM Plasmas. Anomalous Faraday Rotation

Mikhail Medvedev, University of Kansas, USA

High-amplitude turbulent electromagnetic fluctuations are ubiquitous in space and astrophysical plasmas, where they can be excited by kinetic plasma instabilities at small (even sub-Larmor) scales. Electrons moving through such electromagnetic fields undergo small-angle stochastic deflections of their pitch-angles, thus establishing diffusive transport on long time-scales. The pitch-angle diffusion coefficient, which acts as an effective ``collision'' frequency, may be substantial in these, otherwise, collisionless environments. We show that such ``quasi-collisionality'' may radically alter the expected radiative transport properties of plasmas. Particularly interesting is the case of the Faraday effect -- the magnetically-induced birefringence in plasmas causing rotation of the polarization plane of a linearly polarized electromagnetic wave, -- which is the common and useful probe of cosmic magnetic fields. We show that plasma quasi-collisionality radically alters Faraday rotation as well as other radiative transport properties, e.g., absorption, transmission and reflection. Interestingly, there has been observed a puzzling anomaly in the Faraday rotation measurements in the Cygnus region. We explain the Cygnus puzzle by the anomalous Faraday rotation produced in a thin ``blanket'' of highly turbulent plasma at the front of an interstellar bubble/shock.

SCHEDULE OF TALKS NOTES

Tuesday, March 7: 1:30 PM - 1:55 PM
Presenter: Gedalin, Michael

Probabilistic Shock Crossing and Diffusive Acceleration

M. Gedalin, Ben-Gurion University, Israel
W. Droege and Y.Y. Kartavych, Institute for Theoretical Physics and Astrophysics, University of Wuerzburg, Germany

The accelerated particle distributions are formed as a result of the diffusion upstream and downstream and scatter-free crossing of the shock front. In terms of the gyrophase averaged distributions the shock crossing should be described with the reflection and transition probabilities as functions of the pitch angle. The probabilities depend on the magnetic compression and the shock angle, but are not sensitive to the fine structure. The power spectrum of the accelerated ions is affected even for weak anisotropy.

Tuesday, March 7: 1:55 PM - 2:20 PM
Presenter: Leske, Richard

Improved Understanding of Peculiar Anisotropy Observations in the 23 July 2012 SEP Event

R. A. Leske, A. C. Cummings, C. M. S. Cohen, R. A. Mewaldt, A. W. Labrador, E. C. Stone, California Institute of Technology, USA
M. E. Wiedenbeck, Jet Propulsion Laboratory, California Institute of Technology, USA
E. R. Christian, T. T. von Rosenvinge, NASA/Goddard Space Flight Center, USA

The pitch-angle distributions of solar energetic particles (SEPs) are shaped by the competing effects of scattering and magnetic focusing during their transport through interplanetary space. SEP anisotropies therefore depend on the magnetic field strength, topology, and turbulence at remote heliospheric locations. The Low Energy Telescope (LET) on STEREO measures angular distributions in the ecliptic for SEP ions from protons to iron with energies of about 2-12 MeV/nucleon. At the onset of the 23 July 2012 extreme SEP event, a beamed distribution was observed at STEREO-Ahead. We have previously reported apparent "oscillations" in the pitch-angle width of this beam when using measurements at a 1-minute cadence. Our recent analysis shows this behavior is largely a result of relatively rapid variations in the magnetic field direction along with the fact that energetic particles average over much larger spatial and temporal scales than represented by solar wind measurements at the same cadence. Analysis of similar behavior in an earlier SEP event was done by Bieber and Evenson (1987), resulting in a statistical treatment of the coherence between the magnetic field fluctuations and the fluctuations in the particle distribution function, with potential applications to the study of magnetic turbulence.
We review the STEREO/LET anisotropy observations made during the 23 July 2012 event, present our new interpretation of the apparent oscillations as arising from the effects of magnetic turbulence on the calculated particle pitch angle distributions, and discuss the implications of these observations for SEP transport in the heliosphere.

Tuesday, March 7: 2:20 PM - 2:45 PM
Presenter: Raymond, John

Ion-Ion Equilibration in a Fast Shock Wave

John Raymond, CfA, USA

Heating in shock waves depends on the ion mass in heliospheric and supernova remnant shocks, but the measurments available are somewhat sparse. In supernova remnants, different elements are close to equilibrium in a 350 km/s shock, but the temperatures are nearly mass-proportional in a 2000 km/s shock. This talk concentrates on an even faster shock in the supernova remnant SN1006, where we have measured the temperatures of H, He and C ions.

SCHEDULE OF TALKS NOTES

Tuesday, March 7: 2:45 PM - 3:10 PM
Presenter: Roelof, Edmond

Acceleration and Propagation of Anomalous Cosmic Rays and Near-Relativisitic Electrons in the Heliosheath

Edmond C. Roelof, Johns Hopkins U./APL, USA

Voyager 1/2 LECP observations at the termination shock (TS) crossings established that energetic ions (40keV-1MeV) appeared to be locally accelerated "termination shock particles" (and since then have exhibited remarkably steady and similar intensities at both spacecraft) throughout the heliosheath (HS). On the other hand, the anomalous cosmic rays (ACRs, 4-80 MeV total energy H, He, and O ions) increased more or less steadily across the shock and then gradually peaked years later. All the time in the HS, the ACRs at each spacecraft exhibited a striking "common spectrum", i.e., closely similar intensity histories when ordered by total energy. Near-relativistic electrons (30 keV-1 MeV) exhibited seemingly mutually inconsistent behavior while the two Voyagers transited the shock and HS, with the VGR2 electrons peaking at the shock, but later disappearing for a year (in 2010) and then slowly recovering, as opposed to the less variable VGR1 electrons whose remarkably smooth time history (2008-2012) was very similar to the VGR1 ACRs. Consequently, shock acceleration seems to be operating locally at the TS along with another spatially distributed acceleration/transport mechanism within the HS. I will argue that the "reservoir" equation (Roelof, AIP Conf. Proc., 1500, 174-179 and 180-184, 2012) offers quantitative explanations for many of these apparently disparate observations, without invoking well-developed plasma turbulence within the HS (which is not observed anyway, except in the immediate vicinity of the TS). Rather, the meso-scale gradients and curvatures in the magnetic field produce transverse transport and (in direct consequence) "transverse compressive" acceleration that relates the fractional rate of momentum d(lnp)/dt=-(1/3)div(Vperp) to the divergence of the component of the plasma velocity transverse to the magnetic field. In the limit of negligible field-aligned streaming, the non-relativistic reservoir equation is independent of particle mass or charge magnitude, depending only upon the total energy of the particle (ion or electron), thus immediately explaining the "common" ACR spectra and the similar behavior of the VGR1 electrons.

Tuesday, March 7: 3:10 PM - 3:35 PM
Presenter: Hill, Matthew

New Horizons/PEPSSI Measurements of Suprathermal and Pickup Ions, Energetic Particles, and Cosmic Rays in the Heliosphere During Transient Shock Events

M.E. Hill, JHU/APL, USA
P. Kollmann, JHU/APL, USA
R.L. McNutt Jr., JHU/APL, USA

In addition to its primary measurement of energetic particles in the ~30 keV – 1 MeV range, the Pluto Energetic Particle Spectrometer Science Investigation (PEPSSI) instrument detects He ions down to ~2 keV/nuc and makes an integral measurement of cosmic ray protons above ~85 MeV. The broad energy coverage allows this single instrument to cover a large range of scale sizes and physical processes. Using these measurements we have observed numerous solar wind shock events at New Horizons during the cruise to Pluto and now during the cruise to the Kuiper Belt Object 2014 MU69, to be encountered 1 January 2019. During these transient events we observe the shock most directly by noting the sharp change in pickup ion (PUI) spectra as the intensities increase and the PUI spectral cut-off shifts in energy. The suprathermal ions and the energetic particles often respond to the shock, sometimes temporally coincident with the shock passage and sometimes offset due to transport effects. These may be particles accelerated very locally or more remotely but associated through magnetic connection. The cosmic rays are seen to display the characteristic Forbush decrease associated with many of the shock events. The intensity decrease is attributed to a region of increased turbulence traveling with the shock that impedes cosmic ray transport, partially shielding the spacecraft from the average cosmic ray flux in the related region of the heliosphere.
Following the 2015 Pluto encounter and the work on the subsequent science reports we have focused on extending the energy range and refining the calibration of PEPSSI more than on new science. The primary measurement is a combination of thin foil & microchannel plate-based time-of-flight (TOF) and solid state detector-based (SSD) energy measurements. Combined in a triple coincidence detection, species separation of H, He, and the CNO group is achieved. The suprathermal and pickup ion measurements are made using only the TOF subsystem of PEPSSI at energies below the ~30 keV SSD threshold. This means that unambiguous composition is not possible, however PEPSSI responds more efficiently to helium than protons, and the species-dependent energy loss in the start foil enables forwarding modeling of the distinctive interstellar pickup ion spectrum to confirm that we are observing helium pickup ions with a suprathermal tail. The mass density of the front foil and the detection efficiency sets the lower energy bound. We have made recent strides in calibrating this challenging low-energy range, including making laboratory measurements with the PEPSSI engineering model, thus improving the scientific capabilities of PEPSSI. On the higher energy end, the SSD system can be used independently to study cosmic rays. The cosmic ray measurement has an estimated proton energy threshold of > 85 MeV and is dominated by protons having energies in the 100s of MeV, i.e., predominantly galactic cosmic rays. (We have taken the average absorber to be 3mm Al, noted the maximum energy measurement capability is ~1 MeV, and used the observed 250 keV, 450 keV FWHM energy loss peak in the 500 micron Si solid state detector.) We will highlight the new results that stem from these ongoing improvements.

SCHEDULE OF TALKS

NOTES

Tuesday, March 7: 3:55 PM - 4:20 PM
Presenter: Lario, David

Large Energetic Particle Pressures in Solar Cycles 23 and 24

D. Lario, R.B. Decker, E.C. Roelof, The Johns Hopkins University, Applied Physics Laboratory, USA
A.-F. Viñas, NASA Goddard Space Flight Center, USA
R. Wimmer-Schweingruber, L. Berger, Institute for Experimental and Applied Physics (IEAP), Christian-Albrechts-University of Kiel, Germany

We study periods of elevated energetic particle intensities observed at the L1 Sun-Earth Lagrangian point when the partial energy density associated with energetic (≥80 keV) particles (P_EP) dominates that of the magnetic field (P_B) and thermal plasma populations (P_PLS). These periods are not uncommon and are frequently observed prior to the passage of interplanetary (IP) shocks. Because of the significant decreases in key solar wind parameters observed during solar cycle 24 [e.g., McComas et al., 2013], we were motivated to perform a comparative statistical analysis to determine if the occurrence rate of periods when P_EP exceeded P_B or P_PLS, or both, differed between solar cycles 23 and 24. We find that the decrease of P_B and P_PLS in solar cycle 24 is also accompanied by a general decrease of periods with elevated P_EP. The result is that solar cycle 23 showed a larger number of time intervals dominated by P_EP. We analyze whether these differences can be related to the properties of the IP shocks observed at L1. Incomplete datasets of shock parameters show a weak trend for faster IP shocks in solar cycle 23; however these differences are not significant enough to explain the difference in the number of periods with P_EP> P_B and P_EP> P_PLS. We analyze the averaged plasma parameters measured in the upstream region of the shocks and find significantly lower solar wind proton temperatures for IP shocks in solar cycle 24 compared with those of solar cycle 23. This research is partially supported by the NASA HGI program. We use data from the Heliospheric Shock Database, generated and maintained at the University of Helsinki.

Tuesday, March 7: 4:20 PM - 4:45 PM
Presenter: Mostafavi, Parisa

Structure of Energetic Particle Mediated Shocks Revisited

Parisa Mostafavi, Department of Space Science, University of Alabama in Huntsville, Huntsville, USA
Gary Zank, Department of Space Science, University of Alabama in Huntsville, Huntsville, USA
Gary Webb, Center for Space Plasma and Aeronomic Research (CSPAR), University of Alabama in Huntsville, Huntsville, USA

The structure of collisionless shock waves is often modified by the presence of energetic particles that are not equilibrated with the thermal plasma (e.g., cosmic rays, pickup ions (PUIs), and solar energetic particles (SEPs)). This is relevant to the inner and outer heliosphere and the Very Local Interstellar Medium (VLISM) where observations of shock waves in e.g., the inner heliosphere show that both the magnetic field and the thermal gas pressures are less than the energetic particle component pressure (Lario et al., 2015). Voyager 2 observations revealed that the heliospheric termination shock (HTS) is very broad and mediated by energetic particles (Burlaga et al. (2008)), and the shock wave observed in the VLISM (Burlaga et al., 2013) is also unusually broad. Energetic particles contribute both a collisionless heat flux and a higher-order collisionless viscosity. Based on the model by Zank et al. 2014, in analogy with classical hydrodynamics, we show that the incorporation of both effects can completely determine the structure of collisionless shocks mediated by energetic ions. Unlike classical 2-fluid cosmic rays models (Axford et al., 1982, Drury and Voelk, 1981), which admitted in some parameter regimes a double-valued downstream solution for which a gas sub-shock was inserted to reach a downstream state, the inclusion of viscosity completely resolves the structure. The inclusion of a collisionless viscosity associated with energetic particles indicates that in some cases it is reflected energetic particles that provide the primary small-scale dissipation at a shock (Zank et al.,1996, Richardson, 2008) rather than reflected thermal ions. By considering parameters upstream of the heliospheric termination shock (HTS), we show that the thermal gas remains relatively cold and the shock is mediated by PUIs. For the parameter regime in which the classical 2-fluid cosmic ray model admits three possible gas sub-shock solutions, we find the inclusion of heat flux and viscosity ensures that 2-fluid solution with the weakest sub-shock corresponds to the physically correct solution. The downstream state of the heat flux-viscous mediated shocks is determined by the corresponding Rankine-Hugoniot conditions for the system. We conclude by including thermal heat flux and viscosity to consider the most general form of the two-fluid model.

