20th Annual International Astrophysics Conference
Santa Fe, NM, October 31 – November 4, 2022

AGENDA

SUNDAY, OCTOBER 30	
5:00 PM - 8:00 PM	Registration – Julia Patio
6:00 PM - 9:00 PM	Welcome Reception - Julia Patio & Tent

MONDAY, OCTOBER 31		
7:00 AM - 5:00 PM	Registration -Montana Foyer	
8:00 AM - 5:10 PM	GENERAL SESSION – Montana Ballroom	
	CHAIR: Zank	
8:00 AM - 8:25 AM	Zou, Ying	Unsteady Magnetopause Reconnection Under Quasi-Steady Solar Wind Driving
8:25 AM - 8:50 AM	Koepke, Mark	Some Auroral Arcs Last All Night: An Unresolved Theoretical Challenge
8:50 AM - 9:15 AM	Liang, Haoming	Assessing the Role of Interchange Reconnection in Forming Switchbacks
9:15 AM - 9:40 AM	Raeder, Joachim	On the Plasma Entropy in the Magnetosphere and the Solar Corona
9:40 AM - 10:05 AM	Kornbleuth, Marc	An ACR Mediated Termination Shock
10:05 AM - 10:30 AM	Morning Break - Canyon Room	
	CHAIR: McNutt, R.	
10:30 AM - 10:55 AM	McComas, David	Interstellar Pickup Ion Observations in the Outer Heliosphere
10:55 AM - 11:20 AM	Opher, Merav	Evidence that Earth was exposed to Cold Dense Interstellar Medium 2 Myrs Ago as a result of the Encounter with Local Lynx Cold Clouds
11:20 AM - 11:45 AM	Sterken, Veerle	Synergies Between Interstellar Dust and Heliospheric Science
11:45 AM - 12:10 PM	Fuselier, Stephen	ENA Fluxes from the Heliosheath: Constraints from the Voyager 1 and 2 Directions
12:10 PM - 12:35 PM	Fisk, Len	Revisiting the Global Structure and Dominant Particle Acceleration Mechanism of the Heliosheath
12:35 PM - 1:30 PM	Lunch Break - Julia Patio & Tent	
	CHAIR: Shrestha, B.	
1:30 PM - 1:55 PM	Dialynas, Konstantinos	On the 40-139 keV Ion Anisotropies in the Heliosheath and Beyond the Heliopause Measured by LECP on Voyager 1
1:55 PM - 2:20 PM	Fraternale, Federico	Quasi Periodic Oscillations of Cosmic Ray Rates, and Turbulence Observed by Voyager 1 and 2 in the VLISM
2:20 PM - 2:45 PM	Nikoukar, Romina	Energy Dependence of Galactic Cosmic Rays Anisotropies in the Very Local Interstellar Medium: Voyager Observations
2:45 PM - 3:10 PM	Pogorelov, Nikolai	Solar Wind Interaction with the Local Interstellar Medium: Comparison of Models and Observational Validation
3:10 PM - 3:35 PM	Hill, Matthew	Decoding the Transients Events in the Very Local Interstellar Medium Using Heliosphere-Wide Galactic Cosmic Ray Intensity and Anisotropy Measurements
3:35 PM - 3:55 PM	Afternoon Break - Canyon Room	
	CHAIR: Zhao, L.	
3:55 PM - 4:20 PM	Matsukiyo, Shuichi	Properties of cosmic ray test particles invading the virtual heliosphere in global MHD simulation
4:20 PM - 4:45 PM	Strauss, Du Toit	On the Causality Problem in Focused Particle Transport
4:45 PM - 5:10 PM	Baker, Daniel	Observability of Other Earths
	SESSION ADJORNS	

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AGENDA

TUESDAY, NOVEMBER 01		
7:00 AM - 5:00 PM	Registration -Montana Foyer	
8:00 AM - 5:10 PM	GENERAL SESSION – Montana Ballroom	
CHAIR: Koepke, M.		
8:00 AM - 8:25 AM	Zirnstein, Eric	Explanation of Heliospheric Energetic Neutral Atom Fluxes Observed by the Interstellar Boundary Explorer
8:25 AM - 8:50 AM	Bellan, Paul	Neutral-charged-particle Collisions as the Mechanism for Accretion Disk Angular Momentum Transport
8:50 AM - 9:15 AM	Salem, Chadi	Electric Field Turbulence in the Solar Wind at 1AU from MHD down to Electron Scales: Artemis Observations and Numerical Simulations
9:15 AM - 9:40 AM	Zank, Gary	HelioSwarm: A Multi-Spacecraft Mission to Study Turbulence in Space Plasmas
9:40 AM - 10:05 AM	Zhao, Lulu	SOFIE (Solar-wind with Field-lines and Energetic-particles): A Data-driven and Self-consistent SEP Modeling and Forecasting Tool
10:05 AM - 10:30 AM	Morning Break - Canyon Room	
CHAIR: Yalim, M.		
10:30 AM - 10:55 AM	Chen, Xiaohang	The Spatial and Temporal Evolution of Solar Energetic Particles at a CME-Driven Shock
10:55 AM - 11:20 AM	Ho, George	What Have we Learned About 3He-rich Solar Energetic Particle Events so far on Solar Orbiter?
11:20 AM - 11:45 AM	Kahler, Stephen	Evolution of Gaussian Longitudinal Fits to the SEP Event of 2012 January 23
11:45 AM - 12:10 PM	Lario, David	High-Energy Proton Intensity Enhancements Associated with the Passage of Interplanetary Shocks at 1 AU
12:10 PM - 12:35 PM	Slavin, Jonathan	Inhomogeneity and Evolution in the Very Local Interstellar Medium
12:35 PM - 1:30 PM	Lunch Break - Julia Patio & Tent	
CHAIR: Goldstein, M.		
1:30 PM - 1:55 PM	Giacalone, Joe	The Form of the Transport Equation for the Distribution of Passive Tracers in a Turbulent Fluid.
1:55 PM - 2:20 PM	Consolini, Giuseppe	On the Sub-ion Scale Scaling Features in Turbulent Space Plasmas.
2:20 PM - 2:45 PM	Zhao, Lingling	Observations of the Frequency-wavenumber Spectrum of Solar Wind Turbulence
2:45 PM - 3:10 PM	Pitna, Alexander	Transmission of Turbulence Across Collisionless Shock Waves: Comparison of Theory and Observations
3:10 PM - 3:35 PM	Hu, Qiang	Magnetic Flux Rope: “What Is It?”
3:35 PM - 3:55 PM	Afternoon Break - Canyon Room	
CHAIR: Brandt., P.		
3:55 PM - 4:20 PM	Bera, Ratan	Using Kinetically-derived Rankine-Hugoniot Conditions for Pickup Ions in Modeling the Solar Wind-Local Interstellar Medium Interaction
4:20 PM - 4:45 PM	Mueller, Hans	Secondary Helium Neutrals in the Heliosphere
4:45 PM - 5:10 PM	Kim, Tae	An Empirically Driven Time-Dependent Model of the Solar Wind and Local Interstellar Medium Interactions
SESSION ADJOURNS		

AGENDA

WEDNESDAY, NOVEMBER 02		
7:00 AM - 5:00 PM	Registration -Montana Foyer	
8:00 AM - 5:10 PM	GENERAL SESSION – Montana Ballroom	
CHAIR: Ho, G.		
8:00 AM - 8:25 AM	Hegde, Dinesha Vasanta	Validation of Data-Driven MHD Models of the Solar Wind Using Multi-Spacecraft In-Situ Observations
8:25 AM - 8:50 AM	Singh, Talwinder	Improving the Arrival Time Prediction of Coronal Mass Ejections using Magnetohydrodynamic Ensemble Modeling, Heliospheric Imager data and Machine Learning
8:50 AM - 9:15 AM	Verniero, Jaye	Tracing the Cosmic Energy Flow with Parker Solar Probe: Universal Processes
9:15 AM - 9:40 AM	Yalim, Mehmet Sarp	Understanding the Heating Mechanism of the Solar Active Region Atmosphere Extending from the Photosphere to Chromosphere and Corona
9:40 AM - 10:05 AM	Asgari-Targhi, Mahboubeh	Dynamics and the Acceleration of the Alfvenic Slow Solar Wind
10:05 AM - 10:30 AM	Morning Break - Canyon Room	
CHAIR: Du, S.		
10:30 AM - 10:55 AM	Che, Haihong	Ion Acceleration and the Development of a Power-law Energy Spectrum in Magnetic Reconnection
10:55 AM - 11:20 AM	Oka, Mitsuo	Electron Acceleration and Thermal-to-non-Thermal Energy Partition During Magnetotail Reconnection
11:20 AM - 11:45 AM	Nakanotani, Masaru	Pickup Ion Mediated Magnetic Reconnection
11:45 AM - 12:10 PM	Guo, Fan	Three-dimensional Turbulent Magnetic Reconnection and Its Particle Energization
12:10 PM - 12:35 PM	Zank, Gary	On Magnetohydrodynamics, Fluctuations, Structures, and Turbulence
12:35 PM - 1:30 PM	Lunch Break - Julia Patio & Tent	
CHAIR: Kahler, S.		
1:30 PM - 1:55 PM	Du, Senbei	Density Fluctuations in Compressible Magnetohydrodynamic Turbulence: Connection between 3D Simulations and In-situ Solar Wind Observations
1:55 PM - 2:20 PM	le Roux, Jakobus	Anomalous Transport and Acceleration of Energetic Particles interacting with Dynamic Small-Scale Magnetic Flux Rope Structures
2:20 PM - 2:45 PM	Fu, Xiangrong	Parametric Decay Instability and Density Fluctuations near the Sun
2:45 PM - 3:10 PM	Boldyrev, Stanislav	Turbulence and Particle Acceleration in a Relativistic Plasma
3:10 PM - 3:35 PM	Medvedev, Mikhail	Plasma Production in a Black Hole Magnetosphere
3:35 PM - 3:55 PM	Afternoon Break - Canyon Room	
CHAIR: Opher, M.		
3:55 PM - 4:20 PM	Roelof, Edmond	Possible Coronal Source of ~30-day Voyager-1 Magnetic Field Variations at 155 AU
4:20 PM - 4:45 PM	Shrestha, Bishwas L.	Evolution of Polar Coronal Holes Observed by IBEX
SESSION ADJOURNS		
6:00 PM - 6:30 PM	Beer & Wine Social	
6:30 PM - 9: 30 PM	Group Dinner - Julia Patio & Tent	

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THURSDAY, NOVEMBER 03		
7:00 AM - 5:00 PM	Registration -Montana Foyer	
8:00 AM - 5:10 PM	GENERAL SESSION – Montana Ballroom	
CHAIR: Nakanotani, M.		
8:00 AM - 8:25 AM	Ghanbari, Keyvan	Effects of Viscosity and Heat flux on Collisional Shock Structures in the VLISM
8:25 AM - 8:50 AM	Zieger, Bertalan	Global and Local Multi-fluid Simulations of the Solar Bow Shock
8:50 AM - 9:15 AM	Raymond, John	Electron-Ion Equilibration in Collisionless Shocks
9:15 AM - 9:40 AM	Wang, Bingbing	Turbulent Cosmic Ray-Mediated Shocks in the Hot Ionized Interstellar Medium
9:40 AM - 10:05 AM	Moradi, Ashraf	The Intensity Profile and the Pitch-angle distributions of the GV rigidity solar protons at 1 AU in the Large-scale Turbulent Interplanetary Magnetic Field
10:05 AM - 10:30 AM	Morning Break - Canyon Room	
CHAIR: Raeder, J.		
10:30 AM - 10:55 AM	Mostafavi, Parisa	Solar Wind Protons and Alphas Properties Close to the Sun: Parker Solar Probe Observations
10:55 AM - 11:20 AM	Panasenco, Olga	Connecting Parker Solar Probe and Solar Orbiter to the Sun
11:20 AM - 11:45 AM	Adhikari, Laxman	Modeling of Joint Parker Solar Probe – Metis/Solar Orbiter Observations
11:45 AM - 12:10 PM	Terres, Michael	Parker Solar Probe Observations of Periods of Sustained Low Cross Helicity and Negative Residual Energy
12:10 PM - 12:35 PM	Reisenfeld, Daniel	Advances in Mapping the Three-Dimensional Boundary of the Heliosphere
12:35 PM - 1:30 PM	Lunch Break - Julia Patio & Tent	
CHAIR: Reisenfeld, D.		
1:30 PM - 1:55 PM	Swaczyna, Pawel	Temporal Evolution of Separated Energetic Neutral Atom Flux Components Observed by IBEX
1:55 PM - 2:20 PM	Kurth, William	Voyager Plasma Wave Observations and Inferred Electron Densities in the Very Local Interstellar Medium
2:20 PM - 2:45 PM	Brandt, Pontus	New Horizons' Planned Future Observations and the Heliophysics System Observatory
2:45 PM - 3:10 PM	McNutt, Ralph	The Pragmatic Interstellar Probe: Next Step to Interstellar Space
3:10 PM - 3:35 PM	Huang, Yifan	A Numerical Model for Understanding Pickup-Ion Dynamics in the Outer Heliosphere and IBEX Observations of the ENA Ribbon
3:35 PM - 3:55 PM	Afternoon Break - Canyon Room	
CHAIR: Mostafavi, P.		
3:55 PM - 4:20 PM	Strumik, Marek	Contributions of the Extra-Heliospheric Background, Solar-UV-Output Anisotropy and Multiple Scattering Effects to the Heliospheric Lyman-Alpha Glow Observed at 1 AU From the Sun
4:20 PM - 4:45 PM	Isenberg, Phil	Turbulence Driving by Interstellar Pickup Ions in the Outer Solar Wind
4:45 PM - 5:10 PM	Huang, Zhenguang	Modeling the Solar Wind During Different Phases of the Last Solar Cycle
SESSION ADJOURNS		

AGENDA

FRIDAY, NOVEMBER 04		
7:00 AM - 5:00 PM	Registration -Montana Foyer	
8:00 AM – 6:00 PM	GENERAL SESSION – Montana Ballroom	
CHAIR: Slavin, J.		
8:00 AM - 8:25 AM	Li, Gang	On the Meandering Nature of the Solar Wind Magnetic Field
8:25 AM - 8:50 AM	Yuen, Ka Ho	Origin of Magnetically Elongated Cold Neutral Media in Multiphase Interstellar Media
8:50 AM - 9:15 AM	Donders, Nicolas	Why Developing a Full-sun UV Spectrograph Sounding Rocket is Difficult but Necessary
9:15 AM - 10:05 AM	Goldstein, Melvin	N/A
10:05 AM - 10:30 AM	Morning Break - Canyon Room	
END OF CONFERENCE		