SCHEDULE OF TALKS

NOTES

Tuesday, March 7: 4:45 PM - 5:10 PM
Presenter: Li, Gang

Some Issues on Particle Acceleration and Transport in the Inner Heliosphere

Gang Li, University of Alabama in Huntsville, USA

Our Sun is the most efficient natural particle accelerator in the solar system. Protons and heavy ions can be accelerated to over ~GeV/nucleon during solar flares and coronal mass ejections (CMEs). In solar flares acceleration due to magnetic reconnection may dominate; in comparison, diffusive shock acceleration at the CME-driven shock dominates the CME events. Besides solar flares and CMEs, particle acceleration is also observed in other places in the solar system, including the termination shock and planetary bow shocks. One notable place in the inner heliosphere is the Corotation Interaction Regions (CIRs), where acceleration of particles are found at both the forward and the reverse shocks bounding the CIR. Understanding how particles are accelerated in these phenomena has been a central topic of space physics. However, because observations of these phenomena are often made at spacecraft near the Earth, transport of energetic particles in the solar wind smears out many distinct features of the acceleration process. Because the propagation of a charged particle in a plasma is closely related to the turbulent magnetic field through particle wave interaction, one therefore expects that a correct interpretation of the observations would require a understanding of the solar wind turbulence. Conversely, one can deduce the solar wind turbulence property using energetic particles. In this talk I discuss a few related topics concerning particle acceleration and transport in the inner heliosphere. Understanding these topics/problems may help us to better understand the underlying particle acceleration and transport process.

Tuesday, March 7: 5:10 PM - 5:35 PM
Presenter: Mewaldt, Richard

What Caused the Large Deficit of High-Energy Solar Particles in Solar Cycle 24?

Richard Mewaldt, Caltech, USA
Junxiang Hu, University of Alabama/Huntsville USA
Gang Li, University of Alabama/Huntsville, USA
Christina Cohen, Caltech, USA

It is well known that the number of large SEP events in solar cycle 24 is reduced by a factor of about 2 compared to cycle 23. In the first 8 years of this cycle there have been only 38 “GOES” proton events compared to 79 at this point of cycle 23. What is less well known is that the fluence of protons and heavier ions is reduced by even greater factors (by 6 times for greater than 10 MeV protons, and by 9 times for greater than 100 MeV protons. Indeed the spectral breaks for H, O, and Fe are all occurring about 3 times lower in energy/nucleon in cycle 24. This talk will study the reduced acceleration efficiency in cycle 24 by simulating SEP acceleration using an improved version of the Particle Acceleration and Transport in the Heliosphere (PATH) model, known as iPATH, which can simulate SEP acceleration at a CME-driven shock in two dimensions. Specifically, we will investigate how SEP fluences and energy spectra depend on variables that include CME properties, the interplanetary magnetic field strength and turbulence level, and the density and spectrum of suprathermal seed particles.

Tuesday, March 7: 5:35 PM - 6:00 PM
Presenter: Yan, Huirong

Cross Field Transport of Cosmic Ray in MHD Turbulence

Huirong Yan, DESY & Uni Potsdam, Germany

CR transport largely depends on the structure of magnetic field. While the parallel transport is dominated by scattering with compressible fast modes, the cross field transport is mainly determined by field line geometry controlled by Alfvenic turbulence. I shall address the issue of the cross field transport of CRs and show that the concept of cosmic ray subdiffusion is only important for restricted cases when the ambient turbulence is far from that suggested by numerical simulations. I will demonstrate that cosmic ray cross field transport is diffusive on large scales and superdiffusive on scales less than the injection scale of turbulence, which are supported by both numerical simulations and observations. Implications for the superdiffusion on shock acceleration will be discussed.

SCHEDULE OF TALKS

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Tuesday, March 7: 6:00 PM - 6:10 PM
Presenter: Sokol, Justyna

Polar Conic Current Sheets as Sources of Energetic Particles in the High-latitude Heliosphere during Solar Minima

Olga Khabarova, Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation of RAS (IZMIRAN), Russia
Helmi Malova, Scobeltsyn Nuclear Physics Institute of Lomonosov Moscow State University, Russia
Roman Kislov, Space Research Institute of the Russian Academy of Sciences (IKI), Russia
Lev Zelenyi, Space Research Institute of the Russian Academy of Sciences (IKI), Russia
Vladimir Obridko, Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation of RAS (IZMIRAN), Russia
Alexander Kharshiladze, Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation of RAS (IZMIRAN), Russia
Justyna Sokół, Space Research Centre of the Polish Academy of Sciences (CBK PAN), Poland
Stan Grzedzielski, Space Research Centre of the Polish Academy of Sciences (CBK PAN), Poland
Munetoshi Tokumaru, Institute for Space-Earth Environmental Research, Nagoya University, Japan
Ken'ichi Fujiki, Institute for Space-Earth Environmental Research, Nagoya University, Japan

The existence of a large-scale magnetically separated conic region inside the polar coronal hole has been predicted by the Fisk-Parker hybrid heliospheric magnetic field model in the modification of Burger and co-workers (Burger et al., ApJ, 2008). Recently, long-lived conic (or cylindrical) current sheets (CCSs) have been found from Ulysses observations at high heliolatitudes (Khabarova et al., ApJ, 2017). The characteristic scale of these structures is several times lesser than a typical width of coronal holes. CCSs can be observed at 2-3 AU for several months. The occurrence of long-lived CCSs in the high-latitude solar wind could shed light on how energetic particles reach high heliolatitudes. Energetic particle enhancements up to tens MeV were observed by Ulysses at edges of CCSs both in 1994 and 2007. Accelerated particles could be produced either by magnetic reconnection at edges of a CCS in the solar corona or in the solar wind. We discuss the role of high-latitude CCSs in propagation of energetic particles in the heliosphere and revisit previous studies of energetic particle enhancements at high heliolatitudes.

Wednesday, March 8: 8:00 AM - 8:25 AM
Presenter: McKenzie, David

Recent Findings from High-Resolution Observations of Turbulent Motions in Solar Flare Current Sheets

David E. McKenzie, Montana State University, USA

Historically, the presence of turbulence in solar flares has often been inferred from residual broadening of the relevant X-ray or extreme ultraviolet spectral lines, after the removal of instrumental and thermal broadenings from the observational data. Compelling as these 'non thermal broadenings' are, the lack of spatial resolution inherent in the measurements makes it difficult to distinguish turbulence from waves and bulk motions. I will present recent observations with improved spatial resolution which demonstrate that the flaring coronal plasma frequently harbors significant shears in velocity, giving the appearance of vortices and stagnations in the plane of the sky. The amplitude of these evidently turbulent flows, as well as their spatial variation, are comparable to line-of-sight non-thermal broadenings measured in the same flares. The flows appear to have a direct relationship to local heating in the coronal plasma. In coronal flare structures where the plasma beta exceeds unity, the relationship between the turbulent motions and the embedded magnetic field is likely to be complicated, involving dynamic fluid processes that produce small length scales in and near the flare current sheet. Such processes may be crucial for accelerating reconnection in the corona, and may have ramifications for particle acceleration.

SCHEDULE OF TALKS

NOTES

Wednesday, March 8: 8:25 AM - 8:50 AM
Presenter: Salem, Chadi

Solar Wind Electron Microphysics and Kinetic-Scale Electromagnetic Fluctuations in the Solar Wind at 1 AU

Chadi Salem, Space Sciences Laboratory, University of California Berkeley, USA
Marc Pulupa, Space Sciences Laboratory, University of California Berkeley, USA
Stuart Bale, Space Sciences Laboratory, University of California Berkeley, USA

We present an investigation of solar wind electron properties at 1AU and their relation to kinetic-scale electromagnetic fluctuations. This work uses the newly developed dataset of (several years of) accurate measurements of core, halo and strahl electron parameters from the 3D-Plasma experiment on Wind.
We investigate the properties of the – core, halo and strahl – components of the electron velocity distribution functions in the solar wind, including field-aligned speed drifts, temperature anisotropies, and heat flux. We investigate the physical processe(s) that likely act to control and regulate them, focussing on collisional versus collisionless processes.
We also analyze solar wind electromagnetic fluctuations above 20 Hz and any possible relationship with the variation of electron properties in the solar wind. Are these fluctuations whistler-like fluctuations? How do they affect electron properties?
Our new observations emphasize the non-negligible role of Coulomb collisions in shaping the electron distribution function and regulating of the thermal and supra thermal electrons, combined to that of electromagnetic fluctuations (turbulence and waves). In addition, the solar wind electron expansion and compression are limited fundamentally by some instabilities under certain conditions.

Wednesday, March 8: 8:50 AM - 9:15 AM
Presenter: Consolini, Giuseppe

A Hilbert-Huang Transform Approach to Space Plasma Turbulence at Kinetic Scales

G. Consolini, INAF-Istituto di Astrofisica e Planetologia Spaziali, Italy
T. Alberti, Dept. Physics, University of Calabria, Italy
E. Yordanova, Swedish Institute for Space Physics, Sweeden
M.F. Marcucci, INAF-Istituto di Astrofisica e Planetologia Spaziali, Italy
M. Echim,Belgian Institute for Aeronomy, Belgium

Heliospheric space plasmas are highly turbulent and display multi-scale fluctuations over a very wide range of scales from the magnetohydrodynamic domain down to the kinetic one. The study of turbulence features is traditionally based on spectral and canonical structure function analysis. Here, we present a novel approach to the analysis of the multi-scale nature of plasma turbulent fluctuations by means of Hilbert-Huang Transform. In particular, we present an application of this technique to magnetic field fluctuations at kinetic scales.

SCHEDULE OF TALKS | NOTES

Wednesday, March 8: 9:15 AM - 9:40 AM
Presenter: Matthaeus, William

Kinetic Plasma Turbulence: Energy Cascade, Coherent Atructures, and Heating of Protons and Electrons

W Matthaeus. Department of Physics and Astronomy, University of Delaware, USA
Yan Yang, State Key Laboratory for Turbulence and Complex Systems, Center for Applied Physics and Technology, College of Engineering, Peking University, China
Tulasi Parashar, University of Delaware, USA
Minping Wan, Department of Mechanics and Aerospace Engineering, South University of Science and Technology of China, China
Vadim Roytershteyn, Space Science Institute, USA
William Daughton, Los Alamos National Lab, USA

Classical energy cascade theory suggests that energy is transferred from large to small scales at a constant rate and nonlinear interactions occur predominately between comparable scales. This scenario is of great importance in explaining the heating of corona and solar wind. Energy residing in large-scale fluctuations is transported to smaller scales where dissipation occurs and finally drives kinetic processes that absorb the energy flux and energize charged particles. The fluid scale cascade has been well studied, but less is known about energy transfer and nonlinear processes at sub-ion kinetic scales. Here we discuss turbulence based on a Vlasov description, with considerable assistance of large scale kinetic simulation. We describe kinetic effects that occur in or near coherent structures associated with electric current density, vorticity, and the symmetric stress tensors for electron and proton flows. Disruption of proton orbits near these structures is associated with enhancements of proton heating when the turbulent cascade is stronger. The available pathways for energy conversion into heat are described in some detail, with a focus on J.E and on pressure related effects, namely the pressure dilation, p div(u), and the traceless pressure "Pi-D" interaction. Preliminary results on scale filtering analysis of these and other candidate cascade terms will be presented, emphasizing influences on dissipation and heating.

Wednesday, March 8: 9:40 AM - 10:05 AM
Presenter: Boldyrev, Stanislav

Inertial Kinetic-Alfven and Whistler Turbulence in a Non-isothermal Plasma

Stanislav Boldyrev, University of Wisconsin - Madison, USA
Christopher H. K. Chen, Imperial College London, UK

Motivated by the recent MMS measurements of turbulence in the Earth's magnetosheath, we present a model of kinetic-scale turbulence in non-isothermal plasmas where the ions are significantly hotter than the electrons. We argue that the electron inertial effects qualitatively change the properties of the kinetic-Alfven and whistler turbulence, and, in particular, modify the anisotropy of the energy cascade and the scaling of the energy spectrum.

SCHEDULE OF TALKS

NOTES

Wednesday, March 8: 10:30 AM - 10:55 AM
Presenter: Smith, Charles

Observations of Low-Frequency Magnetic Waves due to Newborn Interstellar Pickup Ions Using ACE, Ulysses, and Voyager Data

Charles W. Smith, Univ. New Hampshire
Poornima Aggarwal, Cooper Union
Matthew R. Argall, Univ. New Hampshire
Leonard F. Burlaga, NASA/GSFC
Maciej Bzowski, Space Res. Center, Polish Acad. Sciences
Bradford E. Cannon, Florida State Univ.
S. Peter Gary, Space Science Inst.
Meghan K. Fisher, Univ. New Hampshire
Jason A. Gilbert, Univ. of Michigan
Sophia J. Hollick, Univ. New Hampshire
Philip A. Isenberg, Univ. New Hampshire
Colin J. Joyce, Univ. New Hampshire
Neil Murphy, NASA Jet Propulsion Lab
Raquel G. Nuno, Arizona State Univ.
Zackary B. Pine, Univ. New Hampshire
John D. Richardson, Mass. Inst. Technology
Nathan A. Schwadron, Univ. New Hampshire
Ruth M. Skoug, Los Alamos National Laboratory
Justyna M. Sokół, Space Res. Center, Polish Acad. Sciences
David K. Taylor, Rensselaer Polytechnic Inst.
Bernard J. Vasquez, Univ. New Hampshire
Thomas H. Zurbuchen, NASA Headquarters

Wave excitation by newborn interstellar pickup ions (PUIs) play a significant role in theories that attempt to describe IBEX and Voyager observations in the heliosheath as well as solar wind heating. The same dynamic processes can be far-reaching and extend into the inner heliosphere to at least 1AU and likely to smaller heliocentric distances. While the high-resolution magnetic field measurements required to study these waves are not yet available in the heliosheath, we have studied a range of available observations and found evidence of waves due to interstellar PUIs using ACE (1998-2015 at 1 AU), Ulysses (1996-2006 at 2 to 5 AU, high and low latitudes) and Voyager (1978-1979 and 2 to 6 AU) observations. Efforts to extend the Voyager observations to 35 AU are ongoing. We have examined these data sets and report on observations of low-frequency waves that result from newborn interstellar pickup H+ and He+ ions. Although not as common as theory once predicted, we presently have identified 524 independent occurrences. Our conclusion from studying these waves is that they are seen only when the ambient turbulence is sufficiently weak. The instability that leads to the generation of these waves requires a slow accumulation of wave energy over several to tens of hours to achieve the observed wave amplitudes. In regions where the turbulence is moderate to strong, the turbulence consumes the wave energy before it can reach observable levels and transports the energy to the dissipation scales where it heats the background thermal particles. Only intervals with the weakest turbulence will permit energy accumulation over this time scale. These conditions are most often, but not exclusively, achieved in solar wind rarefaction regions.

SCHEDULE OF TALKS

NOTES

Wednesday, March 8: 10:55 AM - 11:20 AM
Presenter: Usmanov, Arcadi

A Global MHD Simulation of the Solar Corona, Solar Wind and Heliosphere with Turbulence Transport

Arcadi V. Usmanov, University of Delaware, USA
William H. Matthaeus, University of Delaware, USA
Melvyn L. Goldstein, NASA Goddard Space Flight Center, USA

We present initial results from a fully three-dimensional MHD solar corona, solar wind and global heliosphere model in the entire region from the coronal base to the interstellar medium. Turbulence transport equations for turbulence energy, cross helicity, and correlation length are coupled and solved simultaneously with Reynolds-averaged mean-flow equations. In the inner heliosphere, the mean-flow equations are two-fluid and include separate energy equations for thermal protons and electrons. The equations for distant solar wind additionally include continuity and energy equations for pickup protons. The electron, thermal proton and pickup protons are assumed to move with the same velocity. A fourth fluid in the outer heliosphere region is the interstellar hydrogen described by separate continuity, momentum and energy equations that are coupled to the charged component equations by photoionization and charge exchange. We evaluate the effects of turbulence transport on the global heliospheric structure and compute the distribution of plasma, magnetic field, and turbulence parameters throughout the heliosphere for representative solar minimum and maximum conditions.

Wednesday, March 8: 11:20 AM - 11:45 AM
Presenter: Zank, Gary

A Nearly Incompressible Description of Low-Frequency Turbulence in the Solar Wind

G.P. Zank, University of Alabama in Huntsville, USA
L. Adhikari, University of Alabama in Huntsville, USA
P. Hunana, University of Alabama in Huntsville, USA
D. Shioto, Nagoya University, Japan
R. Bruno, INAF-IAPS Istituto di Astrofisica e Planetologia Spaziali, Italy
D. Telloni, INAF - Astrophysical Observatory of Torino, Italy

The theory of nearly incompressible magnetohydrodynamics (NI NHD) was developed largely in the early 1990’s together with an important extension to inhomogeneous flows in 2010. Much of the focus in the earlier work was to understand the apparent incompressibility of the solar wind and other plasma environments, and the relationship of density fluctuations to apparently incompressible manifestations of turbulence in the solar wind and interstellar medium. Further important predictions about the “dimensionality” of solar wind turbulence and its relationship to the plasma beta were made and subsequently confirmed observationally. However, despite the initial success of NI MHD in describing fluctuations in the solar wind, a detailed application to solar wind turbulence has not been undertaken. Here, we use the equations of NI MHD to describe solar wind turbulence, rewriting the system in terms of Elsasser variables. Distinct descriptions of 2D and slab turbulence emerge naturally from the Elsasser formulation of NI MHD, as do the nonlinear couplings between 2D and slab components. For plasma beta order 1 or less regions, distinct predictions for 2D and slab spectra result from the NI MHD description, and predictions for the spectral characteristics of density fluctuations can be made. We conclude by presenting a NI formulation describing the transport of turbulence throughout the solar wind, including low plasma beta environments such as the solar corona. A preliminary comparison of theory and observations is presented.

SCHEDULE OF TALKS

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Wednesday, March 8: 11:45 AM - 12:10 PM
Presenter: Adhikari, Laxman

Transport of Nearly Incompressible Magnetohydrodynamic Turbulence from 1 - 75 AU

Gary P. Zank, The University of Alabama in Huntsville, USA
Peter Hunana, The Center for Space Plasma and Aeronomic, USA
Daikou Shiota, Institute for Space-Earth Environmental Research, Japan
Roberto Bruno, INAF-IAPS Instituto di Astrofisica e Planetologia Spaziali, Italy
Qiang Hu, The University of Alabama in Huntsville, USA
Daniele Telloni, INAF - Astrophysical Observatory of Torino, Italy

The thermal plasma beta in the solar wind and the solar corona is of order beta ~ 1 and beta << 1. Zank et al. (2017) developed a NI MHD turbulence formalism for a coupled two-component 2D and slab turbulence model suitable for the beta ~ 1 and beta << 1 solar wind and corona. We solve the Zank et al. (2017) NI MHD coupled turbulence transport equations for the inhomogeneous solar wind from 1 to 75 AU, and compare the numerical solutions to Voyager 2 observations. We find good agreement between theory and observations. We find that 1) the 2D turbulent energies are dominant in comparison to the slab energies throughout the heliosphere; 2) the 2D turbulent energies decrease more slowly than the slab turbulent energies within ~ 10 AU, while the slab energies increase and the 2D energies flatten with increasing heliocentric distance in the outer heliosphere; 3) the normalized cross-helicity corresponding to 2D turbulence decreases faster than slab turbulence within ~ 10 AU; 4) the normalized residual energy of the 2D turbulence is more magnetically dominated than the slab turbulence; 5) the fluctuating magnetic and kinetic energies in solar wind slab turbulence are equipartioned within ~ 10 AU and for 2D turbulence, beyond ~ 10 AU; 6) the variance of density fluctuations decreases more rapidly than r^{-4} within ~ 10 AU, and more slowly in the outer heliosphere, and 7) the observed variance in magnetic field fluctuations as a function of the thermal plasma beta is observed by the two-component turbulence transport model. In summary, the NI MHD two-component Zank et al. (2017) turbulence transport model captures the behavior of the forward, backward and total energies in the fluctuating Elsasser variables, the variance in the magnetic field, kinetic energy, and density fluctuations, the cross-helicities and residual energies, the thermal temperature and plasma beta, and the various correlation lengths.

Wednesday, March 8: 1:30 PM - 1:55 PM
Presenter: Hunana, Peter

On the Parallel and Oblique Firehose Instability in Fluid Models

Peter Hunana, CSPAR & SPA, University of Alabama in Huntsville, USA
Gary P. Zank, CSPAR & SPA, University of Alabama in Huntsville, USA

A brief analysis of the proton parallel and oblique firehose instability is presented from a fluid perspective and the results are compared to kinetic theory solutions obtained by the WHAMP code. It is shown that the classical CGL model very accurately describes the growth rate of these instabilities at sufficiently long spatial scales (small wavenumbers). The required stabilization of these instabilities at small spatial scales (high wavenumbers) naturally requires dispersive effects and the stabilization is due to the Hall term and finite Larmor radius corrections (FLR) corrections to the pressure tensor. Even though the stabilization is not completely accurate since a strong ion-cyclotron damping of the ion-cyclotron mode comes into effect that is coupled to the dynamics of the whistler mode, we find that the main concepts of the maximum growth rate and the stabilization of these instabilities is indeed present in the fluid description. However, there are differences that are quite pronounced when close to the firehose threshold and that clarify the different profiles for marginally stable states with a prescribed maximum growth rate in the simple fluid models considered here and the kinetic description.

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Wednesday, March 8: 1:55 PM - 2:20 PM
Presenter: Giacalone, Joe

The Acceleration of Solar Wind Protons and Minor Ions at a Strong, Quasi-Parallel, Interplanetary Shock

Joe Giacalone, Department of Planetary Sciences, University of Arizona, USA

We present and discuss results from a self-consistent plasma simulation of a quasi-parallel shock that accelerates thermal protons and minor ions to energies much greater than the shock kinetic energy. The results are compared to spacecraft observations of an interplanetary shock with similar plasma and shock parameters, observed by the Advanced Composition Explorer on DOY 94, 2001. The comparison between the simulation and observations suggest that thermal solar wind is a significant source of high-energy protons and minor ions. We will discuss these results in the context of the physics of so-called "injection problem.

Wednesday, March 8: 2:20 PM - 2:45 PM
Presenter: Golla, Thejappa

In Situ Waves Observed in the Vicinity of Interplanetary Shocks

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

We present the high time resolution observations of the in situ waves obtained by the time domain sampler (TDS) of the WAVES experiment on the STEREO spacecraft in the vicinity of a typical quasi-perpendicular and super-critical interplanetary shock. We show that (1) Langmuir waves occur as coherent one dimensional magnetic field aligned wave packets in the upstream region, (2) these waves persist over large distances of the order of 0.2 AU, (3) some of these wave packets contain spectral signatures of the strong Langmuir turbulence process, called the oscillating two stream instability (OTSI), (4) the spatial scales and peak intensities of some of the wave packets satisfy the necessary conditions for them to be stable Langmuir solitons formed as a result OTSI, and (5) Langmuir waves occur in the transition region as very incoherent emissions by exhibiting broad fundamental and second harmonic spectral peaks. We also show that very intense low frequency ion sound waves occur in the transition as well as downstream regions. We discuss the implications of these observations on the theories of (1) strong Langmuir turbulence, (2) beam stabilization, (3) emission mechanisms of solar type II radio bursts, (4) wave-particle interactions responsible for collisionless dissipation, and (5) heating of the downstream plasma.

Wednesday, March 8: 2:45 PM - 3:10 PM
Presenter: Gary, S. Peter

Electron and Ion Heating by Kinetic Range Turbulence: Three-Dimensional Particle-in-Cell Simulations

S. Peter Gary, SSI, USA
R. Scott Hughes, USC, USA
Joseph Wang, USC, USA

Three-dimensional particle-in-cell simulations of the forward cascade of decaying kinetic range turbulence have been carried out on a model of collisionless, homogeneous, magnetized plasma with parameters similar to those of the solar wind. The initial conditions are an ensemble of relatively isotropic, narrowband field spectra of relatively long wavelength modes; the fluctuations then cascade to anisotropic, broadband spectra of relatively short wavelength turbulence. Most results concern whistler mode turbulence, although there may be some results for kinetic Alfven wave turbulence at the time of the meeting. The emphasis here will be the maximum electron and ion dissipation rates due to the cascading turbulence as functions of simulation domain size, initial magnetic fluctuation energy density (epsilon_o), and initial electron beta. The most important results to date are that, for whistler turbulence over 0.01 < beta_e < 0.25, the maximum electron heating scales as epsilon_o whereas the maximum ion heating scalers as epsilon_o^3/2, suggesting that electron heating is a quasilinear process whereas ion heating is a nonlinear process akin to "stochastic" ion heating.