TALKS BY PARTICIPANT

Adhikari, Laxman	Thu, Nov 3	11:20 AM - 11:45 AM	Modeling of Joint Parker Solar Probe – Metis/Solar Orbiter Observations
Asgari-Targhi, Mahboubeh	Wed, Nov 2	9:40 AM - 10:05 AM	Dynamics and the Acceleration of the Alfvenic Slow Solar Wind
Baker, Daniel	Mon, Oct 31	4:45 PM - 5:10 PM	Observability of Other Earths
Bellan, Paul	Tue, Nov 1	8:25 AM - 8:50 AM	Neutral-charged-particle Collisions as the Mechanism for Accretion Disk Angular Momentum Transport
Bera, Ratan	Tue, Nov 1	3:55 PM - 4:20 PM	Using Kinetically-derived Rankine-Hugoniot Conditions for Pickup Ions in Modeling the Solar Wind-Local Interstellar Medium Interaction
Boldyrev, Stanislav	Wed, Nov 2	2:45 PM - 3:10 PM	Turbulence and Particle Acceleration in a Relativistic Plasma
Brandt, Pontus	Thu, Nov 3	2:20 PM - 2:45 PM	New Horizons' Planned Future Observations and the Heliophysics System Observatory
Che, Haihong	Wed, Nov 2	10:30 AM - 10:55 AM	Ion Acceleration and the Development of a Power-law Energy Spectrum in Magnetic Reconnection
Chen, Xiaohang	Tue, Nov 1	10:30 AM - 10:55 AM	The Spatial and Temporal Evolution of Solar Energetic Particles at a CME-Driven Shock
Consolini, Giuseppe	Tue, Nov 1	1:55 PM - 2:20 PM	On the Sub-ion Scale Scaling Features in Turbulent Space Plasmas.
Dialynas, Konstantinos	Mon, Oct 31	1:30 PM - 1:55 PM	On the 40-139 keV Ion Anisotropies in the Heliosheath and Beyond the Heliopause Measured by LECP on Voyager 1
Donders, Nicolas	Fri, Nov 4	8:50 AM - 9:15 AM	Why Developing a Full-sun UV Spectrograph Sounding Rocket is Difficult but Necessary
Du, Senbei	Wed, Nov 2	1:30 PM - 1:55 PM	Density Fluctuations in Compressible Magnetohydrodynamic Turbulence: Connection between 3D Simulations and In-situ Solar Wind Observations
Fisk, Len	Mon, Oct 31	12:10 PM - 12:35 PM	Revisiting the Global Structure and Dominant Particle Acceleration Mechanism of the Heliosheath
Fraternale, Federico	Mon, Oct 31	1:55 PM - 2:20 PM	Quasi Periodic Oscillations of Cosmic Ray Rates, and Turbulence Observed by Voyager 1 and 2 in the VLISM
Fu, Xiangrong	Wed, Nov 2	2:20 PM - 2:45 PM	Parametric Decay Instability and Density Fluctuations near the Sun
Fuselier, Stephen	Mon, Oct 31	11:45 AM - 12:10 PM	ENA Fluxes from the Heliosheath: Constraints from the Voyager 1 and 2 Directions
Ghanbari, Keyvan	Thu, Nov 3	8:00 AM - 8:25 AM	Effects of Viscosity and Heat flux on Collisional Shock Structures in the VLISM
Giacalone, Joe	Tue, Nov 1	1:30 PM - 1:55 PM	The Form of the Transport Equation for the Distribution of Passive Tracers in a Turbulent Fluid.
Goldstein, Melvin	Fri, Nov 4	9:15 AM - 10:05 AM	N/A
Guo, Fan	Wed, Nov 2	11:45 AM - 12:10 PM	Three-dimensional Turbulent Magnetic Reconnection and Its Particle Energization
Hegde, Dinesha Vasanta	Wed, Nov 2	8:00 AM - 8:25 AM	Validation of Data-Driven MHD Models of the Solar Wind Using Multi-Spacecraft In-Situ Observations
Hill, Matthew	Mon, Oct 31	3:10 PM - 3:35 PM	Decoding the Transients Events in the Very Local Interstellar Medium Using Heliosphere-Wide Galactic Cosmic Ray Intensity and Anisotropy Measurements
Ho, George	Tue, Nov 1	10:55 AM - 11:20 AM	What Have we Learned About 3He-rich Solar Energetic Particle Events so far on Solar Orbiter?
Hu, Qiang	Tue, Nov 1	3:10 PM - 3:35 PM	Magnetic Flux Rope: "What Is It?"
Huang, Yifan	Thu, Nov 3	3:10 PM - 3:35 PM	A Numerical Model for Understanding Pickup-Ion Dynamics in the Outer Heliosphere and IBEX Observations of the ENA Ribbon
Huang, Zhenguang	Thu, Nov 3	4:45 PM - 5:10 PM	Modeling the Solar Wind During Different Phases of the Last Solar Cycle
Isenberg, Phil	Thu, Nov 3	4:20 PM - 4:45 PM	Turbulence Driving by Interstellar Pickup Ions in the Outer Solar Wind

TALKS BY PARTICIPANT

Kahler, Stephen	Tue, Nov 1	11:20 AM - 11:45 AM	Evolution of Gaussian Longitudinal Fits to the SEP Event of 2012 January 23
Kim, Tae	Tue, Nov 1	4:45 PM - 5:10 PM	An Empirically Driven Time-Dependent Model of the Solar Wind and Local Interstellar Medium Interactions
Koepke, Mark	Mon, Oct 31	8:25 AM - 8:50 AM	Some Auroral Arcs Last All Night: An Unresolved Theoretical Challenge
Kornbleuth, Marc	Mon, Oct 31	9:40 AM - 10:05 AM	An ACR Mediated Termination Shock
Kurth, William	Thu, Nov 3	1:55 PM - 2:20 PM	Voyager Plasma Wave Observations and Inferred Electron Densities in the Very Local Interstellar Medium
Lario, David	Tue, Nov 1	11:45 AM - 12:10 PM	High-Energy Proton Intensity Enhancements Associated with the Passage of Interplanetary Shocks at 1 AU
le Roux, Jakobus	Wed, Nov 2	1:55 PM - 2:20 PM	Anomalous Transport and Acceleration of Energetic Particles interacting with Dynamic Small-Scale Magnetic Flux Rope Structures
Li, Gang	Fri, Nov 4	8:00 AM - 8:25 AM	On the Meandering Nature of the Solar Wind Magnetic Field
Liang, Haoming	Mon, Oct 31	8:50 AM - 9:15 AM	Assessing the Role of Interchange Reconnection in Forming Switchbacks
Matsukiyo, Shuichi	Mon, Oct 31	3:55 PM - 4:20 PM	Properties of cosmic ray test particles invading the virtual heliosphere in global MHD simulation
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Moradi, Ashraf	Thu, Nov 3	9:40 AM - 10:05 AM	The Intensity Profile and the Pitch-angle distributions of the GV rigidity solar protons at 1 AU in the Large-scale Turbulent Interplanetary Magnetic Field
Mostafavi, Parisa	Thu, Nov 3	10:30 AM - 10:55 AM	Solar Wind Protons and Alphas Properties Close to the Sun: Parker Solar Probe Observations
Mueller, Hans	Tue, Nov 1	4:20 PM - 4:45 PM	Secondary Helium Neutrals in the Heliosphere
Nakanotani, Masaru	Wed, Nov 2	11:20 AM - 11:45 AM	Pickup Ion Mediated Magnetic Reconnection
Nikoukar, Romina	Mon, Oct 31	2:20 PM - 2:45 PM	Energy Dependence of Galactic Cosmic Rays Anisotropies in the Very Local Interstellar Medium: Voyager Observations
Oka, Mitsuo	Wed, Nov 2	10:55 AM - 11:20 AM	Electron Acceleration and Thermal-to-non-Thermal Energy Partition During Magnetotail Reconnection
Opher, Merav	Mon, Oct 31	10:55 AM - 11:20 AM	Evidence that Earth was exposed to Cold Dense Interstellar Medium 2 Myrs Ago as a result of the Encounter with Local Lynx Cold Clouds
Panasenco, Olga	Thu, Nov 3	10:55 AM - 11:20 AM	Connecting Parker Solar Probe and Solar Orbiter to the Sun
Pitna, Alexander	Tue, Nov 1	2:45 PM - 3:10 PM	Transmission of Turbulence Across Collisionless Shock Waves: Comparison of Theory and Observations
Pogorelov, Nikolai	Mon, Oct 31	2:45 PM - 3:10 PM	Solar Wind Interaction with the Local Interstellar Medium: Comparison of Models and Observational Validation
Raeder, Joachim	Mon, Oct 31	9:15 AM - 9:40 AM	On the Plasma Entropy in the Magnetosphere and the Solar Corona
Raymond, John	Thu, Nov 3	8:50 AM - 9:15 AM	Electron-Ion Equilibration in Collisionless Shocks
Reisenfeld, Daniel	Thu, Nov 3	12:10 PM - 12:35 PM	Advances in Mapping the Three-Dimensional Boundary of the Heliosphere
Roelof, Edmond	Wed, Nov 2	3:55 PM - 4:20 PM	Possible Coronal Source of ~30-day Voyager-1 Magnetic Field Variations at 155 AU

Salem, Chadi	Tue, Nov 1	8:50 AM - 9:15 AM	Electric Field Turbulence in the Solar Wind at 1AU from MHD down to Electron Scales: Artemis Observations and Numerical Simulations
Shrestha, Bishwas L.	Wed, Nov 2	4:20 PM - 4:45 PM	Evolution of Polar Coronal Holes Observed by IBEX
Singh, Talwinder	Wed, Nov 2	8:25 AM - 8:50 AM	Improving the Arrival Time Prediction of Coronal Mass Ejections using Magnetohydrodynamic Ensemble Modeling, Heliospheric Imager data and Machine Learning
Slavin, Jonathan	Tue, Nov 1	12:10 PM - 12:35 PM	Inhomogeneity and Evolution in the Very Local Interstellar Medium
Sterken, Veerle	Mon, Oct 31	11:20 AM - 11:45 AM	Synergies Between Interstellar Dust and Heliospheric Science
Strauss, Du Toit	Mon, Oct 31	4:20 PM - 4:45 PM	On the Causality Problem in Focused Particle Transport
Strumik, Marek	Thu, Nov 3	3:55 PM - 4:20 PM	Contributions of the Extra-Heliospheric Background, Solar-UV-Output Anisotropy and Multiple Scattering Effects to the Heliospheric Lyman-Alpha Glow Observed at 1 AU From the Sun
Swaczyna, Pawel	Thu, Nov 3	1:30 PM - 1:55 PM	Temporal Evolution of Separated Energetic Neutral Atom Flux Components Observed by IBEX
Terres, Michael	Thu, Nov 3	11:45 AM - 12:10 PM	Parker Solar Probe Observations of Periods of Sustained Low Cross Helicity and Negative Residual Energy
Verniero, Jaye	Wed, Nov 2	8:50 AM - 9:15 AM	Tracing the Cosmic Energy Flow with Parker Solar Probe: Universal Processes
Wang, Bingbing	Thu, Nov 3	9:15 AM - 9:40 AM	Turbulent Cosmic Ray-Mediated Shocks in the Hot Ionized Interstellar Medium
Yalim, Mehmet Sarp	Wed, Nov 2	9:15 AM - 9:40 AM	Understanding the Heating Mechanism of the Solar Active Region Atmosphere Extending from the Photosphere to Chromosphere and Corona
Yuen, Ka Ho	Fri, Nov 4	8:25 AM - 8:50 AM	Origin of Magnetically Elongated Cold Neutral Media in Multiphase Interstellar Media
Zank, Gary	Tue, Nov 1	9:15 AM - 9:40 AM	HelioSwarm: A Multi-Spacecraft Mission to Study Turbulence in Space Plasmas
Zank, Gary	Wed, Nov 2	12:10 PM - 12:35 PM	On Magnetohydrodynamics, Fluctuations, Structures, and Turbulence
Zhao, Lingling	Tue, Nov 1	2:20 PM - 2:45 PM	Observations of the Frequency-wavenumber Spectrum of Solar Wind Turbulence
Zhao, Lulu	Tue, Nov 1	9:40 AM - 10:05 AM	SOFIE (Solar-wind with Field-lines and Energetic-particles): A Data-driven and Self-consistent SEP Modeling and Forecasting Tool
Zieger, Bertalan	Thu, Nov 3	8:25 AM - 8:50 AM	Global and Local Multi-fluid Simulations of the Solar Bow Shock
Zirnstein, Eric	Tue, Nov 1	8:00 AM - 8:25 AM	Explanation of Heliospheric Energetic Neutral Atom Fluxes Observed by the Interstellar Boundary Explorer
Zou, Ying	Mon, Oct 31	8:00 AM - 8:25 AM	Unsteady Magnetopause Reconnection Under Quasi-Steady Solar Wind Driving

SCHEDULE OF TALKS

Monday, October 31: 8:00 AM - 8:25 AM
Presenter: Zou, Ying

Unsteady Magnetopause Reconnection Under Quasi-Steady Solar Wind Driving

Ying Zou, UAH, USA
Brian M. Walsh, BU, USA
Li-Jen Chen, NASA, USA
Jonathan Ng, University of Maryland, USA
Xueling Shi, Virginia Tech, USA
Chih-Ping Wang, UCLA, USA
Larry Lyons, UCLA, USA
Jiang Liu, UCLA, USA
Vassilis Angelopoulos, UCLA, USA
J. Michael Ruohoniemi, Virginia Tech, USA

The intrinsic temporal nature of magnetic reconnection at the magnetopause has been an active area of research. Both temporally steady and intermittent reconnection have been reported. We examine the steadiness of reconnection using space-ground conjunctions under quasi-steady solar wind driving. The spacecraft suggests that reconnection is first inactive, and then activates. The radar further suggests that after activation, reconnection proceeds continuously but unsteadily. The reconnection electric field shows variations at frequencies below 10 mHz with peaks at 3 and 5 mHz. The variation amplitudes are ~10–30 mV/m in the ionosphere, and 0.3–0.8 mV/m at the equatorial magnetopause. Such amplitudes represent 30%-60% of the peak reconnection electric field. The unsteadiness of reconnection can be plausibly explained by the fluctuating magnetic field in the turbulent magnetosheath. A comparison with a previous global hybrid simulation suggests that it is the foreshock waves that drive the magnetosheath fluctuations, and hence modulate the reconnection.

Monday, October 31: 8:25 AM - 8:50 AM
Presenter: Koepke, Mark

Some Auroral Arcs Last All Night: An Unresolved Theoretical Challenge

M.E. Koepke, WVU, USA
S.H. Nogami, WVU, USA
M. Tornquist, WVU, USA
E. Donovan, U. Calgary, Canada
D.M. Gillies, U. Calgary, Canada
D.J. Knudsen, U. Calgary, Canada

Single and multiple discrete auroral arcs, the commonly observed bright bands of light often characterized by their curtain-like appearance, arise as part of the electrodynamic coupling between the solar wind, Earth's magnetosphere, and the auroral ionosphere. Efforts to describe theoretically the formation of discrete auroral arcs often focus on their spatial characteristics, such as thickness, spacing, and orientation [Maggs and Davis 1968; Knudsen et al 2001; Gillies et al 2014], or on plasma phenomena, such as wave-particle interactions. The lifetimes of 3264 discrete auroral arcs have been determined by analyzing images of discrete auroral arcs captured by all-sky imagers (ASI). These images were taken from archival data from 2007 and 2008 from three ASI cameras that are part of the THEMIS Ground-Based ASI Array during ideal viewing conditions. Arcs were tracked at 1-minute intervals throughout their entire life cycle or until they left the camera field of view. We find that the arc lifetime distribution does not reveal a preferred value and this serves to constrain the number of arc generation mechanisms that could be responsible for the aurora observed in this study. Approximately 25% of arcs observed in this study had lifetime greater than 20 minutes. Arcs with such a long lifetime are especially difficult to explain. The mostly featureless lifetime distribution exhibits power-law behavior with a power-law index of (-1.5 +/- 0.2) which emphasizes the possible importance of timescale invariant generation mechanisms. Importantly, arcs with lifetimes longer than 100 minutes are part of the distribution suggesting that the same physics is responsible for discrete arcs of all lifetimes and the turning off of an arc is due to suppression of the physical conditions in the magnetosphere that supported it.

Monday, October 31: 8:50 AM - 9:15 AM
Presenter: Liang, Haoming

Assessing the Role of Interchange Reconnection in Forming Switchbacks

Haoming Liang, University of Alabama in Huntsville, USA
Gary P. Zank, University of Alabama in Huntsville, USA
Masaru Nakanotani, University of Alabama in Huntsville, USA
Ling-Ling Zhao, University of Alabama in Huntsville, USA

Abrupt large radial deflections of the magnetic field in the solar wind, referred to as “switchbacks,” are frequently observed by the Parker Solar Probe (PSP) during its encounters and are believed to play an important role in unveiling the nature of solar corona heating and solar wind acceleration in the inner heliosphere. Many attempts were made to understand the nature of switchbacks. However, the origin, propagation, and evolution of switchbacks are still under debate. In this study, we use the nearly-incompressible MHD theory of Zank et al. to interpret the switchback observations. We select 96 simple one-humped switchback events during the first encounter of PSP and use a Markov Chain Monte Carlo (MCMC) technique to fit the observed magnetic field and plasma variables with the model predictions for each event. A chi-squared goodness-of-fit test is used to evaluate the fittings. We find that about 47.9% and 42.7% of the events are accepted as good fits below 95% and 90% critical values, respectively. This statistical study validates the reliability of the nearly-incompressible MHD theory of Zank et al. for a significant number of switchback events. The statistical analysis provides the most probable initial conditions for switchbacks generated by interchange reconnection, which provides insight into the environment at which interchange reconnection was occurring. The nearly-incompressible MHD theory with MCMC technique has also been used to predict the evalution of switchback from Metis coronagraph observation on board Solar Orbiter.

Monday, October 31: 9:15 AM - 9:40 AM
Presenter: Raeder, Joachim

On the Plasma Entropy in the Magnetosphere and the Solar Corona

Joachim Raeder, Space Science Center, UNH, USA

The specific entropy of a plasma in space is an important parameter because it can give clues about the origins of the plasma populations and the heating processes they have undergone. The plasma of the solar corona and the Earth's magnetosphere share a common trait, namely, that they are hotter than they should be compared to their known sources and boundaries. Analysis of the Ohm's law of a collisionless plasma shows that only collisions can provide true dissipation of electromagnetic energy, which makes the heating processes elusive. Although there are also clear differences between the corona and the magnetosphere, a comparison seem in order, in particular, because the magnetosphere is accessible to in situ measurements. Here, we will present a summary of what we know about the magnetosphere plasma entropy distribution, how it depends on solar wind parameters, and an attempt to understand its origin.

Monday, October 31: 9:40 AM - 10:05 AM
Presenter: Kornbleuth, Marc

An ACR Mediated Termination Shock

Marc Kornbleuth, Boston University, USA
Merav Opher, Boston University, USA
Gary Zank, University of Alabama in Huntsville, USA
Bingbing Wang, University of Alabama in Huntsville, USA
Joe Giacalone, University of Arizona, USA
Matina Gkioulidou, Johns Hopkins University Applied Physics Laboratory, USA
Konstantinos Dialynas, Academy of Athens, Greece

The Voyager 2 crossing of the termination shock indicated that most of the energy from the thermal solar wind ions was transferred to pickup ions (PUIs) and other energetic particles at the shock (Richardson et al. 2008). Here, following the work of Gkiouldiou et al. (2022), we use hybrid simulations at the termination shock for the Voyager 2, flank, and tail directions from Giacalone et al. (2021) to evaluate the distributions of different ion species at the shock over the energy range of 0.52 to 55 keV. As an update to Gkioulidou et al. (2022), we include the contribution from accelerated particles that are shown to be important and mediate the termination shock (Florinski et al. 2010) as distinct from reflected PUIs. We model thermal solar wind ions, transmitted PUIs, and reflected PUIs with Maxwellian distributions, and an accelerated PUI population via power law distributions. We find that the hybrid model indicates a population of anomalous cosmic rays (ACRs) is derived from the acceleration of reflected PUIs, which have an energy density of 23% in the Voyager 2 direction. Extrapolating these ion distributions to all directions, we perform global ENA modeling of the heliosphere in the IBEX-Hi and INCA energy range using an MHD model with solar minimum conditions for the solar wind and a neutral hydrogen density of nH=0.18 cm-3 in the ISM, which is compatible with results from Swaczyna et al. (2020). We find that the scaling factor (roughly a factor of 2) used by prior modeling works to quantitatively compare with IBEX-Hi observations (Zirnstein et al. 2017; Kornbleuth et al. 2021) is no longer required at energies up to 2.73 keV due to the inclusion of a separate accelerated PUI population. The gap between predicted ENAs and observed ENAs in the 4.29 keV channel of IBEX and at INCA energies still exists, and a spectral break is required to match the higher energies of INCA.

Monday, October 31: 10:30 AM - 10:55 AM
Presenter: McComas, David

Interstellar Pickup Ion Observations in the Outer Heliosphere

David McComas, Princeton University, USA

This talk discusses in situ observations of interstellar pickup ions (PUIs) out to beyond 50 au. These observations are from the Solar Wind Around Pluto (SWAP) instrument on New Horizons (McComas et al. 2008). Those measurements have progressively charted the growing dominance of PUIs in the internal pressure of the distant solar wind and allowed good extrapolations of the properties to just ahead of the more distant termination shock. Most recently, we found a way to reprogram SWAP to produce ~30-minute resolution compared to the prior ~24-hour time resolution data points. This enabled us to look not just at the large-scale variations in PUIs, but also directly at PUIs mediating interplanetary shocks with high-time resolution data for the first time. The initial study of the high time resolution data (McComas et al. 2022) examined seven relatively small shocks: six forward and one reverse. We found compression ratios from ~1.2-1.8, with little PUI heating for ratios less than ~1.5, and progressively more PUI heating as the compression ratio increased above that. The core solar wind properties, in contrast, did not show any consistent changes across the shocks, indicating that these particles do not participate significantly in the large-scale fluid-like aspects of the outer heliosphere's combined solar wind and PUI plasma and that they cannot be used to characterize PUI mediated shocks, as prior studies sought to do. The six forward shock crossings showed gradual increases in PUI pressure over broad shock widths of ~0.05-0.13 au, roughly three decades larger than characteristic particle scales such as the PUI gyroradii. Collectively, the SWAP observations are providing critical new ground truth for both the overall evolution of PUI properties in the outer heliosphere and the detailed role of PUIs in mediating interplanetary shocks. The former is important for understanding the global outer heliospheric interaction as observed through charge exchange energetic neutral atoms (ENAs) by IBEX. The latter is the only direct measurement available anywhere, as far as we know, of PUI-mediated shocks.

Monday, October 31: 10:55 AM - 11:20 AM
Presenter: Opher, Merav

Evidence that Earth was exposed to Cold Dense Interstellar Medium 2 Myrs Ago as a result of the Encounter with Local Lynx Cold Clouds

Merav Opher, Abraham Loeb, Joshua Peek

The relationship between the location of the Sun in the interstellar medium (ISM) and terrestrial effects has been explored in connection with the filtration of Galactic Cosmic Rays (GCR) as the heliosphere, the solar system's protective bubble formed by the solar wind, shrinks or expands as a result of different ISM environments. The connection between GCR and terrestrial climate, however, is still uncertain. So far, the impact of the compact cold clouds that are 4-5 order of magnitude denser than the ISM along the direct path of the Sun, was neglected. There is geological evidence from 60Fe and 244Pu isotopes that Earth was in direct contact with the ISM, about 2-3 million years ago. It is known that the local ISM is home to several nearby cold clouds. Using new modeling of 21-cm data from the HI4PI survey, we derive the velocity field of the Local Ribbon of Cold Clouds (LRCC). We show that the solar system may have passed through the Local Ribbon of Cold Clouds in the constellation Lynx(LxCC). The likelihood of a random encounter with a dense cloud is 1.3%. Using a state-of-the-art simulation of the heliosphere, we show that during the passage the heliosphere had shrunk to a scale of 0.22AU, smaller than the Earth's orbit around the Sun. As a result, Earth was exposed to a neutral hydrogen density above 3000cm-3. This could have had drastic effects on Earth's climate, as suggested by records of oxygen isotopes derived from forminifera in the sea floor and potentially on human evolution at that time where Australopithecus afarensis ("Lucy") went extinct, leading to the emergence of the Homo lineage.

Monday, October 31: 11:20 AM - 11:45 AM
Presenter: Sterken, Veerle

Synergies Between Interstellar Dust and Heliospheric Science

V.J. Sterken, ETH Zuerich, CH
S. Hunziker, ETH Zuerich, CH
K. Dialynas, Acad. of Athens, GR
K. Herbst, Univ. Kiel, DE
A. Li, Univ. of Missouri, USA
L.R. Baalmann, ETH Zuerich, CH
M. Blanc, IRAP Toulouse, FR
M. Sommer, IRS Stuttgart, DE
M. Rowan-Robinson, Imperial College, UK
F. Postberg, FU Berlin, DE
P. Frisch, Univ. Chicago, USA
I. Mann, Arctic Univ. Norway, NO
J. Miller, Boston Univ., USA
J. Baggaley, Univ. of Canterbury, NZ

In this talk we focus on the synergies between heliospheric and dust science, and on the space missions that can propel these two fields and their interrelations forward. We review the current state of knowledge of interstellar dust in the Local Interstellar Cloud and in the heliosphere, in particular of the last 20 years: our place in the local "dust" interstellar environment, the satellite measurements in the solar system, observations using astronomical methods, modelling efforts and the dust dynamics in the heliosphere. We then review the open and compelling science questions related to the dust-heliosphere interaction that are still open. We explain how an Interstellar Probe mission with an optimized dust suite is optimal for such measurements, and how the science yield can be enhanced by a simultaneous dust-and-plasma-properties measuring mission inside the solar system. Finally, we stress that this is a new emerging and promising topic in heliosphere research, with a lot of traction in Europe as well as in the USA.

SCHEDULE OF TALKS

Monday, October 31: 11:45 AM - 12:10 PM
Presenter: Fuselier, Stephen

ENA Fluxes from the Heliosheath: Constraints from the Voyager 1 and 2 Directions

S. A. Fuselier, Southwest Research Institute, University of Texas at San Antonio, USA
E. J. Zirnstein, Princeton University, USA
J. Heerikhuisen, University of Waikato, New Zealand
A. Galli, University of Bern, Switzerland
J. D. Richardson, Massachusetts Institute of Technology, USA
D. B. Reisenfeld, Los Alamos National Laboratory, USA
M. A. Dayeh, Southwest Research Institute, University of Texas at San Antonio, USA
N. A. Schwadron, University of New Hampshire, USA
D. J. McComas, Princeton University, USA

IBEX observes Energetic Neutral Atom (ENA) fluxes from the heliosphere over the energy range from 0.01 to 6 keV. In addition to the relatively narrow, circular region of enhanced emissions, called the IBEX Ribbon, IBEX observes a diffuse ENA flux from all directions. This diffuse flux is called the globally distributed flux (GDF). These directions include the lines-of-sight of the Voyager 1 and 2 trajectories through the heliosheath. With the Voyager 2 crossing of the heliopause, there is now a continuous record of the shocked solar wind plasma parameters spanning the entire heliosheath from the termination shock to the heliopause. While there are no direct shocked solar wind plasma measurements from Voyager 1, it is clear that key plasma parameters along the Voyager 1 and 2 trajectories are similar. This talk uses in situ observations and MHD modeling to place constraints on the ENA fluxes from the heliosheath from the Voyager 1 and 2 lines-of-sight. These model ENA fluxes are compared with observed IBEX ENA fluxes. Particular focus is on low energy (<0.4 keV) ENAs.

Monday, October 31: 12:10 PM - 12:35 PM
Presenter: Fisk, Len

Revisiting the Global Structure and Dominant Particle Acceleration Mechanism of the Heliosheath

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

In 2012 Voyager 1 (V1) encountered an apparent boundary in the heliosheath where there was a precipitous decrease in energetic particles accelerated in the heliosheath, the so-called ACRs, and, from the occasional plasma density measurements on V1, a density comparable to the expected density in the interstellar medium. In 2013, the Voyager Principal Investigators announced that their apparent boundary was the heliopause and that V1 had entered the interstellar medium. In 2014, Fisk & Gloeckler published a detailed model that demonstrated that the apparent boundary was simply an internal surface within the heliosheath, across which compressed solar wind flows and will continue to flow until it encounters the actual heliopause. Much of the discussion of the Fisk & Gloeckler model occurred at these Annual Conferences, in 2014, 2015, and 2016, but the model has not gained acceptance. Fisk & Gloeckler also developed a new acceleration mechanism, a pump acceleration, to explain the acceleration of ACRs in the heliosheath. This new acceleration mechanism was also discussed at these Annual Conferences, in 2008, 2010, 2012, and 2017, and has not gained wide acceptance. There are now new analyses of V1 data as well as previously unexplained mysteries, which will be discussed, that provide compelling observational evidence that the model of Fisk & Gloeckler for heliosheath is correct, V1 did not cross the heliopause in 2012 and is not now in the interstellar medium, and the ACRs are accelerated in the heliosheath by the pump acceleration, not by diffusive shock acceleration.

SCHEDULE OF TALKS

Monday, October 31: 1:30 PM - 1:55 PM
Presenter: Dialynas, Konstantinos

On the 40-139 keV Ion Anisotropies in the Heliosheath and Beyond the Heliopause Measured by LECP on Voyager 1

Dialynas K., Office of Space Research and Technology, Academy of Athens, Greece.
Krimigis, S.M., Applied Physics Laboratory, The Johns Hopkins University, USA.
Decker, R.B., Applied Physics Laboratory, The Johns Hopkins University, USA.
Hill, M.E., Applied Physics Laboratory, The Johns Hopkins University, USA.

The crossing from the Heliopause by Voyager 1 (V1) in August 2012 was associated with a precipitous decrease of solar material to apparent background levels of the Low Energy Charged Particle (LECP) instrument, suggesting that suprathermal particles essentially vanish in the Very Local Interstellar Medium (VLISM). We use measurements of 40-139 keV ions obtained by LECP on V1 between the years 2000 and 2022, to determine the energetic ion anisotropies in the heliosheath and upstream of the heliopause. The results from the LECP sectors that are perpendicular to the magnetic field show an average radial inflow of 40-139 keV ions for about 9-10 AU inside the heliosheath and a radial outflow of ions over a spatial range of about 33 AU past the HP. The ion intensity spectrum upstream at the heliopause was found to be consistent with a power law form in energy, similar to energy spectra measured by both V1 and V2/LECP inside the heliosheath. These results suggest strongly that the 40-139 keV ion population upstream is leaking from the heliosheath into interstellar space. Early results from the LECP sectors that are parallel to the magnetic field indicate that the 40-139 keV ion anisotropy turns to -T direction (RTN system) just before the termination shock and persist in the same direction up to the heliopause. However, there seems to be no azimuthal anisotropy beyond the heliopause. These ion measurements provide a direct observation of the communication between the heliosheath and the VLISM.

Monday, October 31: 1:55 PM - 2:20 PM
Presenter: Fraternale, Federico

Quasi Periodic Oscillations of Cosmic Ray Rates, and Turbulence Observed by Voyager 1 and 2 in the VLISM

Federico Fraternale, The University of Alabama in Huntsville, USA
Alan C. Cummings, California Institute of Technology, USA
Nikolai V. Pogorelov, The University of Alabama in Huntsville, USA

The Voyager 1 and 2 spacecraft (V1, V2) are still making unique in situ measurements of compressible turbulence in the very local interstellar medium (VLISM) out to ~150 au from the Sun. In-depth analyses of magnetic field fluctuations at V1 have shown the presence of low-frequency, quasi periodic waveforms with the period ranging from ~10 to ~100 days. These structures contribute significantly to the magnetic turbulence power spectra. A question remains about their origin and nature. However, they may be induced by the heliopause (HP) motion due to waves and turbulence from the inner heliosheath, or associated with possible instabilities of the HP itself. Here, we investigate the properties of magnetic turbulence in the VLISM from high-resolution V2 data and compare them with V1 observations. Recently, the Voyager CRS team identified unexpected, quasi periodic oscillations of the cosmic ray (CR) electron rates measured by V2/TET near the HP. The typical periodicities range from ~10 to ~30 days, and the amplitudes are quasi close to the statistical error of the measurements. This makes it challenging to assess the physical nature of these oscillations. In this study, we demonstrate that physically relevant oscillations exist in both proton and electron CR rates, at both spacecraft. We identify intervals of high correlation between the HET/Guard rates (proton dominated) and the TET/TAN electron rates. The former follow a f^{-2} power-law scaling at low frequencies (f<10^{-6} Hz), associated with the large-scale pitch-angle anisotropy. Remarkably, instances of high spectral coherence between CR rates and magnetic field longitudinal fluctuations are found, which suggests that the origin of oscillations of CR fluxes in the VLISM may be sought in the compressible turbulence.