SCHEDULE OF TALKS

NOTES

Wednesday, March 8: 3:10 PM - 3:35 PM
Presenter: Klein, Kristopher

A General Method for Instability Identification in Solar Wind Observations as Illustrated by Particular Application to WIND Observations

Kristopher Klein, University of Michigan, USA
Justin Kasper, University of Michigan, USA
Kelly Korreck, Smithsonian Astrophysical Observatory, USA

Understanding the role instabilities play in heating thermal plasmas and accelerating superthermal particles is a key component to characterizing the behavior of space and astrophysical environments. Such instabilities have been studied since the dawn of the space age using in situ measurements of solar wind plasma, with significant recent advancements enabled by the statistical analysis of decades worth of data from missions such as WIND. Typical studies focus on comparing theoretical marginal stability boundaries from a single source of free energy in a reduced parameter space, such as the canonical plasma beta versus temperature anisotropy plane, to measured properties projected onto that space. We present a more general method of assessing the effects of free energy, accounting for all contributions which may stabilize or destabilize the plasma. By applying Nyquist's instability criterion to the dispersion relation calculated using parameters from solar wind observation, we can efficiently determine if the plasma is linearly unstable, and if so, how many unstable modes the plasma supports. Such identification will enable us to identify which free energy sources are dominant in destabilizing solar wind plasma. The theory behind this approach is reviewed, followed by a discussion of our methods for a robust numerical implementation, and an initial application to select events from the WIND data set. Further application of this method to observations from current missions, such as WIND, upcoming missions, including Solar Probe Plus and Solar Orbiter, and missions currently in preliminary planning phases, such as THOR and IMAP, will help elucidate how instabilities shape the evolution of the heliosphere.

Wednesday, March 8: 3:55 PM - 4:20 PM
Presenter: Manchester, Ward

The Evolution of Alfven-wave Turbulence at CME-driven Shocks

Bart van der Holst, University of Michigan, USA

We examine simulations of CME-driven shocks to better understand their affects on Alfven wave turbulence in the solar wind, which is an essential aspect of particle acceleration. Our simulations show how the structure and evolution of Alfven wave turbulence depends on the complex interaction of several physical processes that amplify, reflect and dissipate waves. Alfven waves are energized by compression of the plasma, which occurs at the CME-driven shock and also in the sheath region itself. Enhanced wave reflection occurs at the shock surface and in the plasma depletion region within the CME sheath, which results in enhanced turbulent dissipation that causes isotropic electron heating and anisotropic proton heating. Ion temperature anisotropy, with elevated perpendicular temperature may then drive mirror-mode instabilities. Evidence of such complex dynamics is made manifest by the presence of increased temperature anisotropy and mirror mode waves (Liu et al 2006). We will attempt to explain these observations with simulations performed with the recently developed Alfven Wave Solar Model (AWSoM, van der Holst et al. (2014)). This global three-dimensional solar corona and inner heliosphere model incorporates low-frequency Alfven wave turbulence to address the coronal heating and solar wind acceleration, which allows us to self-consistently simulate the turbulent dissipation that causes isotropic electron heating and anisotropic proton heating.

SCHEDULE OF TALKS

NOTES

Wednesday, March 8: 4:20 PM - 4:45 PM
Presenter: Luhmann, Janet

**Observer Magnetic Field Mapping to ICME Shocks:
Implications of ENLIL Results for Shock Normal Angle Influences**

J.G. Luhmann, SSL, University of California, Berkeley, USA
M. Leila Mays, CCMC NASA GSFC, USA
D. Odstrcil, George Mason University, USA
Yan Li, SSL, USA
Hazel Bain, NOAA SWPC, USA
C.O. Lee, SSL
C.M.S. Cohen, SRL Caltech, USA
R.A. Mewaldt, SRL Caltech, USA
R.A. Leske, SRL Caltech, USA

The role of shock normal angle in the acceleration of protons in gradual solar energetic particle events continues to be debated (e.g. Desai and Giacalone, 2016). Studies of both prompt and ESP components produce a variety of results and conclusions. In the former case, the challenge is in part the remote inference of theta-BN. In the case of local ESP events, the challenge includes knowing how the structure is crossed by the spacecraft, among others. The ability to use WSA-ENLIL-cone field line mapping from an observer to a heliospheric shock has been used by several authors to investigate shock connectivity as a requirement for the detection of SEPs - with some success (e.g. Luhmann et al., 2013; Rouillard et al., 2015;, Bain et al., 2016). We describe some related analyses that look more closely at the inferred shock normal angle influences based on ENLIL results for a sampling of events.

Wednesday, March 8: 4:45 PM - 5:10 PM
Presenter: Gopalswamy, Nat

A Hierarchical Relationship between the Fluence Spectra and CME Kinematics in Large Solar Energetic Particle Events

N. Gopalswamy, NASA/GSFC
S. Yashiro, P. Makela, N. Thakur, S. Akiyama, and H. Xie, The Catholic University of America

We report on a finding that coronal mass ejections (CMEs) with high initial acceleration are associated with solar energetic particle (SEP) events with the hardest fluence spectra, while those with lowest initial acceleration have the softest SEP fluence spectra. Consistent with this trend, CMEs with intermediate initial acceleration result have moderately hard SEP fluence spectra. Physically speaking, impulsive acceleration leading to high initial CME speeds close to the Sun results in shock formation close to the Sun, where the ambient magnetic field and density are high and the particles are energized more efficiently. On the other hand, slowly accelerating CMEs can form shocks only at several solar radii from the Sun, where the magnetic field and density have fallen off significantly, reducing the efficiency of shock acceleration. The ground level enhancement (GLE) in SEP events represent the high initial acceleration class, while SEP events associated with CMEs from quiescent filament region (FE SEP events) represent the low initial acceleration class. We illustrate this hierarchical relationship by computing the initial acceleration of CMEs and identifying the starting frequency of type II radio bursts. This finding strongly supports the idea that large SEP events are primarily due to CME-driven shocks.

Wednesday, March 8: 5:10 PM - 5:35 PM
Presenter: Chapman, Sandra

Quantifying the Variability of the Solar Wind and its Solar Cycle Dependence

S. C. Chapman, CFSA, Physics, University of Warwick, UK
E. Tindale, CFSA, Physics, University of Warwick, UK

The solar wind is inherently variable across a wide range of spatio-temporal scales; embedded in the flow are the signatures of distinct non-linear physical processes from evolving turbulence to the dynamical solar corona. These dynamical fluctuations in turn can diffusively accelerate charged particles so that a quantitative understanding of solar wind variability can in turn parameterize this diffusive acceleration. In-situ satellite observations of solar wind magnetic field and velocity are at minute and below time resolution and now extend over several solar cycles. Each solar cycle is unique, and has solar wind variability that changes within, and across, each distinct solar cycle. We will use data-data quantile-quantile (DQQ) plots [1] to quantify how the variability in solar wind magnetic field, energy density and Poynting flux vary with fast and slow solar wind and how they change with the solar cycle(s) by determining how the full underlying statistical distributions are changing. Importantly this method does not require any assumptions concerning the underlying functional form of the distribution and can identify multi-component behaviour that is changing in time. This can be used to determine when a sub-range of a given solar wind parameter is undergoing a change in statistical distribution, or where the moments of the distribution only are changing and the functional form of the underlying distribution is not changing in time; these are distinct scenarios in terms of the underlying physics. The method is quite general; we use data from the WIND satellite to compare the solar wind across the minima and maxima of solar cycles 23 and 24.[1] Tindale, E., and S.C. Chapman (2016), Geophys. Res. Lett., 43(11), doi: 10.1002/2016GL068920.

Wednesday, March 8: 5:35 PM - 6:00 PM
Presenter: Tang, Bofeng

The Transport of Solar Wind Electrons: Preliminary Results

Bofeng Tang, The University of Alabama in Huntsville, USA
G. P. Zank, The University of Alabama in Huntsville, USA
V. Kolobov, CFD Research Corporation, USA

The electron velocity distribution function in the solar wind at 1 AU is comprised of a Maxwellian core, a suprathermal halo, and a strahl. Wave-particle interactions are thought to be responsible for isotropizing the electron distribution function. We have derived wave-particle induced drag and scattering terms in the electron Vlasov equation. For the present, we assume a relatively simple scattering operator and develop a numerical scheme to solve for the electron distribution function. We consider first a kinetic problem that describes runaway electrons. The kinetic equation can be expressed in the form of an advection-diffusion function, thereby allowing us to use continuum methods to solve it numerically. Preliminary results are presented.

SCHEDULE OF TALKS

NOTES

Thursday, March 9: 8:00 AM - 8:25 AM
Presenter: McComas, David

Seven Years of Imaging the Global Heliosphere with IBEX

D.J. McComas, Princeton University, USA
E.J. Zirnstein, Princeton University, USA
M. Bzowski, Space Research Centre of the Polish Academy of Sciences, Poland
M.A. Dayeh, Southwest Research Institute, USA
H.O. Funsten, Los Alamos National Laborator, USA
S.A. Fuselier, Southwest Research Institute, USA
P.H. Janzen, University of Montana, USA
M.A. Kubiak, Space Research Centre of the Polish Academy of Sciences, Poland
H. Kucharek, University of New Hampshire, USA
E. Mobius, University of New Hampshire, USA
D.B. Reisenfeld, University of Montana, USA
N.A. Schwadron, University of New Hampshire, USA
J.M. Sokol, Space Research Centre of the Polish Academy of Sciences, Poland
J.R. Szalay, Southwest Research Institute, USA
M. Tokumaru, Nagoya University, Japan

The Interstellar Boundary Explorer (IBEX) has now operated in space for seven years and returned nearly continuous observations that have led to scientific discoveries and reshaped our entire understanding of the outer heliosphere and its interaction with the local interstellar medium. Here we extend prior work, adding the 2014-2015 data for the first time and examine, validate, initially analyze, and provide a complete seven year set of Energetic Neutral Atom (ENA) observations from ~0.1 to 6 keV. The data, maps, and documentation provided here represent the tenth major release of IBEX data and include improvements to various prior corrections to provide the citable reference for the current version of IBEX data. We are now able to study time variations in the outer heliosphere and interstellar interaction over more than half a solar cycle. We find that the Ribbon has evolved differently than the globally distributed flux (GDF) with a leveling off and partial recovery of ENAs from the GDF, owing to solar wind output flattening and recovery. The Ribbon has now also lost its latitudinal ordering, which reflects the breakdown of solar minimum solar wind conditions, and exhibits a greater time delay than for the surrounding GDF. Together, the IBEX observations strongly support a secondary ENA source for the Ribbon and we suggest that this be adopted as the nominal explanation of the Ribbon going forward.

Thursday, March 9: 8:25 AM - 8:50 AM
Presenter: Bzowski, Maciej

First shot at synthesizing the Warm Breeze from first principles

M. Bzowski, M.A. Kubiak, A. Czechowski, J. Grygorczuk
Space Research Centre PAS (CBK PAN), Poland

The Warm Breeze, which is a newly discovered population of neutral He atoms different to the pristine interstellar neutral (ISN) He gas, has recently been interpreted as the heliospheric secondary population, created in the outer heliosheath due to charge exchange between the compressed and heated He+ ions and the pristine ISN He atoms. This interpretation was based solely on geometrical arguments: the inflow direction of the Warm Breeze, and of the ISN He, H, and O are co-planar with each other, as predicted by heliospheric models which take into account a distortion of the heliosphere by the interstellar magnetic field. These models predict that as a result of this distortion, the inflow direction of the secondary populations of interstellar neutrals will be deflected from that of the unperturbed ISN gas inflow in a plane defined by the direction of Sun's motion through the Local Interstellar Cloud and the direction of the IS magnetic field, which is very likely coincident with the center of the IBEX ribbon. However, the model of the Warm Breeze used up to now to interpret the IBEX observations of the Warm Breeze is not physically realistic: it assumes that the ISN He and the Warm Breeze do not interact with each other at all and that both of them are due to Maxwell-Boltzmann populations with the densities, velocities, and temperatures homogeneous in space. Clearly, the assumption of a location-independent parameters of the Warm Breeze all the way to infinity cannot hold if the Warm Breeze is created in the outer heliosheath, which is limited to a few hundred AU from the heliopause. Adopting the secondary population hypothesis, we attempt to synthesize the observed neutral He signal as due to charge-exchange collisions operating in front of the heliopause. We assume various properties of the interstellar gas in front of the heliopause and calculate the production and losses balance of neutral He atoms precisely on the trajectories that lead the atoms to the IBEX detectors. We are able to reproduce the signal observed by IBEX due to the pristine ISN He, but not the Warm Breeze, assuming that the plasma and neutral gas are co-moving and thermalized at a few thousand AU from the Sun, but there is no heliosheath at all. However, when assuming a more realistic scenarios with some form of disturbance in the interstellar medium in front of the heliopause, we generate a signal where an additional population of neutral He atoms is visible in those regions in the sky where the Warm Breeze was observed. We investigate the sensitivity of this signal to the geometrical dimensions of the outer heliosheath, the distribution of plasma, and its distortions from axial symmetry. We find that the hypothesis that the Warm Breeze is the secondary population of interstellar neutral atoms is plausible. The generated signal is sensitive to the distortion and dimensions of the outer heliosheath. The source region for the atoms observed by IBEX as the pristine ISN gas is a few thousand AU from the Sun, but for the Warm Breeze atoms it is just a few hundred AU from the Sun. These findings point out a tremendous diagnostic potential of observations of neutral He atoms with low energies, as those carried out presently by IBEX and planned for the future IMAP mission, for the general structure of the outer heliosheath, the plasma flow in this region, and the geometry of the local interstellar magnetic field.