SCHEDULE OF TALKS

Monday, October 31: 2:20 PM - 2:45 PM
Presenter: Nikoukar, Romina

Energy Dependence of Galactic Cosmic Rays Anisotropies in the Very Local Interstellar Medium: Voyager Observations

Romina Nikoukar, Johns Hopkins University Applied Physics Laboratory, USA
Matthew E. Hill, Johns Hopkins University Applied Physics Laboratory, USA
Lawrence Brown, Johns Hopkins University Applied Physics Laboratory, USA
Jozsef Kota, University of Arizona, USA
Robert B. Decker, Johns Hopkins University Applied Physics Laboratory, USA
Konstantinos Dialynas, Office of Space Research and Technology, Greece
Douglas C. Hamilton, University of Maryland, USA
Stamatios M. Krimigis, Johns Hopkins University Applied Physics Laboratory, USA
Scott Lasley, University of Maryland, USA
Edmond C. Roelof, Johns Hopkins University Applied Physics Laboratory, USA
J. Grant Mitchell, George Washington University, USA
Vladimir. Florinski , University of Alabama in Huntsville, USA
Joe. Giacalone, University of Arizona, USA
John Richardson, MIT, Cambridge, USA
Merav Opher, Boston University, USA

This work focuses on energy dependence of the galactic cosmic rays in the very local interstellar medium (VLISM) based on the measurements from the Low Energy Charged Particle (LECP) instrument on voyager spacecraft. Since Voyager 1 heliopause crossing in 2012, we have observed several episodes of anisotropic behavior of GCRs, depletion of 90 deg pitch angle protons, in LECP ≥211 MeV channel measurements. Examining the data from LECP lower energy channels reveals a similar behavior, depletion of 90 deg pitch angle particles indicating a second-order anisotropy. However, our analysis show that the amplitude of this anisotropy varies as a function of energy. In this work, we discuss this energy dependence, and present preliminary analysis of the LECP data from Voyager 2 spacecraft.

Monday, October 31: 2:45 PM - 3:10 PM
Presenter: Pogorelov, Nikolai

Solar Wind Interaction with the Local Interstellar Medium: Comparison of Models and Observational Validation

Nikolai Pogoreov, Department of Space Science, University of Alabama in Huntsville, USA
Ratan Bera, CSPAR, University of Alabama in Huntsville, USA
Federico Fraternale, CSPAR, University of Alabama in Huntsville, USA
Michael Gedalin, Ben Gurion University of the Negev, Israel
Jacob Heerikhuisen, University of Waikato, New Zealand
Tae Kim, CSPAR, University of Alabama in Huntsville, USA
Vadim Roytershteyn, Space Science Institute, Boulder, USA

We compare different modeling results related to the SW-LISM interaction. Special attention is paid to situations where observational validation is possible. The role of He atoms and electrons is discussed.

SCHEDULE OF TALKS

Monday, October 31: 3:10 PM - 3:35 PM
Presenter: Hill, Matthew

Decoding the Transients Events in the Very Local Interstellar Medium Using Heliosphere-Wide Galactic Cosmic Ray Intensity and Anisotropy Measurements

M.E. Hill, JHU Applied Phys. Lab., USA
R. Nikoukar, JHU Applied Phys. Lab., USA
R.B. Decker, JHU Applied Phys. Lab., USA
L.E. Brown, JHU Applied Phys. Lab., USA
P. Kollmann, JHU Applied Phys. Lab., USA
R.L. McNutt Jr., JHU Applied Phys. Lab., USA
R.C. Allen, JHU Applied Phys. Lab., USA
S.M. Krimigis, JHU Applied Phys. Lab., USA
P. Mostafavi, JHU Applied Phys. Lab., USA
E.C. Roelof, JHU Applied Phys. Lab., USA
J.G. Mitchell, George Washington U., USA
K. Dialynas, Academy of Athens, Greece
M. Opher, Boston U., USA
J.D. Richardson, Massachusetts Inst. of Tech., USA
J. Kota, U. of Arizona, USA
V. Florinski, U. of Alabama, USA
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F. Bagenal J, U. of Colorado, USA
P.C. Brandt, JHU Applied Phys. Lab., USA
S.A. Stern, Southwest Research Institute, USA

In an earlier work [1] we proposed an explanation for the unusual behavior of key measurements in the very local interstellar medium (VLISM)—namely plasma density, magnetic field strength and orientation, plasma wave activity, and galactic cosmic ray (GCR) intensity and anisotropy—which reveal the existence of transient shocks and pressure pulses [2,3], electron plasma oscillations [4], and second-order GCR anisotropy episodes [1,5,6]. The onset of these clear temporal features was first seen at Voyager 1 (V1), and now Voyager 2 (V2) has some preliminary related measurements, but they are misaligned temporally according to standard assumptions regarding propagation into the VLISM. Our goal here is to further elaborate on our explanation, as we do not believe it has become sufficiently understood within the community. The main ingredients for the explanation arise from two probable features of the VLISM region. First, the draping of the VLISM magnetic field around the heliosphere [7] results in a geometry where V1 can be on magnetic field lines that come close to the heliopause (HP) away from the V1 position near the nose (e.g., on the flank or nearer to the V2 location) even when V1 itself is far (10s of AU) from the HP. The second main ingredient is the very fast (near-relativistic) transmission of disturbance signals traveling along the direction of the VLISM field, as observed in GCR anisotropy measurements, as opposed to the slow (Alfven-like) propagation of shock-like disturbances in the VLISM [1]. These ingredients allowed us to rely on a comparison of V1 GCR anisotropy variations with intensity variations at V2, New Horizons (NH), and ACE to conclude that VLISM disturbances arrive at V1 as traditionally expected per slow propagation and the GCR anisotropy episodes arrive at V1 as would now be expected (under our explanation) by a combination of traditional, slow propagation to the HP and fast propagation beyond the HP, along the VLISM field to V1. The apparent misaligned timing falls out as a natural result of V1 moving away from the HP, with a quantitatively consistent increasing lag in the time between the GCR anisotropy episode and the arrival of the locally observed disturbance, including disturbances (be they shocks or pressure waves) observed in data unavailable to us [3,8] at the time of publication [1], specifically the fourth disturbance in the VLISM magnetic field measurements [8]. The proposed explanation uses a theoretically defensible, but as yet not fully confirmed mechanism (GCR escape from trapping regions; see the sixth item in the Summary [1]) for generating the GCR anisotropies, and we discuss this open question, the notable lack of GCR electron anisotropies [9], and the role of energy dependence in the second order GCR anisotropies [6]. We also report on preliminary GCR measurements from NH, V1, and V2 (extending beyond the published observations [1] by over four years).

References

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SCHEDULE OF TALKS

Monday, October 31: 3:55 PM - 4:20 PM
Presenter: Matsukiyo, Shuichi

Properties of cosmic ray test particles invading the virtual heliosphere in global MHD simulation

Shuichi Matsukiyo, Kyushu Univ., Japan
Kotaro Yoshida, Kyushu Univ., Japan
Haruichi Washimi, Kyushu Univ., Japan
Tohru Hada, Kyushu Univ., Japan

The motion of galactic cosmic rays (GCRs) invading the heliosphere is strongly affected by the electromagnetic structures of the heliosphere as well as the convection by the solar wind. In this study, we investigate the behavior of GCRs invading the heliosphere at the level of particle trajectory. We conduct test particle simulations of GCRs using the electromagnetic field data obtained from a global MHD simulation of the heliosphere. The MHD simulation assumes steady solar wind and interstellar wind with typical parameters. Equal energy GCR protons are initially distributed outside the heliosphere with isotropic shell distribution, and their motions are calculated using the Buneman-Boris method. Depending on their initial energy, various types of particle motions, such as current sheet drift, polar drift, spiral motion, shock drift, Fermi-like acceleration, linear motion, resonantly scattered motion, and mirror reflection by bottleneck interstellar field, are observed. We further discuss some statistics of the particles reaching the inner boundary of the MHD simulation at 50AU from the sun.

Monday, October 31: 4:20 PM - 4:45 PM
Presenter: Strauss, Du Toit

On the Causality Problem in Focused Particle Transport

Du Toit Strauss, Centre for Space Research, North-West University, South Africa
Jabus van den Berg, Centre for Space Research, North-West University, South Africa

When perpendicular diffusion is included into the focused transport equation, certain assumptions of the perpendicular diffusion coefficient (including the well-known FLRW limit) clearly lead to faster-than-light motion for relativistic particles and transport that does not preserve causality in general. In this work we show that this discrepancy can be solved by including the effect of turbulence on particle drifts, especially the streaming term present in the focused transport equation, leading to a so-called drift reduction factor. We discuss this drift reduction factor, how it solves the above-mentioned causality issues, and its general implications for particle transport. Under certain simplifying assumptions we show the interplay between particle streaming (as a drift process) and perpendicular diffusion and how these processes can be consistently coupled through the turbulent magnetic field.

Monday, October 31: 4:45 PM - 5:10 PM
Presenter: Baker, Daniel

Observability of Other Earths

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

Recent space missions such as Kepler have revealed thousands of planets around other stars in our galaxy. It is a major goal of future space exploration to compare and contrast these new worlds with planets in our own solar system. At CU/LASP, we have immense interest in studying the interaction of solar and stellar forcing drivers (winds and coronal mass ejections) with known planets (e.g., MAVEN at Mars) and exoplanets (e.g., the recently proposed ESCAPE mission). To study the magnetospheric, atmospheric, and surface properties of exoplanets will require extraordinarily sensitive examination of the electromagnetic signals from such bodies viewed against the formidable background glare of the parent stars themselves. Little is presently understood about the dust environment of nearby candidate star systems in which Earthlike planets are known to exist. Zodiacal light in our own solar system presents a major background for many observational objectives and exo-zodiacal dust in remote stellar systems may seriously limit our ability to do spectroscopic examination of candidate "exo-Earths" due to the glare of the reflected stellar light. Flagship NASA astronomy missions now being proposed will seek to study these distant Earths, but must suppress background light of the parent star by 10 orders of magnitude in order to directly image the exoplanets of interest. At present, the zodiacal cloud in our own solar system is only poorly characterized as far as spatial distribution of dust. The very feasibility of studying distant Earthlike systems will be dependent on knowing and characterizing the dust disks and rings around other parent star systems. A key next phase of space exploration and determination of the possibility of harboring life on other distant worlds will be to understand the environments in which these candidate Earths exist. It is our goal to put forth affordable and practical space systems that will characterize exo-zodiacal properties in systems where imaging and planetary spectroscopy are envisaged. This presentation discusses notional approaches to characterizing nearby stellar systems in ways that would reveal the best candidates for future detailed exoplanet exploration.

Tuesday, November 1: 8:00 AM - 8:25 AM
Presenter: Zirnstein, Eric

Explanation of Heliospheric Energetic Neutral Atom Fluxes Observed by the Interstellar Boundary Explorer

Eric J. Zirnstein, Princeton University, USA
Tae K. Kim, University of Alabama in Huntsville, USA
Maher A. Dayeh, Southwest Research Institute, USA
Jamie S. Rankin, Princeton University, USA
David J. McComas, Princeton University, USA
Pawel Swaczyna, Princeton University, USA

Interstellar neutral atoms propagating into the heliosphere experience charge exchange with the supersonic solar wind (SW) plasma, generating ions that are picked up by the SW. These pickup ions (PUIs) constitute ~25% of the proton number density by the time they reach the heliospheric termination shock (HTS). Preferential acceleration of PUIs at the HTS leads to a suprathermal, kappa-like PUI distribution in the heliosheath, which may be further heated in the heliosheath by traveling shocks or pressure waves. We present a study that utilizes a dynamic, 3D magnetohydrodynamic model of the heliosphere to show that dynamic heating of PUIs at the HTS and in the IHS, as well as a background source of ENAs from outside the heliopause, can explain the intensity and evolution heliospheric ENA signal observed by the Interstellar Boundary Explorer (IBEX) in the Voyager 2 direction. We show that the PUI heating process at the HTS is characterized by a polytropic index larger than 5/3, likely ranging from ~2.3 to possibly up to ~2.7 depending on the time in solar cycle 24 and SW conditions. ENA fluxes at energies >1.5 keV show large-scale behavior in time with the solar cycle and SW dynamic pressure, whereas ENAs <1.5 keV primarily exhibit random-like fluctuations associated with SW transients affecting the IHS. We find that <20% of ENAs observed at ~0.5-6 keV comes from another source, likely originating from secondary ENAs outside the heliopause. We further discuss comparisons of the model with Voyager in situ measurements inside and outside the heliopause.

Tuesday, November 1: 8:25 AM - 8:50 AM
Presenter: Bellan, Paul

Neutral-charged-particle Collisions as the Mechanism for Accretion Disk Angular Momentum Transport

Paul Bellan, Caltech, USA
Yang Zhang, Caltech, USA

The matter in an accretion disk must lose angular momentum when moving radially inwards but how this works has long been a mystery. By calculating the trajectories of individual colliding neutrals, ions, and electrons in a weakly ionized 2D plasma containing gravitational and magnetic fields, we numerically simulate accretion disk dynamics at the particle level. As predicted by Lagrangian mechanics, the fundamental conserved global quantity is the total canonical angular momentum, not the ordinary angular momentum. When the Kepler angular velocity and the magnetic field have opposite polarity, collisions between neutrals and charged particles cause: (i) ions to move radially inwards, (ii) electrons to move radially outwards, (iii) neutrals to lose ordinary angular momentum, and (iv) charged particles to gain canonical angular momentum. Neutrals thus spiral inward due to their decrease of ordinary angular momentum while the accumulation of ions at small radius and accumulation of electrons at large radius produces a radially outward electric field. In 3D, this radial electric field would drive an out-of-plane poloidal current that produces the magnetic forces that drive bidirectional astrophysical jets. Because this neutral angular momentum loss depends only on neutrals colliding with charged particles, it should be ubiquitous. Quantitative scaling of the model using plausible disk density, temperature, and magnetic field strength gives an accretion rate of 3 × 10^−8 solar mass per year, which is in good agreement with observed accretion rates.

SCHEDULE OF TALKS

Tuesday, November 1: 8:50 AM - 9:15 AM
Presenter: Salem, Chadi

Electric Field Turbulence in the Solar Wind at 1AU from MHD down to Electron Scales: Artemis Observations and Numerical Simulations

Chadi Salem, University of California, Berkeley CA, USA
John Bonnell, University of California, Berkeley CA, USA
Vadim Roytershteyn, Space Science Institute, CO, USA
Luca Franci, Queen Mary College, London, UK
Kristopher Klein, University of Arizona, Tucson AZ, USA
Daniel Verscharen, University College of London, UK
Christopher Chaston, University of California, Berkeley CA, USA

Recent observational and theoretical work on solar wind turbulence and dissipation suggests that kinetic-scale fluctuations are both heating and isotropizing the solar wind during transit to 1 AU. The nature of these fluctuations and associated heating processes are poorly understood. Whatever the dissipative process that links the fields and particles - Landau damping, cyclotron damping, stochastic heating, or energization through coherent structures - heating and acceleration of ions and electrons occurs because of electric field fluctuations. The dissipation due to the fluctuations depends intimately upon the temporal and spatial variations of those fluctuations in the plasma frame. In order to derive that distribution in the plasma frame, one must also use magnetic field and density fluctuations, in addition to electric field fluctuations, as measured in the spacecraft frame (s/c) to help constrain the type of fluctuation and dissipation mechanisms that are at play.
We present here an analysis of electromagnetic fluctuations in the solar wind from MHD scales down to electron scales based on data from the Artemis spacecraft at 1 AU. We focus on a few time intervals of pristine solar wind, covering a reasonable range of solar wind properties (temperature ratios and anisotropies; plasma beta; and solar wind speed). We analyze magnetic, electric field, and density fluctuations from the 0.01 Hz (well in the inertial range) up to 1 kHz. We compute parameters such as the electric to magnetic field ratio, the magnetic compressibility, magnetic helicity, compressibility and other relevant quantities in order to diagnose the nature of the fluctuations at those scales between the ion and electron cyclotron frequencies, extracting information on the dominant modes composing the fluctuations. We also use linear Vlasov-Maxwell solvers, PLUME and/or ALPS, to determine the various relevant modes of the plasma with parameters from the observed solar wind intervals. These results are supplemented by analysis of fully nonlinear kinetic simulations of decaying turbulence at small scales. We discuss the results and highlight the relevant modes as well as the major differences between our results in the solar wind and results in the magnetosheath.

Tuesday, November 1: 9:15 AM - 9:40 AM
Presenter: Zank, Gary

HelioSwarm: A Multi-Spacecraft Mission to Study Turbulence in Space Plasmas

G.P. Zank, University of Alabama in Huntsville, USA
K. Klein,University of Arizona, USA
H. Spence, University of New Hampshire, USA
The HelioSwarm Science and Engineering Teams

Turbulence is the process by which energy in fluctuating magnetic fields and plasma motion is nonlinearly transported between structures of different spatial scales, until it is ultimately converted into thermal energy of the charged particles comprising the plasma. Quantifying the nature of turbulent fluctuations and the associated cascade of energy requires simultaneous measurements at multiple points spanning several characteristic length scales. Here, we present HelioSwarm, a NASA MidEx mission, which has been designed to reveal the three-dimensional, dynamic mechanisms controlling the physics of plasma turbulence. The HelioSwarm Observatory measures the plasma and magnetic fields with a novel configuration of spacecraft in the solar wind, magnetosheath, and magnetosphere. These simultaneous multi-point, multi-scale measurements span MHD, transition, and ion-scales, allowing us to address two overarching science goals: 1) Reveal the 3D spatial structure and dynamics of turbulence in a weakly collisional plasma and 2) Ascertain the mutual impact of turbulence near boundaries and large-scale structures. Addressing these goals is achieved using a first-ever "swarm" of nine spacecraft, consisting of a "hub" spacecraft and eight "node" spacecraft. The nine-spacecraft co-orbit in a P/2 lunar resonant Earth orbit, with a 2-week period and an apogee/perigee of ~60/11 Earth radii. Flight dynamics design and on-board propulsion produce ideal inter-spacecraft separations ranging from fluid scales (1000's of km) to sub-ion kinetic scales (10's of km) in the necessary geometries to enable the application of a variety of established analysis techniques that distinguish between proposed models of turbulence. Each node possesses an identical instrument suite that consists of a Faraday cup, a fluxgate magnetometer, and a search coil magnetometer. The hub has the same instrument suite as the nodes, plus an ion electrostatic analyzer. With these measurements, the HelioSwarm Observatory promises an unprecedented view into the nature of space plasma turbulence.

Tuesday, November 1: 9:40 AM - 10:05 AM
Presenter: Zhao, Lulu

SOFIE (Solar-wind with Field-lines and Energetic-particles): A Data-driven and Self-consistent SEP Modeling and Forecasting Tool

Lulu Zhao, University of Michigan, USA
Igor Sokolov, University of Michigan, USA
Tamas Gombosi, University of Michigan, USA
Valeriy Tenishev, University of Michigan, USA
Zhenguang Huang, University of Michigan, USA
Gabor Toth, University of Michigan, USA
Nishtha Sachdeva, University of Michigan, USA
Ward Manchester, University of Michigan, USA
Bart van de Holst, University of Michigan, USA

We present a data-driven and self-consistent SEP model, SOFIE, to simulate the acceleration and transport processes of energetic particles using the Space Weather Modeling Framework (SWMF). In this model, the background solar wind plasma in the solar corona and interplanetary space is modeled by the Alfven Wave Solar-atmosphere Model(-Realtime) (AWSoM(-R)) driven by the near-real-time hourly updated GONG (bihourly ADAPT-GONG) magnetogram. In the background solar wind, the CMEs are launched employing the Eruptive Event Generator using Gibson-Low configuration (EEGGL), by inserting a flux rope estimated from the free magnetic energy in the active region. The acceleration and transport processes are then modeled self-consistently by the multiple magnetic field line tracker (M-FLAMPA) and the Adaptive Mesh Particle Simulator (AMPS). We will demonstrate the capability of SOFIE to demystify the acceleration processes by the CME-driven shock in the low corona and the modulation of energetic particles by the solar wind structures. Besides, using selected historical SEP events, e.g. 2013 Apr 11 event, we will illustrate the progresses toward a faster-than-real-time prediction of SEPs.

Tuesday, November 1: 10:30 AM - 10:55 AM
Presenter: Chen, Xiaohang

The Spatial and Temporal Evolution of Solar Energetic Particles at a CME-Driven Shock

Xiaohang Chen, University of Arizona, USA
Joe Giacalone, University of Arizona, USA
Fan Guo, Los Alamos National Laboratory, USA
David Lario, NASA/GSFC, USA
Ryun Young Kwon, Korea Astronomy and Space Science Institute, Korea

Multi-spacecraft observations have shown that the time-intensity profiles of large solar energetic particle (SEP) events can vary significantly at widely separated heliospheric locations. A number of factors are believed to be responsible for the variation, such as magnetic connectivity, shock normal angle, Alfven Mach number and diffusion coefficients. However, it still remains unclear which one is the dominant factor and how they modulate SEP acceleration as the shock propagates from the lower corona to 1 AU. In this work, we quantitively analyze the contributions of these factors (shock normal angle, Alfven Mach number and diffusion coefficients) to SEP acceleration and transport, and present the evolution of SEPs near the shock in both space and time. These results will help better understand the longitudinal variation in SEP intensities and provide new insights into large SEP events observed by multi-spacecraft, especially those close to the Sun, such as Parker Solar Probe and Solar Orbiter.

Tuesday, November 1: 10:55 AM - 11:20 AM
Presenter: Ho, George

What Have we Learned About 3He-rich Solar Energetic Particle Events so far on Solar Orbiter?

G.M. Mason, The Johns Hopkins University Applied Physics Laboratory, USA
R.C. Allen, The Johns Hopkins University Applied Physics Laboratory, USA
R.F. Wimmer-Schweingruber, University of Kiel, Institut für Experimentelle und Angewandte Physik, Germany
J. R-, Pacheco. University of Alcalá, Space Research Group, Spain

Ever since the first 3He-enhanced solar energetic particle (SEP) event was reported in the literature in 1970, the exact mechanism by which the isotope is enhanced orders of magnitude higher than its solar wind value remains unknown. Observations with ACE and Wind in the last decade showed evidences that these 3He-rich SEP events are often accompanied by energetic electrons (10s-100s of keV), type III radio emission, and enhancements of heavy ions. Some events also appear to be associated with solar jets and have ion dropouts at 1 au. The number of observed 3He-rich events is generally correlated with the solar activity. However, no correlation has been found between the enrichment of 3He with other accompanying observations.
Solar Orbiter that was launched in February 2020, is designed to study the Sun and inner heliosphere in greater detail than ever before. The Energetic Particle Detector (EPD) investigation on Solar Orbiter is a suite of four different sensors that measure the energetic particles from slightly above solar wind energies to hundreds of MeV/nucleon. During the first two years in orbit, the Supathermal Ion Spectrograph (SIS) on EPD observed numerous 3He-rich SEP events inside of 1 au in greater temporal and spectral resolutions than ever before. Many of the findings such as the correlation with energetic electrons, type III bursts, and/or solar jets are similar to prior observations near 1 au. In this work, we will report some of the new/old features that we have identified with two years of Solar Orbiter data.

Tuesday, November 1: 11:20 AM - 11:45 AM
Presenter: Kahler, Stephen

Evolution of Gaussian Longitudinal Fits to the SEP Event of 2012 January 23

Stephen Kahler, Air Force Research Lab, USA
Alan Ling, Atmospheric Environmental Research, USA
Donald Reames, University of Maryland, USA

The longitudinal extents of solar energetic (E > 10 MeV) particle (SEP) events in the heliosphere are important for understanding both SEP acceleration and transport, in addition to their space weather effects. SEP detectors on the STEREO A and B spacecraft, combined with those on Earth-orbiting spacecraft, have enabled recent studies of this characteristic for many events. Each SEP event distribution has been characterized previously by a single central longitude, width, and amplitude derived from Gaussian fits to peak intensities or fluences at each spacecraft. Dynamic changes of those parameters through a SEP event are therefore not captured. We apply Gaussian fits with 1-hour resolution to track the parametric changes through a large 20-MeV proton event, which we plot in solar-based Carrington Longitude coordinates. The angular widths sigma are increasing throughout the event, as expected, while the projected Gaussian centers start at 45 degrees east of the associated flare, remain stationary for several days, and move west toward the flare as the event amplitudes decrease. We introduce a schematic polar plot to show successive snapshots of SEP event longitudes and amplitudes.

SCHEDULE OF TALKS

Tuesday, November 1: 11:45 AM - 12:10 PM
Presenter: Lario, David

High-Energy Proton Intensity Enhancements Associated with the Passage of Interplanetary Shocks at 1 AU

D. Lario, Heliophysics Science Division, NASA Goddard Space Flight Center, USA
I.G. Richardson, Department of Astronomy, University of Maryland at College Park, USA and Heliophysics Science Division, NASA Goddard Space Flight Center, USA
A. Aran, Department of Quantum Physics and Astrophysics, Institute of Cosmos Sciences (ICCUB), Universitat de Barcelona (UB-IEEC), Spain

We analyze periods with elevated >40 MeV proton intensities observed near Earth over a time span of 43 years (1973-2016) that coincide with the passage of interplanetary shocks. Commonly, these elevated proton intensities result from large solar energetic particle (SEP) events. The interplanetary shocks observed during these elevated-intensity periods may or may not be related to the origin of the SEP events. By choosing those cases when the observed interplanetary shocks can be confidently associated with the solar eruption that generated the SEP event, we analyze the energy extent of the energetic storm particle (ESP) component of these SEP events, paying special attention to the most energetic ESP events ever observed at 1 AU over the last 4 solar cycles. The longitudes of the solar eruptions at the origin of the shocks producing high-energy (>40 MeV) proton ESP intensity enhancements are within 50 deg of the central meridian, and the mean of the average transit speeds to travel from the Sun to 1 AU is about ~1000 km/s. The ESP events with the largest intensity increases tend to occur when the nearby medium where the shock propagates is affected by the presence of solar wind structures such as intervening interplanetary coronal mass ejections and other unrelated shocks that may contribute to enhance the high-energy component of the ESP event. Special emphasis is made on those few ESP events that display proton intensity enhancements at energies ~100 MeV. Among the different shock parameters, only the shock speed shows a certain degree of correlation with the ESP intensity increase.

Tuesday, November 1: 12:10 PM - 12:35 PM
Presenter: Slavin, Jonathan

Inhomogeneity and Evolution in the Very Local Interstellar Medium

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

The Very Local Interstellar Medium (VLISM) that surrounds the Solar System, in concert with the solar wind, governs the state and evolution of the heliosphere. Assessing the temperature, density and ionization state of the inflowing interstellar gas is a necessary ingredient for understanding the physical processes at work in the heliosphere, especially at the heliopause. Some of our information about the VLISM has been gained by in situ detections once the gas has penetrated into the inner heliosphere, such as energetic neutral H and He, but line-of-sight observations through the clouds in the Complex of Local Interstellar Clouds (CLIC) are still critical inputs. I will present the results of models for the local ISM including the CLIC and surrounding Local Bubble of hot gas. In particular I will characterize the degree of uniformity and how much variation we might expect in such a collection of clouds that have been shocked in the past and exist in an evolving hot bubble.

Tuesday, November 1: 1:30 PM - 1:55 PM
Presenter: Giacalone, Joe

The Form of the Transport Equation for the Distribution of Passive Tracers in a Turbulent Fluid.

Joe Giacalone, Lunar and Planetary Laboratory, University of Arizona

We discuss the physics of the motion of passive additives embedded within a turbulent fluid whose statistical properties vary in space. This study has application to, for example, the distribution of radial magnetic fields in the solar photosphere and may be relevant to our understanding of interchange reconnection. We are particularly interested in the form of the resulting transport equation for the distribution of the passive tracers. We use both numerical experiments and analytic theory. We find that when the fluid turbulence has zero divergence, the relevant transport equation is the ordinary diffusion equation, but a different equation results when the turbulent fluid velocity has a non-zero divergence.

SCHEDULE OF TALKS

Tuesday, November 1: 1:55 PM - 2:20 PM
Presenter: Consolini, Giuseppe

On the Sub-ion Scale Scaling Features in Turbulent Space Plasmas.

INAF-Istituto di Astrofisica e Planetologia Spaziali, Italy

Turbulence in space plasma is observed over a wide range of scales from MHD ones down to kinetic scales. In particular, fluctuations of magnetic field at sub-protonic scales have been discussed in terms of of a turbulence phenomenon involving different wave modes (KAW, Whistler waves, …). In contrast to the MHD domain, a peculiar feature of fluctuations at sub-protonic scales in space plasma is the the occurrence of a global scale invariance, I.e., the lack of an anomalous scaling of the structure functions. This point seems to be a critical issue for the occurrence of strong intermittent turbulence. Here, using high-resolution data from the some recent missions we attempt an analysis of the universal character of the scale invariant features of magnetic field fluctuations at sub-protonic scales using different approaches: i) the structure function analysis and ii) the singularity spectrum analysis. The aim is to unveil the complexity of magnetic field fluctuations at sub-protonic scales adding some extra information useful to overcome the controversial issue related to the occurrence of intermittency at these scales.
Funded by PRIN-MIUR 2017 grant 2017APKP7T “Circumterrestrial Environment: Impact of Sun-Earth Interaction”

Tuesday, November 1: 2:20 PM - 2:45 PM
Presenter: Zhao, Lingling

Observations of the Frequency-wavenumber Spectrum of Solar Wind Turbulence

Lingling Zhao, Department of Space Science, The University of Alabama in Huntsville, Huntsville, USA
Gary Zank, Department of Space Science, The University of Alabama in Huntsville, Huntsville, USA
Masaru Nakanotani, Center for Space Plasma and Aeronomic Research (CSPAR), The University of Alabama in Huntsville, USA
Laxman Adhikari, Department of Space Science, The University of Alabama in Huntsville, USA

A well-known shortcoming for single-spacecraft spectral analysis is that only 1D wavenumber spectra can be observed assuming that the characteristic wave propagation speed is much smaller than the solar wind flow speed. This limitation has led to the debate of whether turbulence is related to waves or structures. Multi-spacecraft analysis techniques can be used to calculate the wavevector independent of the observed frequency, thus allowing one to study directly the frequency-wavenumber spectrum of turbulence. Thus, the dispersion relation of waves can be identified, which distinguishes them from non-propagating structures. We use magnetic field data from the four Magnetospheric Multiscale (MMS) spacecraft to measure the frequency-wavenumber spectrum of solar wind turbulence based on the k-filtering and phase differencing techniques. Both techniques have been used successfully in the past for the Earth’s magnetosphere, although application to solar wind turbulence has been limited. We find that the solar wind turbulence data do show some features of non-propagating structures that are associated with frequencies close to zero in the plasma rest frame, but propagating Alfven waves with nonzero rest-frame frequency are not evident.