SCHEDULE OF TALKS

NOTES

Thursday, March 9: 8:50 AM - 9:15 AM
Presenter: Sokol, Justyna

Anisotropy of the Distribution Function of Interstellar Neutral Gas in the Inner Heliosphere

Justyna M. Sokol, Space Research Centre PAS, Poland
Maciej Bzowski, Space Research Centre PAS, Poland
Marzena A. Kubiak, Space Research Centre PAS, Poland

The neutral component of interstellar medium enters freely the heliosphere and can be detected directly or indirectly from the Earth's orbit. Details of the local distribution function of the interstellar neutral (ISN) gas (inside 1 AU) are important for analysis of the heliospheric backscatter glow and potentially also for details of the spectral flux of pickup ions. The heliospheric backscatter glow is due to the atoms that have radial velocities within the spectral range of the solar spectral line that illuminates the gas (Doppler dimming effect). In many studies it has been assumed that the local distribution functions of the direct and indirect beams of the ISN gas are isotropic. In reality, however, full-sky patterns of the flux of ISN gas observed inside the heliosphere generally features two asymmetric maxima of intensity. These two beams of the ISN gas are referred to as direct and indirect, respectively. The relative intensity of these two beams, as well as their shapes and sizes in the sky depend on the Mach number of the inflowing gas, as well as the angular distance of a location in the heliosphere from the inflow direction and linear distance from the Sun. This is because the focusing effect of the solar gravity makes the distribution function of both the direct and indirect beams of ISN gas highly anisotropic. We show that thermal velocities along the eigenvectors of the distribution functions of the direct and indirect beams of ISN He strongly vary between each other and as a function of the distance from the Sun and angle to the ISN gas inflow direction. We investigate how well the complex forms of the actual distribution functions, known from kinetic simulations, can be approximated by three-axial Maxwell-Boltzmann distributions. We discuss the characteristics of the temperature tensor of the direct and indirect beams and present the conditions for which the approximation of the ISN gas beam by three-axial Maxwell-Boltzmann distribution function holds.

Thursday, March 9: 9:15 AM - 9:40 AM
Presenter: Reisenfeld, Daniel

Probing the Boundaries of the Heliosphere Using Observations of the Polar ENA Flux from IBEX and Cassini/INCA

Daniel B. Reisenfeld, University of Montana, USA
Paul H. Janzen, University of Montana, USA
Maciej Bzowski, Polish Academy of Sciences, Poland
Kostas Dialynas, Academy of Athens, Greece
Herbert O. Funsten, Los Alamos, USA
Stephen A. Fuselier, SwRI, USA
Andre Galli, University of Bern, Switzerland
Marzena A. Kubiak, Polish Academy of Sciences, Poland
David J. McComas, Princeton University, USA
Nathan A. Schwadron, University of New Hampshire, USA
Justyna M. Sokol, Polish Academy of Sciences, Poland

The IBEX Mission has been collecting ENAs from the outer heliosphere for eight years, or three-quarters of a solar cycle. In that time, we have observed clear evidence of the imprint of the solar cycle in the time variation in the ENA flux. The most detailed of such studies has focused on the polar ENA flux observed by IBEX-Hi, as the IBEX spacecraft attitude allows for continuous coverage of the ENA flux incident from the ecliptic poles (Reisenfeld et al. 2012, 2016). By time correlating the ENA-derived heliosheath pressure to the observed 1 AU dynamic pressure, we can estimate the distance to the ENA source region. We now further derive the distance to the termination shock (TS) and the thickness of the inner heliosheath (IHS) by assuming pressure balance at the TS. This requires using the 1 AU observations to derive the dynamic pressure at the TS shock by use of a mass-loaded solar wind propagation model (Schwadron et al. 2011), and by integrating ENA observations across all energies that significantly contribute to the heliosheath pressure. We accomplish this by including polar ENA observations from not only IBEX-Hi, but from IBEX-Lo and Cassini/INCA, spanning an energy range of 15 eV to 40 keV. The result of this analysis indicates a TS distance of 125 AU and a IHS thickness of 190 AU in the north, and a TS distance of 110 AU and a IHS thickness of 165 AU in the south.

Thursday, March 9: 9:40 AM - 10:05 AM
Presenter: Gladstone, Randy

New Horizons Observations of Interplanetary Lyman alpha

G. R. Gladstone, Southwest Research Institute, San Antonio, TX, USA

New observations of interplanetary medium (IPM) Lyman alpha (Lya) emissions in the outer solar system have been obtained by the Alice ultraviolet spectrograph on the New Horizons spacecraft—the first new such data from outside the orbit of Saturn since the Voyager spacecraft. Cruise observations consist of three individual 6 x 360 degree great-circle swaths on the sky, centered on the ecliptic direction (lambda, beta) = (51.3, 44.8 degrees), which were acquired on October 7, 2007, October 18, 2008, and June 19, 2010; the New Horizons spacecraft was 7.6, 11.3, and 17.0 AU from the Sun, respectively, at these times. During the epoch of the Pluto flyby, two detailed IPM Lya sky maps were acquired, each consisting of 6 great-circle swaths on the sky at a spacing of 30 degrees, on June 16, 2015 (28 days before the Pluto flyby) and July 15, 2015 (1 day after the Pluto flyby); the New Horizons spacecraft was 32.7 and 32.9 AU from the Sun, respectively, at these times. The data compare fairly well with model simulations, although the brightness of IPM Lya emissions falls off more slowly than expected with radial distance from the Sun. The IPM Lya brightness near Pluto was ~1.8 times larger than model predictions. Plans are in place to continue the detailed mapping, at 6-month intervals, as New Horizons continues its way out of the solar system, with the aim of searching for large scale structures in the heliosphere. In this talk an overview of the IPM Lya science results will be presented.

SCHEDULE OF TALKS

NOTES

Thursday, March 9: 10:30 AM - 10:55 AM
Presenter: Jokipii, Jack

Pressure Balance at the Heliopause

J. R. Jokipii, University of Arizona, USA
J. Kota, University of Arizona
Joe Giacalone, University of Arizona

Recent observations by Voyager 1 (V1) have demonstrated the complex structure of the heliosphere and its interaction with the solar wind. In 2012, V1 crossed a boundary where the magnetic field, anomalous cosmic ray, galactic cosmic rays changed abruptly. Subsequently, the radio-wave experiment on V1 established the electron density as .08/cc, close to that expected for interstellar plasma. The consensus was that the boundary was the heliopause, and that V1 was in interstellar plasma. There has been some debate as to this interpretation.
The heliopause is an example of a contact discontinuity, where the magnetic field on both sides is in the plane of the boundary. Hence the total pressures on the two sides of the heliopause must balance. Recently, it was pointed out that the pressure balance poses problems. We address this issue by considering physical effects not considered previously.

Thursday, March 9: 10:55 AM - 11:20 AM
Presenter: Richardson, John

The Heliosheath at Solar Maximum

John Richardson M.I.T USA
The Voyager Team

Both Voyager 1 and 2 entered the heliosheath near solar minimum. Voyager 2 is now observing for the first time the heliosheath at solar maximum. Since 2012 Voyager 2 has observed a series of pressure pulses in the plasma associated with increases, then decreases in the galactic cosmic ray intensity and increases in B (in the 2012 and 2013 events for which data are available). These pressure pulses show increases in thermal density and temperature and in energetic particles with keV to MeV energies. They seem similar to those predicted to occur when the MIRs which dominate the solar wind structure of the outer heliosphere at solar maxima reach the termination shock (i.e., Story and Zank JGR 1997). The propagation time of these events to the distance of Voyager 1 is calculated and the data are consistent with these pressure pulses driving the plasma wave events observed at Voyager 1. The largest event at V2 was in late 2015 and it is predicted to arrive at Voyager 1 in early 2018.

Thursday, March 9: 11:20 AM - 11:45 AM
Presenter: Pogorelov, Nikolai

Physical Phenomena at the Heliospheric Interface

Nikolai Pogorelov, UAH, USA
Jacob Heerikhuisen, UAH, USA
Tae Kim, UAH, USA
Vadim Roytershteyn, SSI, USA

Physical phenomena are discussed that affect the plasma flow and magnetic field distributions in the boundary layers created by the solar wind (SW) interaction with the local interstellar medium (LISM). These include the "undraping" of the interstellar magnetic field as Voyager 1 propagates deeper into the time-dependent LISM, the structure of the plasma depletion layer in front of the heliopause, pickup ion behavior, and magnetic field dissipation in the turbulent SW plasma.

SCHEDULE OF TALKS

NOTES

Thursday, March 9: 11:45 AM - 12:10 PM
Presenter: Li, Hui

Plasma heating inside ICMEs by Alfvenic Fluctuations Dissipation

Hui Li, National Space Science Center CAS, China
Chi Wang, National Space Science Center CAS, China
Jiansen He, Peking University, China
Lingqian Zhang, National Space Science Center CAS, China
John D. Richardson, Massachusetts Institute of Technology, USA
John W. Belcher, Massachusetts Institute of Technology, USA
Cui Tu, National Space Science Center CAS, China

Nonlinear cascade of low-frequency Alfvenic fluctuations (AFs) is regarded as one of the candidate energy sources that heat plasma during the non-adiabatic expansion of interplanetary coronal mass ejections (ICMEs). However, AFs inside ICMEs were seldom reported in the literature. In this study, we investigate AFs inside ICMEs using observations from Voyager 2 between 1 and 6 au. It has been found that AFs with a high degree of Alfvenicity frequently occurred inside ICMEs for almost all of the identified ICMEs (30 out of 33 ICMEs) and for 12.6% of the ICME time interval. As ICMEs expand and move outward, the percentage of AF duration decays linearly in general. The occurrence rate of AFs inside ICMEs is much less than that in ambient solar wind, especially within 4.75 au. AFs inside ICMEs are more frequently presented in the center and at the boundaries of ICMEs. In addition, the proton temperature inside ICME has a similar “W”-shaped distribution. These findings suggest significant contribution of AFs on local plasma heating inside ICMEs.

Thursday, March 9: 1:30 PM - 1:55 PM
Presenter: Washimi, Haruichi

Time-Varying Heliospheric Size due to Long- and Short-Time Variations in Solar Activity

Haruichi Washimi, University of Alabama in Huntsville, USA, and Kyushu University, Japan
Takashi Tanaka, Kyushu University, Japan
Gary P. Zank, University of Alabama in Huntsville, USA

Using a three-dimensional MHD simulation, we examine the time-varying scale of the heliopause. Voyager 2 solar wind observations show that an interplanetary shock (IPS) with a ram pressure of the order of several nPa normalized at 1 AU enters the outer heliosphere at an average rate of one per year or even more. In our simulation, we find that this series of IPSs reduces the surrounding interstellar medium pressure acting on the heliopause, and consequently that the estimated distance to the heliopause is 12-15 AU larger when compared to the case when a series of IPSs is not taken into account. In addition, OMNI data shows that the solar wind ram pressure near the Earth increases from ~1.3 nPA in year 2010 and before to 1.7-2.4 nPa after. These variations in the overall ram pressure of the solar wind are also accounted for in our simulation. The inclusion of the time variable solar wind ram pressure and the series of IPSs allows us to illustrate how the realistic heliopause scale varies in response to both long-time and short-time variability in solar activity.

Thursday, March 9: 1:55 PM - 2:20 PM
Presenter: Swaczyna, Pawel

Imaging Heliosphere with Energetic Neutral Atoms of Heavy Elements - Perspectives for ENA Detectors on IMAP

Pawel Swaczyna, Space Research Centre PAS (CBK PAN), Poland
Stan Grzedzielski, Space Research Centre PAS (CBK PAN), Poland
Maciej Bzowski, Space Research Centre PAS (CBK PAN), Poland

Observations of energetic neutral atoms (ENAs) allow for remote sensing of plasma properties in the distant regions of the heliosphere. So far, most of the observations have concerned only hydrogen atoms. In the perspective of the Interstellar Mapping and Acceleration Probe (IMAP) mission, it is expedient to assess expected fluxes of ENAs of heavier elements. The important source of ENAs is the inner heliosheath where they are created by neutralization of pick-up ions (PUIs). Most of the parent energetic PUIs are created in the supersonic solar wind from atoms of the interstellar neutral gas and accelerated at the termination shock. Besides of the dominating hydrogen atoms, the interstellar neutral gas contains some atoms of heavier elements. The most abundant of them are helium, oxygen, neon, and nitrogen. These atoms after ionization create PUIs, which can be sources of heavy ENAs. We calculated expected intensities of heavy ENAs of these elements from the inner heliosheath. For helium, we additionally calculated the contribution of the secondary ENAs created in the outer heliosheath. We assessed the possibility of detection of these ENAs using the next generation of ENA detectors. With the increased sensitivity of the detectors planned for IMAP, observations of heavy ENA should be possible. The detectors must be equipped with a mass spectrometer allowing for recognition of chemical elements to separate these ENAs from the dominating hydrogen signal. We found that observations of the heliosphere via ENAs of heavier elements may bring important insights into the shape of the heliosphere and ion energization processes. Helium ENAs can be particularly usable to image the global structure of the heliosphere. The obtained estimates show very large ratio of intensities of He ENAs from the downwind side to the upwind side. This is due to the long mean free paths against neutralization of helium ions in the inner heliosheath, much longer than that of protons. Consequently, He ENAs are produced in the distant heliospheric tail and can be observed at 1 au from the Sun. This implies that observations of He ENAs can resolve the enigma of the structure of the heliospheric tail, which seems challenging from observation of hydrogen ENAs because energetic protons are neutralized before they reach the tail. Moreover, observations of heavier ENAs should allow for tracking the acceleration processes at the termination shock for corresponding PUIs, which is not available from the in-situ measurements.

Thursday, March 9: 2:20 PM - 2:45 PM
Presenter: Opher, Merav

The Twist of the Draped Interstellar Magnetic Field Ahead of the Heliopause

M. Opher, Boston University
J. F. Drake, Univ. of Maryland
M. Swisdak, Univ. of Maryland
B. Zieger, Boston University
G. Toth, University of Michigan

Because of the expected direction of interstellar magnetic field (highly inclined to the east-west direction of solar magnetic field), earlier models predicted a dramatic rotation of the magnetic field direction upstream of the Heliopause. However, when Voyager 1 crossed the Heliopause, observations revealed an unexpected behavior of the magnetic field: there was almost no change in the direction of the magnetic field. Voyager 1 is four years and almost 16AU beyond the Heliopause and is still measuring angles with solar like values. Previously we showed that the interstellar magnetic field twists as it approaches the HP and acquires a strong T component (East-West) (Opher & Drake 2013). In this talk we present the mechanism responsible for the twist outside of the Heliopause and explore the observational consequences at Voyager 1 and 2.

Thursday, March 9: 2:45 PM - 3:10 PM
Presenter: Fuselier, Stephen

Reconnection at the Heliopause: Predictions for Voyager 2

Stephen A. Fuselier, Southwest Research Institute, USA
University of Texas at San Antonio, USA
Iver H. Cairns, School of Physics, University of Sydney, Australia

Predicted and observed properties of the inner and outer heliosheath were recently used to assess whether magnetic reconnection was occurring in the vicinity of the Voyager 1 crossing of the heliopause. It was concluded that reconnection may not have been occurring locally, but may have been occurring at a location remote from Voyager 1. Interestingly, observations from Voyager 1 provide possible evidence for remote reconnection. Here, the study is extended to the heliopause near the projected crossing location of Voyager 2, where the plasma depletion layer (PDL) should be significantly stronger. The predicted plasma properties are then used to determine if local reconnection is possible at this location.

Thursday, March 9: 3:10 PM - 3:35 PM
Presenter: Frisch, Priscilla

Interstellar Magnetic Field Direction Near the Heliosphere

P. C. Frisch, University of Chicago, USA
V. Piirola, University of Turku, Finland
A. B. Berdyugin, University of Turku, Finland
A. M. Magalhaes, University de Sao Paulo, Brazil
D. B. Seriacopi, University de Sao Paulo, Brazil
T. Ferrari, University de Sao Paulo, Brazil
A. Cole, University of Tasmania, Australia
K. Hill, University of Tasmaia, Australia
C. Harlingten, University of Tasmania, Australia
S. J. Wiktorowicz, Aerospace Corporation, USA
D. Cotton, University of New South Wales, Australia
F. P. Santos, Northwestern University, USA
D. J. McComas, Princeton Plasma Physics Lab, USA
H. O. Funsten, Los Alamos National Laboratory, USA
N. A. Schwadron, University of New Hampshire, USA
G. Livadiotis Southwest Research Institute, USA

We report the results of an ongoing observing program that is mapping the Inter-Stellar Magnetic Field (ISMF) within 40 pc of the Sun. The expectation is that the direction of the magnetic field determined by the IBEX ribbon can also be identified with that derived from the polarized starlight data. Linearly polarized starlight arises from the propagation of light through a dichroic interstellar medium formed by aligned dust grains and the ISMF. Observations collected to date for this project include measurements made at seven observatories in both hemispheres using high-sensitivity optical polarimeters. We find that the magnetic structure of the Loop I superbubble dominates the structure of the ISMF within 40 pc. The stellar polarization position angles in the distant portions of the Loop I superbubble are parallel to the distant filamentary structure of Loop I. Within 40 pc the polarization position angles reveal the ISMF in the front side of the Loop I superbubble. The ISMF direction determined from the IBEX ribbon is consistent with a magnetic field associated with the near side of the Loop I superbubble. These results indicate that the ISMF in the vicinity of the heliosphere is an ordered ISMF. Limits are placed on magnetic field turbulence.

Thursday, March 9: 3:55 PM - 4:20 PM
Presenter: Qin, Gang

Time-dependent Modulation of Glactic Cosmic Rays in the Inner Heliosphere

Gang Qin, Harbin Institute of Technology, China
Zhenning Shen, National Space Science Center, China

The 11 year and 22 year modulation cycles of galactic cosmic rays in the inner heliosphere is studied using a time-dependent modulation model. This model is based on the numerical solution of Parker's transport equations, incorporating a modified Parker heliospheric magnetic field, a time-dependent diffusion coefficients model and a locally static heliosphere. A turbulence model to describe the magnetic turbulence throughout the heliosphere is established, which agrees well with the observations of Voyager 2 and Ulysses. The turbulence model is incorporated in the diffusion coefficients model, then we construct a time dependence in the diffusion coefficients. We also use a simple model to describe the dynamic heliosphere which is considered locally static. The numerical results are compared with the 327-485 MeV proton intensity observations of IMP 8 for the period from year 1980 to 2000. It is shown that our model can successfully reproduce the 11 year and 22 year modulation cycles. Our results are also compared with the proton intensity observations for various energies along the trajectory of Ulysses, Voyager 1 and Voyager 2. All of the results are consistent with the observations.

Thursday, March 9: 4:20 PM - 4:45 PM
Presenter: Czechowski, Andrzej

Heliosphere in a Strong Interstellar Magnetic Field

Andrzej Czechowski, Space Research Center, Poland
Jolanta Grygorczuk, Space Research Center, Poland

We present results of MHD simulations of the global structure of the heliosphere for a wide range of interstellar magnetic field strengths (2-20 muG). For a strong interstellar field, the plasma flow in and around the heliosphere as well as the magnetic field draped over the heliopause have a simple structure, reminiscent of (though not identical to) the analytical model by Parker. We show how this structure evolves as the interstellar field strength is reduced down to the values in the observed range (few muG). We also present an example of applying this evolution to understand the present observations of the heliosphere.

Thursday, March 9: 4:45 PM - 5:10 PM
Presenter: Florinski, Vladimir

Large-scale Magnetic Fluctuations in the Outer Heliosheath and Galactic Cosmic-ray Depletions at the 90 Degree Pitch Angle

V. Florinski, University of Alabama in Huntsville, USA

For the past 4.5 years Voyager 1 has been exploring the region of interstellar space influenced by the heliosphere, known as the outer heliosheath (OHS). The conditions in the OHS are very "quiet", in the sense that the power in turbulent fluctuations relevant to the scattering of cosmic ray particles with energies below a few GeV is orders of magnitude smaller than what is typically measured in the solar wind. The bulk of the turbulent power resides in very long wavelength fluctuations that are thought to have a power law spectrum extending to several parsecs. These fluctuations are compressive, with most of the power in the fluctuating B component parallel to the mean magnetic field. Under such conditions, charged particles with pitch angles close to 90 degrees are excluded from regions of (slightly) stronger magnetic field, resulting in a depletion that resembles the observed "notch" in the angular distribution of galactic cosmic rays measured by the LECP instrument. This is demonstrated by tracing a large number of proton trajectories in a turbulent magnetic field deduced with Voyager 1 observations. The depth and angular extent of the notch depend on the properties of the ambient turbulence and could serve as constraints on the geometry of interstellar turbulence in the OHS.

Thursday, March 9: 5:10 PM - 5:35 PM
Presenter: Zirnstein, Eric

Structure of the Heliotail from Interstellar Boundary Explorer Observations: Implications for the 11 Year Solar Cycle and Pickup Ions in the Heliosheath

Eric J. Zirnstein, Princeton University, USA
Jacob Heerikhuisen, University of Alabama in Huntsville, USA
Gary P. Zank, University of Alabama in Huntsville, USA
Nikolai V. Pogorelov, University of Alabama in Huntsville, USA
Herbert O. Funsten, Los Alamos National Laboratory, USA
David J. McComas, Princeton University, USA
Daniel B. Reisenfeld, University of Montana, USA
Nathan A. Schwadron, University of New Hampshire, USA

Interstellar Boundary Explorer (IBEX) measurements of energetic neutral atoms (ENAs) from the heliotail show a multi-lobe structure of ENA fluxes as a function of energy between 0.71 and 4.29 keV. Below 2 keV, there is a single structure of enhanced ENA fluxes centered near the downwind direction. Above 2 keV, this structure separates into two lobes, one north and one south of the solar equatorial plane. ENA flux from these two lobes can be interpreted as originating from the fast SW propagating through the inner heliosheath (IHS). Alternatively, a recently published model of the heliosphere suggests that the heliotail may split into a croissant-like shape, and that such a geometry could be responsible for the heliotail ENA feature. Here we present results from a time-dependent simulation of the heliosphere that produces a comet-like heliotail, and show that the 11 year solar cycle leads to the formation of ENA lobes with properties remarkably similar to those observed by IBEX. The ENA energy at which the north and south lobes appear suggests that the pickup ion (PUI) temperature in the slow SW of the IHS is 10 MK. Moreover, we demonstrate that the extinction of PUIs by charge-exchange is an essential process required to create the observed global ENA structure. While the shape and locations of the ENA lobes as a function of energy are well reproduced by PUIs that cross the termination shock, the results appear to be sensitive to the form of the distribution of PUIs injected in the IHS.

Thursday, March 9: 5:35 PM - 6:00 PM
Presenter: Wood, Brian

A Search for Secondary He in Ulysses/GAS Data

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

The Interstellar Boundary EXplorer (IBEX) mission has discovered a secondary source of neutral helium flowing through the heliosphere, in addition to the primary source, which are the interstellar neutrals. The secondaries are likely to be neutrals created by charge exchange in the outer heliosphere, beyond the heliopause, and are therefore useful diagnostics of this region. In order to confirm the IBEX detection and to provide additional observational constraints, we search the older Ulysses/GAS database of neutral He observations for evidence of the secondary population, and we find that by coadding all the Ulysses He beam maps, we discern a signal in the data that is consistent with the IBEX secondary population. We discuss how to study the secondary He flow without resorting to the assumption of a laminar flow at infinity, an assumption appropriate for analysis of the primary He, but probably not for the secondary component.

Friday, March 10: 8:00 AM - 8:25 AM
Presenter: Cooper, John

Outer Heliospheric and Local Interstellar Environments of Extreme Kuiper Belt Objects and Planets

John F. Cooper, NASA Goddard Space Flight Center, USA
Steven J. Sturner, University of Maryland Baltimore County, USA

Continuing discoveries of extreme Kuiper Belt Objects, those like Sedna with orbits extending outside the known heliosphere, may also be providing indirect evidence for a 9th planet on a similar orbit. What radiation conditions would such bodies experience in orbital journeys between the boundary regions of the outer heliosphere and local interstellar space? How would these conditions affect atmospheric and surface chemistry of these bodies? The ongoing energetic particle and plasma measurements by the IBEX and Voyager spacecraft, and Earth-based measurements of higher energy galactic cosmic ray particles, are providing a wealth of information that can be used to build models of the radiation conditions and interactions. These data also allow inferences to be made about the LISM-Heliosphere interactions, e.g. the balance of pressure at the heliopause and beyond from magnetic fields, plasma, and energetic particles. The Voyager 1 "heliocliff" further provides insight into how thin magnetic structures can restrict the access of particles from internal and external sources. Might there be further such boundaries to cross before the Voyagers enter into truly interstellar space?