SCHEDULE OF TALKS

Tuesday, November 1: 2:45 PM - 3:10 PM
Presenter: Pitna, Alexander

Transmission of Turbulence Across Collisionless Shock Waves: Comparison of Theory and Observations

Alexander Pitna, Charles University, Czech Republic
Gary Zank, University of Alabama in Huntsville, USA
Masaru Nakanotani, University of Alabama in Huntsville, USA
Ling Ling Zhao, University of Alabama in Huntsville, USA
Laxman Adhikari, University of Alabama in Huntsville, USA
Jana Safrankova, Charles University, Czech Republic
Zdenek Nemecek, Charles University, Czech Republic

Turbulence in space plasma and the physics of collisionless shocks have been investigated separately for decades. The joint analysis of turbulence and shocks has been rare. Recently however a number of observational and theoretical studies focused on this topic. In response to a series of observational studies (Pitna et al 2016, 2017, 2021, Borovsky 2020) Zank et al. (2021) introduced a framework in which the amplitude of the transmitted downstream fluctuations can be straightforwardly estimated from the upstream amplitudes of the incident magnetic islands, vortical, entropic and acoustic modes. The formulation assumes high plasma beta, quasi-perpendicular geometry and an order of one level of fluctuations. We present a statistical analysis of the transmitted magnetic and velocity fluctuations across the shock front and we compare the observed downstream power spectra with their theoretical counterparts. The full statistical set includes roughly 400 fast forward Interplanetary (IP) shocks with varying upstream solar wind conditions, Mach numbers and shock geometries. The agreement of the theoretically predicted and observed spectra for a subset of highly quasi-perpendicular IP shocks with large upstream plasma beta (ratio of the plasma and magnetic pressure) is excellent. Surprisingly, if the analysis is enlarged to the whole data set, it yields a similar agreement between the theory and observation. This finding suggests that the shock-turbulence transmission model of Zank et al. (2021) may be adopted for a wider range of IP shocks than it was originally derived for.

Tuesday, November 1: 3:10 PM - 3:35 PM
Presenter: Hu, Qiang

Magnetic Flux Rope: "What Is It?"

Qiang Hu, Department of Space Science, The University of Alabama in Huntsville, USA

The Solar-Terrestrial space is permeated with a wide variety of structures and processes governed by the fundamental principles in plasma physics. Magnetic flux ropes constitute an important type of such structures that manifest in many processes in the heliosphere through both remote-sensing and in-situ spacecraft observations. We present a brief overview of these processes and focus on the state of the art in and recent advancement (twenty years in the making) on the characterization of these structures. In particular we describe the practical approaches to deriving both two-dimensional (2D) and three-dimensional (3D) spatial configurations of magnetic flux ropes by employing in-situ spacecraft data. We also illustrate the latest efforts in using multi-spacecraft measurements to validate and better interpret the results. We demonstrate the applicability of these approaches to flux ropes of a wide range of scale sizes, ranging from a few hundred kilometers to a few tenths of an au in cross-section size, and to all relevant heliospheric spacecraft missions, including the Parker Solar Probe and Solar Orbiter.

SCHEDULE OF TALKS

Tuesday, November 1: 3:55 PM - 4:20 PM
Presenter: Bera, Ratan

Using Kinetically-derived Rankine-Hugoniot Conditions for Pickup Ions in Modeling the Solar Wind-Local Interstellar Medium Interaction

Ratan Bera, Center for Space Plasma and Aeronomic Research, University of Alabama in Huntsville, USA
Federico Fraternale, Center for Space Plasma and Aeronomic Research, University of Alabama in Huntsville, USA
Nikolai Pogorelov, Department of Space Science, University of Alabama in Huntsville, USA
Michael Gedalin, Ben Gurion University of the Negev, Israel
Vadim Roytershteyn, Space Science Institute, Boulder, USA

We perform three-dimensional multi-fluid global magnetohydrodynamic (MHD) simulations of the heliosphere to study the effect of pickup ions (PUIs) on the interaction of solar wind (SW) with the local interstellar medium (LISM). The mixture of charged particle populations is described by the ideal MHD equations in conservative form, while the different populations of neutral atoms are governed by a set of individual Euler equations. In this model, PUIs are treated as a separate fluid. As the standard Rankine-Hugoniot relations (RH) do not accurately describe the crossing of the heliospheric termination shock (TS) by highly anisotropic PUIs, we employ in the global model specific kinetically-derived boundary conditions (b.c.'s) at the TS. Such b.c.'s are built upon hybrid simulation results, obtained for wide range of combinations of the parameters in front of the shock. We find that when the new b.c.'s are applied, some of the global properties of the heliosphere undergo significant changes while being more consistent with observational data. The results indicate that the PUI pressure is enhanced by ~40% throughout the inner heliosheath when kinetically-derived b.c.'s are used. This eventually leads to a reduction of the thickness of the heliosheath by ~15%, i.e. ~8-10 AU. Moreover, the density of secondary neutral H atoms produced by charge exchange in the heliosheath increases by ~60%. Our simulation results are validated with recent in-situ observations by the New Horizons spacecraft between 11 and 47 AU.

Tuesday, November 1: 4:20 PM - 4:45 PM
Presenter: Mueller, Hans

Secondary Helium Neutrals in the Heliosphere

Hans-Reinhard Mueller, Dartmouth College, USA
Sophia Rubens, Dartmouth College, USA

Secondary neutral helium atoms measured by IBEX are created via charge exchange in the outer heliosheath. They can be modeled with a conservative method based on the Kepler equations. We carry out these calculations to obtain ab-initio distributions at various points in the heliosphere. Secondary neutrals are generated along hyperbolic trajectories, but bound elliptical orbits are also leading to non-zero fluxes as long as portions of the orbit lie in the outer heliosheath.
[1] Vega, C.; Boldyrev, S.; Roytershteyn, V., & Medvedev, M., Turbulence and Particle Acceleration in a Relativistic Plasma, ApJ 924 (2022) L19.
[2] Vega, C.; Boldyrev, S.; Roytershteyn, V., Spectra of Magnetic Turbulence in a Relativistic Plasma, ApJ 931 (2022) L10.

Tuesday, November 1: 4:45 PM - 5:10 PM
Presenter: Kim, Tae

An Empirically Driven Time-Dependent Model of the Solar Wind and Local Interstellar Medium Interactions

Tae Kim, UAH, USA
Nikolai Pogorelov, UAH, USA
Jon Linker, PSI, USA
Ronald Caplan, PSI, USA
Roberto Lionello, PSI, USA

We use the Multi-Scale Fluid-Kinetic Simulation Suite (MS-FLUKSS) to extend an empirically driven time-dependent model of the solar wind to the outer heliosphere, which is shaped by the dynamic interaction between the solar wind and the local interstellar medium. Driven by potential field solutions from photospheric magnetic maps generated by the Air Force Data Assimilative Photospheric flux Transport (ADAPT) model, the Magnetohydrodynamic Algorithm outside a Sphere (MAS) model provides time-varying solar wind parameters at 40 solar radii for a one-year period from 09/2003 to 08/2004, which MS-FLUKSS takes as input to simulate the solar wind outflow to the distant heliosphere. To ensure correct implementation of the solar wind boundary conditions, we compare the MS-FLUKSS and MAS solutions at Earth and confirm that the two models deliver identical results at 1 AU. The MS-FLUKSS solutions extracted at Earth, Ulysses, and Voyager agree reasonably with observations, suggesting that this approach is suitable for modeling the long-term evolution of the outer heliosphere. This work is also applicable to the next generation space weather modeling software currently under development with joint NSF/NASA support, which will employ a similar model coupling to extend the coronal model to the inner heliosphere.

Wednesday, November 2: 8:00 AM - 8:25 AM
Presenter: Hegde, Dinesha Vasanta

Validation of Data-Driven MHD Models of the Solar Wind Using Multi-Spacecraft In-Situ Observations

Dinesha V. Hegde, Department of Space Science, University of Alabama in Huntsville, USA
Tae K. Kim, CSPAR, University of Alabama in Huntsville, USA
Nikolai V. Pogoreov, Department of Space Science, University of Alabama in Huntsville, USA
Charles N. Arge, NASA Goddard Space Flight Center, USA
Shaela I. Jones, Catholic University of America, USA

The solar wind (SW), an essential part of space weather (SWx), provides a background for solar transients like coronal mass ejections and energetic particles moving towards Earth. A correct description of ambient SW is necessary for models that try to simulate and explain SWx events. Therefore, accurate SWx forecasts require an understanding of the physical processes taking place in the ambient SW plasma. We simulate the global 3D heliosphere using an empirically data-driven MHD model developed within the Multi-Scale Fluid-Kinetic Simulation Suite (MS-FLUKSS). We compare our ensemble of heliospheric SW simulations with the data from PSP, SolO, STEREO-A, ACE, and Wind missions, with an emphasis on stream interaction regions (SIRs), which are one of the key drivers of SWx. We discuss uncertainty quantification based on point-to-point and event-based metrics. Such multi-spacecraft validations would help improve our understanding of SW propagation and optimize our data-driven MHD model for SWx forecasting.

Wednesday, November 2: 8:25 AM - 8:50 AM
Presenter: Singh, Talwinder

Improving the Arrival Time Prediction of Coronal Mass Ejections using Magnetohydrodynamic Ensemble Modeling, Heliospheric Imager data and Machine Learning

Talwinder Singh, Center for Space Plasma and Aeronomic Research, University of Alabama in Huntsville, USA
Bernard Benson, McLeod Software Corporation, USA
Syed Raza, University of Alabama in Birmingham, USA
Tae Kim, Center for Space Plasma and Aeronomic Research, University of Alabama in Huntsville, USA
Nikolai Pogorelov, Department of Space Science, University of Alabama in Huntsville, USA

Coronal mass ejections (CMEs) are responsible for extreme space weather which has many undesirable consequences to our several space-based activities. The arrival time prediction of CMEs is an area of active research. Many methods with varying levels of complexity have been developed to predict CME arrival. However, the mean absolute error in the predictions have remained above 12 hours even with the best methods. In this work, we develop a method for CME arrival time prediction that uses magnetohydrodynamic simulations of a data constrained flux rope-based CME model which is introduced in a data driven solar wind background. We found that for 6 CMEs studied in this work, the mean absolute error in arrival time was 8 hours. We further improved the arrival time predictions by using ensemble modeling and comparing the ensembles with STEREO A and B heliospheric imager data by creating synthetic J-maps from our simulations. A machine learning method called lasso regression was used for this comparison. Our mean absolute error was reduced to 4.1 hours after using this method. This is a significant improvement in the CME arrival time prediction. We further found that using neural networks, we were able to achieve mean absolute error of 5.1 hours and using heliospheric imager data from only STEREO A. Thus, our work highlights the importance of using machine learning techniques in combination of other models for improving space weather predictions.

SCHEDULE OF TALKS

Wednesday, November 2: 8:50 AM - 9:15 AM
Presenter: Verniero, Jaye

Tracing the Cosmic Energy Flow with Parker Solar Probe: Universal Processes

J. L. Verniero, NASA Goddard Space Flight Center, USA
T. D. Phan, UC Berkeley, USA
A. Brosius, NASA Goddard Space Flight Center, USA
A. Szabo, NASA Goddard Space Flight Center, USA
D. E. Larson, UC Berkeley, USA
R. Livi, UC Berkeley, USA
P. L. Whittlesey, UC Berkeley, USA
M. D. McManus, UC Berkeley, USA
A. Rahmati, UC Berkeley, USA
O. Romeo, UC Berkeley, USA
K. W. Paulson, Smithsonian Astrophysical Observatory, USA
P. S. Pyakurel, UC Berkeley, USA
T. A. Bowen, UC Berkeley, USA
M. Velli, UCLA, USA
O. Panasenco, Advanced Heliophysics, USA
J. W. Bonnell, UC Berkeley, USA
B. D. G. Chandran, University of New Hampshire, USA
S. Badman, Smithsonian Astrophysical Observatory, USA
L. B. Wilson, NASA Goddard Space Flight Center, USA
J. Kasper, University of Michigan/BWX Technologies, USA
S. Bale, UC Berkeley, USA

Heliophysics is inherently interdisciplinary, born from multiple subjects to understand how the Sun interacts with its surrounding environment. Heliophysicists and Astrophysicists seldom exchange ideas since the scientific infrastructure partitions research areas by spatial location in the cosmos. Parker Solar Probe (PSP) is sending back puzzling information in regions we have never been before, presenting an opportunity to search for answers in non-traditional ways that are inherently cross-disciplinary. The fundamental processes that govern the physics of the universe, such as wave-particle interactions, turbulence, magnetic reconnection, and shocks, are mechanisms to study cosmic energy flow. We present PSP observations that may enable us to assess the universality of these fundamental processes in – and across boundaries of – various space and astrophysical regimes. Specifically, we focus on the exotic shapes of proton velocity distribution functions and subsequent evolution leading to multi-scale wave generation and particle acceleration. We welcome ideas, tools, and methodologies from all disciplines to understand the systems of systems governing our universe.

Wednesday, November 2: 9:15 AM - 9:40 AM
Presenter: Yalim, Mehmet Sarp

Understanding the Heating Mechanism of the Solar Active Region Atmosphere Extending from the Photosphere to Chromosphere and Corona

Mehmet Sarp Yalim, Center for Space Plasma and Aeronomic Research, University of Alabama in Huntsville, USA
Gary P. Zank, Department of Space Science & Center for Space Plasma and Aeronomic Research, University of Alabama in Huntsville, USA
Mahboubeh Asgari-Targhi, Harvard-Smithsonian Center for Astrophysics, USA
Christian Beck, National Solar Observatory, USA
Debi Prasad Choudhary, Department of Physics and Astronomy, California State University Northridge, USA
Rohan E. Louis, Physical Research Laboratory, Udaipur Solar Observatory, India
Avijeet Prasad, Rosseland Center for Solar Physics, University of Oslo, Norway
Qiang Hu, Department of Space Science & Center for Space Plasma and Aeronomic Research, University of Alabama in Huntsville, USA
Makayla Frisse, Department of Physics, University of Alabama in Huntsville, USA

The plasma temperature from the photosphere to corona increases from ~5,000 K to ~1 million K over a distance of only ~10,000 km from the chromosphere and the transition region to the corona. Understanding the mechanism underlying coronal heating is a fundamental problem in the solar physics community. In this work, we will present an overview of our research on understanding the heating mechanism of the solar active region atmosphere extending from the photosphere to chromosphere and corona. We model the chromosphere as a low temperature plasma environment where ions and neutrals exist simultaneously and their interactions are described by Cowling resistivity. We investigate Joule heating due to the dissipation of currents perpendicular to the magnetic field by the Cowling resistivity as a heating mechanism of the lower solar atmosphere by using a data-constrained analysis based on observational and tabulated theoretical/semi-empirical solar atmosphere model data. The second heating mechanism that we investigate is magnetohydrodynamic (MHD) turbulence in the corona. The transport of waves and turbulence is central to the coronal heating problem. We compare two models, one of which is based on Alfvén wave turbulence and the other on a majority nonlinear structures (flux ropes) component and a minority slab turbulence component. There are fundamental differences between the two approaches as well as certain similarities. These models are described in terms of the Nearly Incompressible Magnetohydrodynamics (NI MHD) turbulence transport model and the Reduced MHD (RMHD) model. The NI MHD model directly solves the transport of turbulence in 3D in terms of its quasi 2D and slab components whereas the source of turbulence in the RMHD model results from the relaxation of turbulence due to the counter-propagation of Alfvén waves that are generated by footpoint motions of the coronal loops on the photosphere. We have simulated the coronal heating problem in a realistic benchmark coronal loop setting by using both models and obtained a remarkable agreement.

Wednesday, November 2: 9:40 AM - 10:05 AM
Presenter: Asgari-Targhi, Mahboubeh

Dynamics and the Acceleration of the Alfvenic Slow Solar Wind

M. Asgari-Targhi, Harvard-Smithsonian Center for Astrophysics, USA
A. Asgari-Targhi, Harvard Faculty of Arts and Sciences, Harvard University, USA
S. R. Habbal, Institute for Astronomy, University of Hawaii, USA

In this talk, I will present a study of the slow solar wind and explore whether the conditions of the equatorial corona as one of the sources of the slow wind can generate sufficient Alfven-wave turbulence to account for the acceleration of the slow solar wind. We use a reduced magnetohydrodynamic (RMHD) model that considers a flux tube extending from the coronal base at 1 solar radius to 20 solar radii. The initial conditions are a background atmosphere constrained by observations. The magnetic field is determined using our Coronal Modeling System (CMS), which extrapolates the observed photospheric magnetic field strength to large heights based on a potential field approximation. Alfven waves are excited at the base of the corona, and the turbulence is driven by nonlinear interactions between the counterpropagating Alfven waves.
We will also explore the role of small-scale density fluctuations in slow solar wind sources and examine how significantly the solar wind characteristics are influenced by the density fluctuations.

Wednesday, November 2: 10:30 AM - 10:55 AM
Presenter: Che, Haihong

Ion Acceleration and the Development of a Power-law Energy Spectrum in Magnetic Reconnection

H. Che, University of Alabama in Hunstville, USA
G. P. Zank, University of Alabama in Huntsville, USA
A. O. Benz , FHNW, & ETH, Switzerland

How charged particles are accelerated efficiently and form a power-law energy spectrum in magnetic reconnection is a problem that is not well understood. In a previous paper, it was shown that the electron Kelvin-Helmholtz instability (EKHI) in force-free magnetic reconnection generates fast-expanding vortices that can accelerate electrons in a few tens of ion gyro-periods (less than 1 ms in the solar corona) to form a power-law energy distribution. In this paper, we present a particle-in-cell (PIC) simulation study of ion acceleration in force-free magnetic reconnection in the presence of the EKHI-induced turbulence. We find that ions are not significantly accelerated by the EKHI-induced stochastic electric field until the magnetic vortices expand to sizes comparable to the ion gyro-radius. The Alfvén waves generated by the EKHI couple with the magnetic vortices, leading to resonance between the ions inside the magnetic vortices and Alfvén waves and enhanced ion heating. The induced Alfvén wave resonance results in a broken power-law energy spectrum with a breakpoint at ~m i v_A^2 , where v_A is the Alfvén velocity. We show that the process that forms the non-thermal tail is a second-order Fermi mechanism and the mean spectral index is α = (1 + 4a2 D/R)/2, where D is the spatial scale of the inductive electric field, R is that of vortices, and a = Bg /B0 , with ratio of guide field Bg and asymptotic B0 .

Wednesday, November 2: 10:55 AM - 11:20 AM
Presenter: Oka, Mitsuo

Electron Acceleration and Thermal-to-non-Thermal Energy Partition During Magnetotail Reconnection

Mitsuo Oka, UC Berkeley, USA
Tai Phan, UC Berkeley, USA
Marit Øieroset, UC Berkeley, USA
Drew L. Turner, Johns Hopkins Applied Physics Laboratory, USA
James F. Drake, University of Maryland, USA
Xiaocan Li, Dartmouth University, USA
Stephen A. Fuselier, SwRI, USA
Daniel J. Gershman, NASA, USA
Barbara L. Giles, NASA, USA
Robert E. Ergun, LASP, USA
Roy B. Torbert, University of New Hampshire, USA
Hanging Wei, UCLA, USA
Robert J. Strangeway, UCLA, USA
Cristopher T. Russell, UCLA, USA
James L. Burch, SwRI, USA

Electrons are energized significantly both in the form of heating and in the form of acceleration to non-thermal energies during explosive energy-release phenomena. While magnetic reconnection is considered to play an important role in this energization, it still remains unclear how electrons are energized and how energy is partitioned between thermal and non-thermal components. Here, we show, based on in situ observations by NASA's Magnetospheric MultiScale mission combined with multi-component spectral fitting methods, that the average electron energy Eavg (or equivalently temperature) is substantially higher when the locally averaged electric field magnitude |E| is also higher. While this result is consistent with the classification of "plasma-sheet" and "tail-lobe" reconnection during which reconnection is considered to occur on closed and open magnetic field lines, respectively, it further suggests that a stochastic Fermi acceleration in 3D, reconnection-driven turbulence is essential for the production and confinement of energetic electrons in the reconnection region. The puzzle is that the non-thermal power-law component can be quite small even when the electric field is large and the bulk population is significantly heated. The fraction of non-thermal electron energies varies from sample to sample between ~20% and ~60%, regardless of the electric field magnitude. Interestingly, these values of non-thermal fractions are similar to those obtained for the above-the-looptop hard X-ray coronal sources for solar flares.

Wednesday, November 2: 11:20 AM - 11:45 AM
Presenter: Nakanotani, Masaru

Pickup Ion Mediated Magnetic Reconnection

Gary Zank, University of Alabama in Huntsville, USA
Ling Ling Zhao, University of Alabama in Huntsville, USA

It is known that pickup ions (PUIs) are a critical component in determining the properties of various structures in the heliosphere, such as the solar wind, termination shock, and heliopause. In the outer heliosphere, newly born PUIs follow an unstable ring-beam distribution and are a source of low-frequency turbulence, thus allocating a certain amount of energy to the solar wind turbulence. Eventually, the dissipation of the turbulence contributes to the heating of the solar wind. PUIs also play a major role in the dissipation of the termination shock rather than the thermal plasma component. This results in a hot PUI component and a relatively cool thermal plasma component in the downstream region of the termination shock (the inner heliosheath). Charge exchange processes between solar wind protons in the inner heliosheath and interstellar hydrogens act as a gravity force and induce Rayleigh-Taylor instabilities at the heliopause. Although PUIs play a dominant role in the heliosphere, it has not been discussed how PUIs mediate magnetic reconnection. Reasons may be because 1) it is not easy to identify the site of magnetic reconnection in the outer heliosphere from observational data unlike the termination shock and heliopause, and 2) magnetic reconnection with PUIs can be regarded as reconnection in the high-beta regime when considering PUIs as a fluid component, and the reconnection rate of a high-beta plasma tends to be lower than that of a low-beta plasma. However, PUIs generate turbulence, heat conduction, and viscosity in plasma. Since these effects are considered to increase the reconnection rate, it is reasonable to speculate that PUIs boost magnetic reconnection. In this case, magnetic reconnection in the outer heliosphere can be more active than the previous thought. We discuss a possibility that PUIs boost magnetic reconnection.

Wednesday, November 2: 11:45 AM - 12:10 PM
Presenter: Guo, Fan

Three-dimensional Turbulent Magnetic Reconnection and Its Particle Energization

Fan Guo, Los Alamos National Laboratory, USA
Xiaocan Li, Dartmouth College
Qile Zhang, Los Alamos National Laboratory, USA
William Daughton, Los Alamos National Laboratory, USA
Hui Li, Los Alamos National Laboratory, USA
Senbei Du, Los Alamos National Laboratory, USA

The properties and effects of 3D magnetic reconnection are among some of the main unknowns in reconnection research. Thanks to the development of extreme-scale computing and forthcoming exascale computers, 3D numerical simulations have become increasingly accessible to magnetic reconnection research. Perhaps the most distinct feature of 3D reconnection is the presence of violent turbulent fluctuations. We show the properties of turbulence in 3D reconnection for a range of different guide fields. While earlier research has been focusing on turbulence from overlapping tearing modes due to multiple resonance surfaces, our new simulations reveal magnetic fluctuations from flux-rope kink instabilities in the low-guide-field regime. We will further discuss the anisotropic scaling of the structure function, superdiffusion of magnetic field lines and the generation of nonthermal particle energy spectra in 3D turbulent magnetic reconnection. These results have critical implications for space and astrophysical plasmas.

SCHEDULE OF TALKS

Wednesday, November 2: 12:10 PM - 12:35 PM
Presenter: Zank, Gary

On Magnetohydrodynamics, Fluctuations, Structures, and Turbulence

G.P. Zank, University of Alabama in Huntsville, USA
L. Adhikari, University of Alabama in Huntsville, USA
L.-L. Zhao, University of Alabama in Huntsville, USA
M. Nakanotani, University of Alabama in Huntsville, USA
H. Liang, University of Alabama in Huntsville, USA
B.-B. Wang, University of Alabama in Huntsville, USA
A. Pitna, Charles University, Czechia
D. Telloni, Astrophysical Observatory of Torino, Italy

Small amplitude fluctuations in the solar wind are measured by a single spacecraft at a particular Doppler-shifted frequency or set of frequencies and a corresponding wave number vector k can be inferred using various techniques. In the magnetohydrodynamics (MHD) description, fluctuations are typically expressed in terms of the wave modes admitted by the system. An important question is how to resolve an observed set of fluctuations, typically plasma moments such as the density, velocity, pressure and magnetic field fluctuations, into their constituent fundamental MHD components. Surprisingly, this problem has not yet been fully resolved despite its importance in understanding the most basic elements of waves and turbulence in the solar wind. For example, a decades long argument has persisted about whether turbulence in the solar wind is Alfvenic (i.e., dominated by Alfven waves) or dominated instead by magnetic structures (i.e., dominated by flux ropes, aka magnetic islands and vorticity). Unfortunately, a method was not hitherto developed to identify between wave modes and advected structures such as magnetic islands. Here, we discuss quite generally the identification of wave modes in an MHD plasma from a set of plasma and magnetic field fluctuations observed by a single spacecraft at a specific frequency and an inferred wave number. We discuss some applications of our approach to fluctuations in the solar wind and to the interaction of fluctuations at shock waves.

Wednesday, November 2: 1:30 PM - 1:55 PM
Presenter: Du, Senbei

Density Fluctuations in Compressible Magnetohydrodynamic Turbulence: Connection between 3D Simulations and In-situ Solar Wind Observations

Senbei Du, Los Alamos National Laboratory, USA
Hui Li, Los Alamos National Laboratory, USA
Xiangrong Fu, New Mexico Consortium, USA
Zhaoming Gan, New Mexico Consortium, USA

Solar wind turbulence is often perceived as weakly compressible and the density fluctuations remain poorly understood both theoretically and observationally. Compressible magnetohydrodynamic simulations provide useful insights into the nature of density fluctuations, such as the scaling between density fluctuation and turbulent Mach number, but some nuances arise when simulations are compared with in-situ solar wind observations. Two important effects associated with in-situ observations are identified using 3D simulations of turbulence. First, observed quantities such as the power spectrum and variance depend on the angle between the sampling trajectory and the mean magnetic field due to anisotropy. The anisotropy effect varies with scale and plasma beta. Second, in-situ measurements tend to exhibit a broad range of variation, so a careful averaging may be needed to reveal the physics from observations. While these effects are not new, they are less appreciated for studies of compressible turbulence. For example, the anisotropy of density fluctuations has not been quantified in the solar wind. The results will be helpful for future modeling and observations of solar wind turbulence.

SCHEDULE OF TALKS

Wednesday, November 2: 1:55 PM - 2:20 PM
Presenter: le Roux, Jakobus

Anomalous Transport and Acceleration of Energetic Particles interacting with Dynamic Small-Scale Magnetic Flux Rope Structures

Jakobus le Roux, Univ. of Alabama in Huntsville, USA

Evidence is increasing that in a magnetically turbulent space plasma with a significant background magnetic field like the solar wind, non-propagating small-scale magnetic flux ropes (SMFRs) naturally form as part of a locally generated quasi-2D MHD turbulence component that dominates other MHD wave turbulence modes. Solar wind observations and simulations show that energetic particles undergo temporary trapping in SMFR structures, which is suggestive of anomalous transport. Some simulations indicate that energetic particles undergo superdiffusion both spatially and in energy space in a turbulent plasma medium with SMFR-like structures separated by turbulently reconnecting small-scale current sheets. In this talk we present new kinetic focused and Parker-type fractional diffusion-advection equations that explicitly model the anomalous propagation and energization of energetic particles in a dynamic SMFR field, derived from first principles starting with the standard focused transport. The fractional Parker equation (FPE) features normal advection terms combined with fractional diffusion terms and predicts parallel superdiffusive behavior controlled solely by a fractional time derivative because the spatial derivatives are normal. We discuss solutions of the FPE to analyze the consequences of this approach when modeling (1) superdiffusive shock acceleration of energetic particles at a parallel shock imbedded in a SMFR field, and (2) acceleration of energetic particles by dynamic SMFRs when both parallel spatial transport and acceleration are time-fractional superdiffusive processes.

Wednesday, November 2: 2:20 PM - 2:45 PM
Presenter: Fu, Xiangrong

Parametric Decay Instability and Density Fluctuations near the Sun

Xiangrong Fu, New Mexico Consortium, USA
Zhaoming Gan, New Mexico Consortium, USA
Senbei Du, Los Alamos National Laboratory, USA
Hui Li, Los Alamos National Laboratory, USA

Enhanced density fluctuations are reported by in-situ and remote sensing observations in the solar wind near the Sun, indicating the importance of compressible fluctuations. One generation mechanism is the parametric decay instability (PDI), where coherent density fluctuations are associated with the slow mode excited by the decay of a large amplitude Alfven wave in a low-beta environment. In this study, we use 1D and 2D MHD simulations to study the generation of density fluctuations in expanding solar wind by injecting incompressible Alfven waves near the solar surface. Density fluctuations both inside and outside the Alfven critical point can be generated. We study the dependence of density fluctuations on wave amplitude, frequency, and coherence, and background solar wind conditions. We compare density fluctuations generated by PDI with those in 3D compressible turbulence simulations.

Wednesday, November 2: 2:45 PM - 3:10 PM
Presenter: Boldyrev, Stanislav

Turbulence and Particle Acceleration in a Relativistic Plasma

Stanislav Boldyrev, University of Wisconsin - Madison, USA

Recently, it has been realized that Alfvenic turbulence in a relativistic plasma provides a very efficient mechanism for particle acceleration. In particular, the particle distribution function over energies develops non-thermal power-law tails with the exponents from -2 to -3 depending on the plasma magnetization. Based on [1,2], we review the recently proposed phenomenological description of relativistic turbulence in a collisionless plasma, discuss a model for particle acceleration in such turbulence, and compare the results with numerical simulations.
[1] Vega, C.; Boldyrev, S.; Roytershteyn, V., Medvedev, M., Turbulence and Particle Acceleration in a Relativistic Plasma, ApJ 924 (2022) L19;
[2] Vega, C.; Boldyrev, S.; Roytershteyn, V., Spectra of Magnetic Turbulence in a Relativistic Plasma, ApJ 931 (2022) L10.