Friday, March 10: 8:25 AM - 8:50 AM
Presenter: Li, Hui

Parametric Decay Instability of Alfven Waves and Particle Heating in Low-Beta Plasmas

Hui Li, LANL, USA
Mijie Shi, PKU, China
Fan Guo, LANL, USA
Xiangrong Fu, NMC, USA

Relatively large-amplitude Alfven waves (dB/B = 0.1-0.3) are often observed in the solar wind. The nonlinear evolution of the parametric decay instability (PDI) of Alfven waves has been studied previously. Here, we investigate the effects of turbulence of the background plasma on the excitation and nonlinear evolution of PDI in low-beta plasmas. We present three-dimensional MHD and kinetic simulation results on the nonlinear evolution of PDI and examine the associated particle heating processes. Implications will be discussed in the context of solar wind heating, solar wind slow wave generation, as well as solar corona and astrophysical accretion disk corona heating.

Friday, March 10: 8:50 AM - 9:15 AM
Presenter: Le, Ari

Enhanced Electron Heating and Mixing in a 3D Kinetic Simulation for MMS Magnetopause Crossings with Weak Guide Fields

Ari Le, LANL, USA
William Daughton, LANL, USA

We present a 3D kinetic simulation of asymmetric reconnection with plasma parameters matching the MMS magetopause diffusion region crossing reported by Burch et al. (Science 2016). The simulation was performed with the code VPIC on LANL's Trinity machine, which enabled relatively high grid resolution and numerical particle numbers to resolve the electron diffusion region dynamics. The simulation not only reproduces the reported crescent distributions but also appears to account for new features observed by MMS in other diffusion region events with weak guide fields. Compared to a 2D simulation with the same plasma parameters, drift turbulence in the 3D simulation substantially enhances the mixing and parallel heating of electrons on the magnetosphere side. This modifies the reconnection rate inferred from a recently introduced electron mixing diagnostic. To the magnetosphere side of the in-plane magnetic null, the parallel electric field exhibits a bipolar structure with polarities opposite to the large-scale E_parallel. The 3D structure of the X line and the particle signature of the inverted bipolar E_parallel have been observed by MMS.

SCHEDULE OF TALKS

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Friday, March 10: 9:15 AM - 9:40 AM
Presenter: Malkov, Mikhail

Transport of Energetic Particles in Astrophysical Plasmas: from Rectilinear to Diffusive Propagation

M.A. Malkov, University of California, San Diego, USA

Propagation of energetic particles through magnetized turbulent media is reconsidered using an exact solution to the Fokker-Planck equation. It strictly applies to isotropic scattering but it captures all relevant propagation regimes, from ballistic to diffusive, for all space- and time-scales relevant to the particle mean free path and collision time. It is found that an intermediate (transdiffusive) propagation regime lasts for a (surprisingly) long time, 3-4 particle scatterings while starting as early as at a one-half of collision time. Since the particle scattering strongly depends on its energy, there always are particles that never propagate diffusively. Their treatment should utilize the exact solution of Fokker-Planck equation. Problems with the application of often used approaches based on the telegraph equation and fractional diffusion are also briefly discussed.

Friday, March 10: 9:40 AM - 10:05 AM
Presenter: Lembege, Bertrand

Microturbulence within the Front of a Quasi-perpendicular Supercritical Shock

LEMBEGE Bertrand, LATMOS-CNR-IPSL-UVSQ, France
MUSCHIETTI Laurent, SSL-UCB, USA

Supercritical shocks are characterized by a noticeable fraction of the incoming ions which is reflected at the steep front, stream across the magnetic field and form a foot upstream of the ramp. These ions accumulate and have several impacts : (i) these are responsible for the shock front self-reformation, (ii) these carry a significant amount of energy and play a key role in transforming the directed bulk energy (upstream) into thermal energy (downstream) and (iii) are source of microturbulence within the shock front itself. Indeed, the relative drift between the reflected ion beam and the incoming electrons within the foot can easily destabilize waves (electron cyclotron drift instability or ECDI) in the electron cyclotron frequency range. By means of linear analysis, several Bernstein harmonics are shown to be unstable, their number being proportional to the drift, yet limited by the ion beam’s temperature. Separate electromagnetic PIC simulations restricted to all ions and electrons populations of the foot region have been performed in order to investigate the nonlinear characteristics of these waves with a high spatial resolution and a high statistics. First, high cyclotron harmonics develop in good agreement with linear dispersion properties and over times much smaller that the characteristic period of the shock front self-reformation. Second, as the high k-modes saturate by trapping ions of the reflected beam, an « inverse cascade-type » signature occurs whereby the spectral power shifts toward lower k-modes to eventually accumulate on the first harmonic. Third, one surprising result in the late phase is the development of a magnetic component to the spectrum that had so far been mostly electrostatic. Fourth, present simulations also evidence a significant energy transfer from the ion beam to the electrons which experience a marked increase in temperature: a preheating takes place before electrons reach the ramp which may impact the global energy partition through the shock front.

SCHEDULE OF TALKS

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Friday, March 10: 10:30 AM - 10:55 AM
Presenter: Mazelle, Christian

Martian Electron Foreshock: New Results from MAVEN and Comparison with Terrestrial Electron Foreshock

C. Mazelle, IRAP, CNRS – UPS, Toulouse, France
K. Meziane, Physics Department, University of New Brunswick, Fredericton, Canada
N. Romanelli, IRAP, CNRS – UPS, Toulouse, France
D.L. Mitchell, Space Sciences Laboratory, University of California, Berkeley, CA, USA

At Mars, significant flux enhancements associated with electrons in the 50 eV-2 keV energy range are always observed when the MAVEN spacecraft is magnetically connected to the shock. A detailed examination of the pitch angle distribution obtained by the Solar Wind Electron Analyzer (SWEA) shows that the enhanced fluxes correspond to electrons moving sunward away from Mars (foreshock backstreaming population). The full 3-dimensional angular distribution shows that the phase space density values are peaked at a non-zero pitch angle and that the electrons appear in a ring centered along the IMF direction. Two different electron populations are identified. The first one consists in electrons in the 50-400 eV energy range emanating from the entire shock region. For this population, electron flux reaches a maximum near the shock surface. The second population consist in spikes of energetic electrons up to ~ 1.5 keV detected near the Martian foreshock boundary. The spikes usually appear following a rotation of the interplanetary magnetic field (IMF). We show that they emanate from a narrow region at the tangency point of the IMF with Martian bow shock. There is no clear evidence that the radius of the ring is energy dependent for these spikes. These features have demonstrated for the first time that Mars acts as a fast magnetic mirror which can reflect solar wind electrons to produce high energy electron bursts. A quantitative analysis has been carried out and a higher bound of the cross-shock potential of Mars bow shock can be estimated. Although striking differences exist between the Earth and Mars shock structures, these observations show strong similarities in both the Terrestrial and Martian electron foreshocks.

Friday, March 10: 10:55 AM - 11:20 AM
Presenter: Parks, George

Mass, Charge and Energy Dependence of Solar Wind Interaction with Earth's Bow Shock

G. K. Parks, Space Sciences Laboratory, UC Berkeley, Berkeley, CA USA
E. S. Lee, Department of Space Science, Kyung Hee University, Suwon, Korea
S. Y. Fu, Department of Geophysics, Peking University, Beijing, China,
N. Lin, Space Sciences Laboratory, UC Berkeley, Berkeley, CA USA
Z. W. Yang, Space Weather, Chinese Academy of Sciences, Beijing, China
Ying Liu, Space Weather, Chinese Academy of Sciences, Beijing, China

Observations, theories and PIC simulations have shown that understanding the Earth's bow shock must include not only the shock itself but also the upstream and downstream dynamics. This talk will discuss how the SW interacts with Earth's bow shock, emphasizing the dependence of mass, energy and charge of solar wind (SW) transport across the shock. We have examined 111 crossings during quiet SW in both quasi-perpendicular and quasi-parallel shock regions and find that 64 crossings show various degrees of heating and thermalization of SW. The remaining 47 show that while the SW H+ ions generally decelerate across the bow shock, the temperatures of H+ and He++ beams can be the same in the upstream and downstream regions indicating that little or no heating had occurred crossing the bow shock. The deceleration of the SW H+ ions is consistent with the shock models that include a potential across the shock, but what physics allows the SW ions to cross the bow shock without heating is not predicted by any models. Our observations are important constraints for developing new models of how the SW interacts with collisionless shocks.

SCHEDULE OF TALKS

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Friday, March 10: 11:20 AM - 11:45 AM
Presenter: Weidl, Martin

Parallel Collisionless Shocks Forming in Simulations of the LAPD Experiment

Martin S. Weidl, UCLA, USA
Peter Heuer, UCLA, USA
Anton Bondarenko, UCLA, USA
Derek Schaeffer, UCLA, USA
Dan Winske, LANL, USA
Carmen Constantin, UCLA, USA
Frank Jenko, UCLA, USA
Christoph Niemann, UCLA, USA

Previous research on parallel collisionless shocks, which constitute an important part of the Earth's bow shock region, has been limited to satellite measurements and simulations. However, whether and how these collisionless shocks form depends on a wide range of parameters and scales, some of which can be established and measured more easily in a laboratory experiment.
Using a kJ-class laser, an ongoing experimental campaign at the Large Plasma Device (LAPD) at UCLA is expected to produce the first laboratory measurements of the formation of a parallel collisionless shock. We present hybrid kinetic/MHD simulations which show how ion-beam instabilities in the background plasma can be driven by ablating carbon ions from a polyethylene target, causing non-linear density oscillations which eventually develop into a propagating shock front.
The free-streaming carbon ions can excite both the resonant right-hand instability and the non-resonant firehose mode, the latter of which has also received a lot of attention among astrophysicists as Bell's instability. We present measurements from a first trial experiment at LAPD, in which we have identified these instabilities, and discuss their respective roles for future shock formation and the basic microphysical processes which drive them.

List of Attendees

Adhikari, Laxman ....University of Alabama in Huntsville, Department of Space Science, 301 Sparkman Drive, Huntsville, AL, 35899, USA, la0004@uah.edu

Antiochos, Spiro ....NASA Goddard Space Flight Center, Heliophysics Science Division, Code 670, Bldg. 21, Rm. 128, Greenbelt, MD, 20771, USA, spiro.antiochos@nasa.gov

Baker, Dan ....University of Colorado Boulder, Laboratory for Atmospheric & Space Phyiscs, 3665 Discovery Drive, LASP, Boulder, CO, 80303, USA, daniel.baker@lasp.colorado.edu

Boldyrev, Stanislav..................................University of Wisconsin - Madison, Physics, 1150 University Ave., Madison, WI, 53706, USA, boldyrev@wisc.edu

Bučík, Radoslav ....University of Göttingen, Institute for Astrophysics, Friedrich-Hund-Platz 1, Göttingen, Lower Saxony, 37077, GERMANY, rbucik@astro.physik.uni-goettingen.de

Bzowski, Maciej..Polish Academy of Sciences, Space Research Centre, Bartycka 18 A, Warsaw, 00-716, POLAND, bzowski@cbk.waw.pl

Chapman, Sandra ....University of Warwick, Physics, Gibett Hill Road, Coventry, Warwick, CV4 7AL, UK, s.c.chapman@warwick.ac.uk

Coates, Andrew..University College London, Mullard Space Science Laboratory, Holmbury St. Mary, Dorking, Surrey, RH5 6NT, UK, a.coates@ucl.ac.uk

Consolini, Giuseppe.................................INAF-IAPS, ITALY, giuseppe.consolini@inaf.it

Cooper, John..NASA, USA, John.F.Cooper@nasa.gov

Cummings, Alan ....Caltech, Space Radiation Lab, Mail Code 290-17, Pasadena, CA, 91125, USA, ace@srl.caltech.edu

Czechowski, Andrzej ....Polish Academy of Sciences, Space Research Center, Bratycka 18A, Warsaw, Mazowieckie, 00716, POLAND, ace@cbk.waw.pl

Fisk, Len..University of Michigan, Climate & Space Sciences and Engineering, 2455 Hayward St., Ann Arbor, MI, 48109-2143, USA, lafisk@umich.edu

Florinski, Vladimir....................................University of Alabama in Huntsville, Space Science, 320 Sparkman Dr., Huntsville, AL, 35899, USA, vaf0001@uah.edu

Fox, Nicola ....JHU/APL, Space Exploration Sector, 11101 Johns Hopkins Road, Laurel, MD, 20723, USA, nicola.fox@jhuapl.edu

Frisch, Priscilla ....University of Chicago, Astronomy and Astrophysics, 5640 South Ellis Avenue, Chicago, IL, 60637, USA, frisch@oddjob.uchicago.edu

Funsten, Herbert ....Los Alamos National Laboratory, Intelligence and Space Research Division, MS B241, Los Alamos, NM, 87545, USA, hfunsten@lanl.gov

Fuselier, Stephen ....Southwest Research Institute, Space Science & Engineering Division, 6220 Culebra Road, P.O. Drawer 28510, San Antonio, TX, 78228-0510, USA, sfuselier@swri.edu

List of Attendees

Gary, S. Peter.. Space Science Institute, Physics, 1101 Piedra Alto, Santa Fe, NM, 87501, USA, pgary@lanl.gov

Gedalin, Michael .... Ben-Gurion University, Department of Physics, Beer-Sheva, 84105, ISRAEL, gedalin@bgu.ac.il

Giacalone, Joe .... University of Arizona, Lunar and Planetary Laboratory, 1629 E. University, Tucson, AZ, 85721, USA, giacalon@lpl.arizona.edu

Gladstone, Randy .... Southwest Research Institute, Space Science and Engineering, 6220 Culebra Road, San Antonio, TX, 78238, USA, rgladstone@swri.edu

Gloeckler, George .... University of Michigan, Climate & Space Sciences and Engineering, 2455 Hayward St., Ann Arbor, MI, 48109-2143, USA, gglo@umich.edu

Golla, Thejappa...................................... University of Maryland, Astronomy, College Park, MD, 20742, USA, thejappa.golla@nasa.gov

Gopalswamy, Nat................................... NASA Goddard Space Flight Center, Heliophysics, Code 671, Greenbelt, MD, 20771, USA, nat.gopalswamy@nasa.gov

Guo, Xiaocheng...................................... Chinese Academy of Sciences, National Space Science Center, Beijing, CHINA, xcguo@spaceweather.ac.cn

Guo, Fan .... Los Alamos National Laboratory, Theoretical Division, MS 227, Los Alamos, NM, 87544, USA, guofan.ustc@gmail.com

Hill, Matthew... Johns Hopkins University, Applied Physics Laboratory - Space Department, 11100 Johns Hopkins Road, Laurel, MD, 20723-6099, USA, matthew.hill@jhuapl.edu

Hunana, Peter .... University of Alabama in Huntsville, CSPAR, 320 Sparkman Drive, NSSTC Building, Huntsville, AL, 35805, USA, peter.hunana@gmail.com

Jeffrey, Natasha .... University of Glasgow, Physics and Astronomy, Room 614, Kelvin Building, University Avenue, Glasgow, Lanarkshire, G12 8QQ, UK, natasha.jeffrey@glasgow.ac.uk

Jokipii, Jack .... University of Arizona, Planetary Sciences and Astronomy, Kuiper Space Sciences, Bldg. 92, Tucson, AZ, 85721, USA, jokipii@lpl.arizona.edu

Kahler, Stephen...................................... Air Force Research Laboratory, Space Vehicles Division/Space Environment Branch, 3550 Aberdeen Ave SE, Bldg 570, Kirtland AFB, NM, 87117-5776, USA, stephen.kahler@us.af.mil

Klein, Kristopher..................................... University of Michigan, Climate and Space Sciences, 28527 Carlton Way Drive, Novi, MI, 48377, USA, kris.klein@gmail.com

Kong, Xiangliang .... Shandong University, CHINA, kongx@sdu.edu.cn

Krimigis, Stamatios .... Johns Hopkins Applied Physics Laboratory, Space, 11100 Johns Hopkins Rd., Laurel, MD, 20723, USA, tom.krimigis@jhuapl.edu

List of Attendees

Kucharek, Harald .... University of New Hampshire, Space Science Department, 8 College Road, Durham, NH, 03857, USA, harald.kucharek@unh.edu

Kumar, Rahul .... Princeton University, Department of Astrophysical Sciences, 4 Ivy Lane, Princeton, NJ, 08544, USA, rahuliitk@gmail.com

Lario, David .... The Johns Hopkins University, Applied Physics Laboratory, 11100 Johns Hopkins Rd., Laurel, MD, 20723, USA, david.lario@jhuapl.edu

Le, Ari .... LANL, Plasma Theory & Applications, 308 Alta Vista St., Santa Fe, NM, 87505, USA, arile@lanl.gov

Le Roux, Jakobus.................................. University of Alabama in Huntsville, Space Science, 320 Sparkman Drive, Cramer Hall/NSSTC 2040, Huntsville, AL, 35805, USA, jar0013@uah.edu

Lembege, Bertrand .... LATMOS-IPSL-UVSQ-CNRS, HEPPI, 11 Bd d'Alembert, Guyancourt, 78280, FRANCE, bertrand.lembege@latmos.ipsl.fr

Leske, Richard .... California Institute of Technology, Space Radiation Laboratory, Mail Code 290-17, Pasadena, CA, 91125, USA, ral@srl.caltech.edu

Li, Hui .... Los Alamos National Laboratory, MS B227, Los Alamos, NM, 87545, USA, hli@lanl.gov

Li, Xiaocan .... Los Alamos National Laboratory, T-2, 802 9th St. Apt. 9, Los Alamos, NM, 87544, USA, phyxiaolee@gmail.com

Li, Gang.................................. University of Alabama in Huntsville, Space Science, NSSTC Bldg, Huntsville, AL, 35899, USA, gang.li@uah.edu

Li, Hui .... National Space Science Center, CAS, State Key Laboratory of Space Weather, NO. 1 Nanertiao, Haidian District, Beijing, 100190, CHINA, hli@spaceweather.ac.cn

Lin, Yu .... Auburn University, Physics Department, 206 Allison Laboratory, Auburn, AL, 36849, USA, ylin@physics.auburn.edu

Livadiotis, George .... Southwest Research Institute, Space Science & Engineering, 6220 Culebra Road, Div. 15, San Antonio, TX, 78238, USA, glivadiotis@swri.edu

Lu, Quanming.................................. University of Science & Technology of China, Geophysics and Planetary Science, 96 Jinzhai Road, Hefei, Anhui, 230026, CHINA, qmlu@ustc.edu.cn

Luhmann, Janet .... University of California, Berkeley, Space Sciences Laboratory, 7 Gauss Way, Berkeley, CA, 94720, USA, jgluhman@ssl.berkeley.edu

Malkov, Mikhail.................................. University of California, San Diego, Physics, CASS, 9500 Gilman Drive # 0424, La Jolla, CA, 92093-0424, USA, mmalkov@ucsd.edu

Manchester, Ward .... University of Michigan, Climate & Space Sciences and Engineering, 2455 Hayward Street, Ann Arbor, MI, 48109-2143, USA, chipm@umich.edu

List of Attendees

Matthaeus, William .... University of Delaware, USA, yswhm@bartol.udel.edu

Mazelle, Christian .... IRAP/University of Toulouse-CNRS, Solar System Department, 9, Avenue du Colonel Roche, Toulouse, 31400, FRANCE, christian.mazelle@cesr.fr

McComas, Dave .... Princeton University, Princeton Plasma Physics Laboratory, 100 Stellarator Road, Princeton, NJ, 08558, USA, dmccomas@princeton.edu

McKenzie, David .... Montana State University, Department of Physics, P.O. Box 173840, Bozeman, MT, 59717, USA, mckenzie@solar.physics.montana.edu

Medvedev, Mikhail .... University of Kansas, Physics and Astronomy, 1251 Wescoe Hall Drive, Malott Hall, Room 1082, Lawrence, KS, 66045, USA, medvedev@ku.edu

Mewaldt, Richard .... Caltech, Physics, 290-17 Cahill Laboratory, Pasadena, CA, 91125, USA, rmewaldt@caltech.edu

Mostafavi, Parisa .... University of Alabama in Huntsville, Department of Space Science, 320 Sparkman Drive, Huntsville, AL, 35816, USA, psm0011@uah.edu

Oka, Mitsuo .... University of California, Berkeley, Space Sciences Laboratory, 7 Gauss Way, Berkeley, CA, 94720-7450, USA, moka@ssl.berkeley.edu

Opher, Merav .... Boston University, Astronomy Department, 725 Commonwealth Ave., Boston, MA, 02215, USA, mopher@bu.edu

Parks, George .... University of California, Berkeley, Space Sciences Laboratory, 7 Gauss Way, Berkeley, CA, 94720, USA, parks@ssl.berkeley.edu

Pogorelov, Nikolai .... University of Alabama in Huntsville, Department of Space Science, 320 Sparkman Drive, Huntsville, AL, 35805, USA, np0002@uah.edu

Qin, Gang .... Harbin Institute of Technology, Shenzhen, School of Science, HIT Campus of University Town of Shenzhen, Shenzhen, Guangdong, 518055, CHINA, qingang@hit.edu.cn

Raymond, John .... Center for Astrophysics, SSP, 60 Garden St., Cambridge, MA, 02138, USA, jraymond@cfa.harvard.edu

Reeves, Geoffrey .... Los Alamos and NMC, Space Science and Applications, P.O. Box 1663, Los Alamos, NM, 87545, USA, geoff@reevesresearch.org

Reisenfeld, Daniel .... University of Montana, Department of Physics & Astronomy, 32 Campus Drive, Missoula, MT, 59812, USA, dan.reisenfeld@umontana.edu

Richardson, John .... MIT, Kavli Center, 77 Mass Ave., Cambridge, MA, 01776, USA, jdr@space.mit.edu

Roelof, Edmond .... Johns Hopkins University, Applied Physics Laboratory - Space Sector, 6346 Windharp Way, Columbia, MD, 21045-4535, USA, edmond.roelof@jhuapl.edu

List of Attendees

Salem, Chadi..University of California, Berkeley, Space Science Laboratory, 7 Gauss Way #7450, Berkeley, CA, 94720-7450, USA, salem@ssl.berkeley.edu

Smith, Charles..University of New Hampshire, Institute for the Study of Earth,Oceans and Space, 207 Morse Hall, Durham, NH, 03824, USA, charles.smith@unh.edu

Sokol, Justyna..Polish Academy of Sciences, Space Research Centre, Bartycka 18A, Warsaw, 00-716, POLAND, jsokol@cbk.waw.pl

Stone, Edward..California Institute of Technology, Space Radiation Laboratory, 1200 East California Blvd., Mail Code 290-17, Pasadena, CA, 91125, USA, ecs@srl.caltech.edu

Suess, Steven..NASA MSFC, Retired, Solar Physics, 4303 Panorama Drive, Huntsville, AL, 35801, USA, stevesuess@bellsouth.net

Swaczyna, Pawel....................................Polish Academy of Sciences, Space Research Centre, Bartycka 18A, Warsaw, 00-716, POLAND, pswaczyna@cbk.waw.pl

Swisdak, Marc..University of Maryland, Physics, Energy Research Facility, College Park, MD, 20742, USA, swisdak@umd.edu

Tang, Bofeng..University of Alabama in Huntsville, Department of Space Science, 700 John Wright Dr. NW, Apt. J, Huntsville, AL, 35805, USA, bt0008@uah.edu

Tenishev, Valeriy....................................University of Michigan, Climate & Space Sciences and Engineering, 2455 Hayward Street, Ann Arbor, MI, 48109, USA, vtenishe@umich.edu

Usmanov, Arcadi....................................University of Delaware/NASA GSFC, Department of Physics and Astronomy, 8800 Greenbelt Road, Greenbelt, MD, 20771, USA, arcadi.usmanov@nasa.gov

Wang, Linghua.......................................Peking University, Geophysics Dept., Room 416, North Physics Bldg., Beijing, 100871, USA, wanglhwang@gmail.com

Washimi, Haruichi..................................University of Alabama in Huntsville, CSPAR, 320 Sparkman Dr, Huntsville, AL, 35805, USA, hwashimi2004@hotmail.com

Weidl, Martin..University of California, Los Angeles, Physics & Astronomy, 475 Portola Plaza, Los Angeles, CA, 90095-1547, USA, mwei@physics.ucla.edu

Winske, Dan...Los Alamos National Laboratory, XCP-6, 442 Ridgecrest Ave., Los Alamos, NM, 87547, USA, winske@losalamos.com

Wood, Brian..Naval Research Laboratory, Space Science Division, 4555 Overlook Ave., SW, Washington, DC, 20375, USA, brian.wood@nrl.navy.mil

Yan, Huirong...DESY, Astroparticle Physics, In der Feldmark 4, Potsdam, Brandenburg, 14476, GERMANY, hyan@mail.desy.de

Yoon, Peter..University of Maryland, Institute for Physical Science and Technology, IPST, UMD, College Park, MD, 20742, USA, yoonp@umd.edu

List of Attendees

Zank, Gary... University of Alabama in Huntsville, CSPAR/Dept. of Space Science, 320 Sparkman Drive, Huntsville, AL, 35805, USA, garyp.zank@gmail.com

Zharkova, Valentina .... Northumbria University, Mathematics, Physics and Electrical Engineering, Ellison Square, Ellison Building, Newcastle, Tyne and Wear, NE1 8ST, UK, valentina.zharkova@northumbria.ac.uk

Zheng, Jinlei .... University of Alabama in Huntsville, Department of Space Science, 6331 Karen Davie Dr, Huntsville, AL, 35806, USA, jz0006@uah.edu

Zirnstein, Eric .... Princeton University, Department of Astrophysical Sciences, 4 Ivy Lane, Peyton Hall, Princeton, NJ, 08544, USA, ejz@astro.princeton.edu

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