SCHEDULE OF TALKS

Wednesday, November 2: 3:10 PM - 3:35 PM
Presenter: Medvedev, Mikhail

Plasma Production in a Black Hole Magnetosphere

Mikhail Medvedev, KU & MIT, USA
Michael Sitarz, KU, USA

Supermassive black holes (BH), such as in Active Galactic Nuclei, quasars, and blazars, produce spectacular and powerful relativistic jets. These jets are powered via the Blandford-Znajek process, which taps the spin energy of the BH into the electromagnetic Poynting flux. This process requires the presence of plasma to carry current. Theoretical and numerical studies indicate that the plasma is created and replenished _in situ_ via an electron-positron cascade. Here we discuss the cascade mechanism and present the results of the numerical solutions of the system of coupled ODEs describing the particle and photon fluxes. While this semi-analytical study has some limitations, it allows one to explore important scaling relations between the plasma and astrophysical system parameters, which are hard to deduce from PIC simulations. This work is upported by the NSF grant PHY-2010109 and the DOE EPSCOR grant DE-SC0019474.

Wednesday, November 2: 3:55 PM - 4:20 PM
Presenter: Roelof, Edmond

Possible Coronal Source of ~30-day Voyager-1 Magnetic Field Variations at 155 AU

Edmond C. Roelof, Johns Hopkins U./APL, USA
Ralph L. McNutt, Johns Hopkins U./APL, USA

The Voyager-1 magnetometer (VGR1/MAG) recently observed a train of five quasi-periodic oscillations (~30 days) in the magnetic field intensity (B) at a helioradius of 155AU during days 40-180 of 2021 [Burlaga et al., ApJ, 932:59, 2022]. We have searched for a solar source (~26-day rotation period) of these oscillations by examining the archive of NSO/GONG potential-field source-surface (PFSS) coronal models for the global coronal magnetic field lines (available at gong.nso.edu). The integral Carrington longitude plots are useful in identifying the location of coronal holes, which are known to be sources of the high-speed solar wind streams that produce CIRs and SIRs over a range of heliolatitudes. These stream/stream interactions can persist out to the solar wind termination shock and then can propagate as supra-thermal pressure waves through the heliosheath. At the heliopause they can couple to transverse magneto-sonic waves propagating transverse to the draped magnetic field in the VLISM. We worked backwards in time from the onset of (B) oscillations at VGR1. Assuming a magnetosonic velocity of 30 km/s in the VLISM, the pressure variations required 4.9 years to propagate to the VGR1 radius from the heliopause. We then allowed 0.3yr for the supra-thermal pressure waves to propagate through the heliosheath, and 1yr for the CIRs from the Sun to the termination shock. That implied that the solar disturbance should have commenced 6.2 years earlier, i.e. at year 2014.9, corresponding to Carrington rotation CR2171. From the GONG plots, we found severe distortions of the heliospheric current sheet (HCS) beginning with CR2170, actually forming an unusual double HCS, one of which circumscribed a strong, isolated coronal hole at the latitude of VGR1 (N35deg). This coronal hole lasted seven rotations, terminating abruptly after CR2176 with the re-establishment of the usual (single) HCS. We suggest that it was the solar source of the train of the five ~30-day oscillations in (B) observed by VGR1 at 155 AU at the end of the MAG data presented in the cited 2022 paper. If our identification of the coronal hole source is correct, subsequent VGR1/MAG data should show only two more oscillations in (B) after day 180 of 2021.

Wednesday, November 2: 4:20 PM - 4:45 PM
Presenter: Shrestha, Bishwas L.

Evolution of Polar Coronal Holes Observed by IBEX

Eric J. Zirnstein, Princeton University, USA
David J. McComas, Princeton University, USA
Jamey R. Szalay, Princeton University, USA

Fast solar wind (SW) is emitted radially outward from Polar Coronal Holes (PCHs). The latitudinal extent of the fast SW varies during different phases of solar cycle. The advected fast SW in the inner heliosheath (IHS) results in a less steep proton spectrum that can be observed through energetic neutral atoms (ENAs) by the Interstellar Boundary Explorer (IBEX). In this study, we investigate the evolution of PCHs using high-time resolution ENA flux measurements from IBEX-Hi. The ENA spectral slope over the poles shows a periodic evolution over the solar cycle 24: the area with a less steep ENA spectrum decreased gradually from 2009 to 2014 and then increased again starting 2017. This evolution shows a clear correlation with the change in the PCH area observed at the Sun once the delay in the ENA observation time is included. In addition, the higher-cadence ENA data at the highest latitudes show a rapid evolution of the PCHs in the south pole related to their “closing and opening”. These results also agree qualitatively with the simulated ENA spectral slope evolution using a simple time-dependent heliospheric flow model.

SCHEDULE OF TALKS

Thursday, November 3: 8:00 AM - 8:25 AM
Presenter: Ghanbari, Keyvan

Effects of Viscosity and Heat flux on Collisional Shock Structures in the VLISM

Keyvan Ghanbari, Department of Space science, University of Alabama in Huntsville, USA
Gary P. Zank, Department of Space science, University of Alabama in Huntsville, USA

Both Voyager spacecraft have identified multiple shock structures since crossing the heliopause and entering the very local interstellar medium (VLISM). The studies on these shocks have confirmed their distinctive features in comparison to the shocks investigated within the heliosphere. The VLISM shocks are weak and unusually broad which suggest that the dissipation mechanism is more likely caused by collisional than collisionless processes. On appropriate scales compared to the collisional scale length, one can assume that the VLISM is weakly collisional. This implies that the VLISM shocks may be collisional rather than collisionless, despite their solar origin. In this work, we study the structure of VLISM shocks in the weakly collisional regime. We employ a 1D form of a system of equations presented in Hunana et al. 2022 that uses the Landau collision operator and the moments method of Grad that is appropriate to weakly collisional plasma systems, unlike the classical Chapman-Enskog analysis. This introduces closures that differ from e.g., a diffusive form of the heat flux. We use the weakly collisional form of the magnetized plasma equations to derive the collisional shock evolution equation. In this formulation the viscosity and heat flux are nonzero and therefore play an important role in determining the structure of shocks in the VLISM.

Thursday, November 3: 8:25 AM - 8:50 AM
Presenter: Zieger, Bertalan

Global and Local Multi-fluid Simulations of the Solar Bow Shock

Bertalan Zieger, Boston University, USA
Merav Opher, Boston University, USA
David McComas, Princeton University, USA

The interaction between the heliosphere and the local interstellar medium (LISM) has two alternate plausible scenarios, which can provide the same stand-off distance at the nose of the heliosphere. One is the superfast interaction with the presence of a fast magnetosonic bow shock, and the other is the subfast interaction with the presence of a slow magnetosonic bow shock [Zieger et al., 2013]. A third scenario could be a subfast interaction without a slow bow shock, when αBv, the angle between the interstellar magnetic field (BISM) and the bulk flow velocity of the interstellar wind (vISM), is greater than 45°, which would result in a fast bow wave extending far upstream in the LISM. However, the latter scenario would fail to produce an observable hydrogen wall in the Ly α absorption profiles of nearby stars, as demonstrated by Zank et al. [2013]. The Voyager observations of heliospheric asymmetries support a subfast interaction with strong BISM and small αBv [Opher et al., 2009a; Izmodenov et al. 2009]. IBEX observations also indicated that the interstellar wind is slower than previously thought and therefore most likely subfast [McComas et al., 2012]. The ribbon model of Chalov et al. [2010] uses a strong BISM with small αBv, too. However, other competing ribbon mechanisms [e.g. Heerikhuisen et al., 2010; Schwadron and McComas, 2013] prefer a much weaker magnetic field and larger angles. More recently, Scherer and Fichtner [2014] argued that including the He+ component of the LISM yields a higher fast magnetosonic Mach number that still supports the existence of a marginal fast bow shock. Up to date, there is no general consensus on the nature and existence of a bow shock ahead of the heliosphere. In this paper, we study the nature of LISM-heliosphere interaction for the different possible scenarios, explore the possible relationship between the geometry of the slow bow shock and the IBEX ribbon, investigate the role of He+ in producing turbulence downstream of the fast bow shock, and predict plasma and magnetic field parameters along the Voyager trajectories beyond the heliopause. We employ 3-D global multi-fluid MHD simulations of the heliospheric interface varying the LISM parameters in different interaction scenarios. We fit the edge of the slow bow shock to the observed location of the IBEX ribbon. We also run 1-D local multi-fluid simulations of the fast and slow bow shocks with two ion species (H+ and He+) in the LISM, investigate the microstructure of the bow shock in different scenarios, and determine the level and nature of turbulence downstream of the quasi-parallel, quasi-perpendicular, and oblique regions of the bow shock. This work is supported by NASA within the SHIELD DRIVE Science Center and by NASA's IBEX Explorer mission.

Thursday, November 3: 8:50 AM - 9:15 AM
Presenter: Raymond, John

Electron-Ion Equilibration in Collisionless Shocks

John Raymond, CfA, USA

Collisionless shocks are not obligated to bring different particle species into thermal equilibrium. In particular, electrons are heated less efficiently than protons. Electron-ion temperature ratios estimated in supernova remnant shocks show a decline with Mach number or Alfven Mach number parallel to that seen in solar wind shocks, but at higher Mach numbers. The ratio in SNR shocks declines to less than 0.1 at very high Mach numbers, while PIC simulations indicate at minimum at Mach numbers around 15 and a subsequent rise to a ratio of about 0.3. We investigate the reliability of the SNR electron-ion temperature ratios by comparing 4 estimates based upon 1) the broad-to-narrow component ratio of the H alpha profile, 2) the proper motion shock speed and the X-ray electron temperature, 3) the X-ray temperature and the proton temperature from the H alpha width, and 4) the proper motion shock speed and the proton temperature from H alpha. Each of these estimates has its own systematic uncertainties, but they show very similar trends with Mach number.

Thursday, November 3: 9:15 AM - 9:40 AM
Presenter: Wang, Bingbing

Turbulent Cosmic Ray–Mediated Shocks in the Hot Ionized Interstellar Medium

Bingbing Wang, UAH, CSPAR, USA
Gary Zank, UAH, CSPAR, USA
Laxman Adhikari, UAH, CSPAR, USA
Lingling Zhao, UAH, CSPAR, USA

The structure of shocks and turbulence are strongly modified during the acceleration of cosmic rays (CRs) at a shock wave. The pressure and the collisionless viscous stress decelerate the incoming thermal gas and thus modify the shock structure. A CR streaming instability ahead of the shock generates the turbulence on which CRs scatter. The turbulent magnetic field in turn determines the CR diffusion coefficient and further affects the CR energy spectrum and pressure distribution. The dissipation of turbulence contributes to heating the thermal gas. Within a multicomponent fluid framework, CRs and thermal gas are treated as fluids and are closely coupled to the turbulence. The system equations comprise the gas dynamic equations, the CR pressure evolution equation, and the turbulence transport equations, and we adopt typical parameters for the hot ionized interstellar medium. It is shown that the shock has no discontinuity but possesses a narrow but smooth transition. The self-generated turbulent magnetic field is much stronger than both the large-scale magnetic field and the preexisting turbulent magnetic field. The resulting CR diffusion coefficient is substantially suppressed and is more than three orders smaller near the shock than it is far upstream. The results are qualitatively consistent with certain observations.

Thursday, November 3: 9:40 AM - 10:05 AM
Presenter: Moradi, Ashraf

The Intensity Profile and the Pitch-angle distributions of the GV rigidity solar protons at 1 AU in the Large-scale Turbulent Interplanetary Magnetic Field

Ashraf Moradi, University of Arizona, USA
Joe Giacalone, University of Arizona, USA

Solar protons with rigidities higher than 1 GV (432 MeV) penetrate Earth's atmosphere, generate secondary neutrons that reach the ground level neutron monitors. These events are called ground-level enhancement (GLE). The time-intensity profiles of the usual GLE events show a sharp rise followed by a slow decay. However, in 1989 OCT 22 (GLE 44), an unusual time-intensity profile was observed in several ground-level stations (Cramp 1997). The time-intensity profile showed a very sharp initial spike followed by a second smaller spike with a substantially slower rise and slower decay. Cramp (1997), also, obtained the pitch-angle distribution of the event. The pitch-angle distributions of the first arriving protons had a strong peak along the local IMF. Later, there was two peaks in the pitch-angle distribution, one along the local IMF and the other in the opposite direction. We adopt Giacalone (2004) fluctuating interplanetary magnetic field (IMF) and apply a 3D fully relativistic test particle model. The pitch-angle scattering is included by applying the ad hoc scattering. We investigate the the time-inetnsity profile and the pitch-angle distributions of the 500 MeV and 1 GeV solar protons at 1 AU in a weak pitch-angle scattering (parallel mean free path = 1 AU) with various parameters: Five IMF including Parker field and turbulent IMF with two realizations and two fluctuating rms velocity amplitude (Vrms) of 0.6 and 2 km/s, and A+ and A- field polarity. We release these solar protons in a 10x10 degrees area near the HCS (N1), relatively far (N10) and far from HCS (N20 and N30). The intensity profile and the pitch-angle distributions are recorded in the observer’s location, whose position relative to the HCS is varied.
We show that the time-intensity profile and pitch-angle distributions seen at 1 AU in the turbulent IMF varies considerably depending on the magnetic connection to the source, IMF Parameters and IMF polarity. We also find that in the case of the “weak” scattering and A- polarity, the same parallel mean free path and IMF polarity as the GLE 44 in 1989 OCT 22 event, the double-spike and both outward and reflected fluxes of protons can exist at 1 AU in some observer's locations which can explain the unusual GLE Event of OCT 22, 1989 (Moradi and Giacalone 2022).

Thursday, November 3: 10:30 AM - 10:55 AM
Presenter: Mostafavi, Parisa

Solar Wind Protons and Alphas Properties Close to the Sun: Parker Solar Probe Observations

P. Mostafavi, Johns Hopkins University Applied Physics Lab, USA
R. C. Allen, Johns Hopkins University Applied Physics Lab, USA
S. Badman, University of California, Berkeley, USA
G. C. Ho, Johns Hopkins University Applied Physics Lab, USA
N. E. Raouafi, Johns Hopkins University Applied Physics Lab, USA
D. E. Larson, Space Sciences Laboratory, University of California, USA
R. Livi, Space Sciences Laboratory, University of California, USA
A. Rahmati, Space Sciences Laboratory, University of California, USA
S. D. Bale, Space Sciences Laboratory, University of California, USA and Imperial College London, UK
J. C. Kasper, University of Michigan, USA

Protons and alpha particles are the two most abundant elements in the solar wind and usually have different velocities, densities, and temperatures. Investigating the alpha particle properties and how they differ from protons is essential in understanding the fundamental nature of solar wind. Parker Solar Probe (PSP) enables us to make direct in-situ measurements of the young solar wind closer than any spacecraft before. Initial statistical analysis of the PSP observations down to 0.09 au showed the super-acceleration of alpha particles close to the Sun, confirming the dependency of alpha-proton differential flow on solar wind speed and radial distance from the Sun (Mostafavi et al., 2022). Kasper et al. (2019) suggested that the preferential acceleration of the alpha particles occurs within the magnetically dominated region where the solar wind moves slower than Alfvén speed (i.e., Alfvénic critical surface). PSP crossed the Alfvén Surface during its 8th encounter and became the first spacecraft ever to sample the sub-Alfvénic solar wind close to the Sun. Since then, PSP has crossed/observed the sub-Alfvenic region multiple times. These unexplored regions enable us to investigate protons and alpha particles, and their properties close to the source of the solar wind acceleration for the first time. Here, we present the properties of protons and alphas close to the sun observed by PSP. We compare the properties of both protons and alphas in the sub-Alfvénic and super-Alfvénic regions. Further, we present the PSP connection to its source surface during these periods to understand the possible source of these variations.

SCHEDULE OF TALKS

Thursday, November 3: 10:55 AM - 11:20 AM
Presenter: Panasenco, Olga

Connecting Parker Solar Probe and Solar Orbiter to the Sun

Marco Velli, EPSS UCLA, USA
Aram Panasenco, Advanced Heliophysics Inc., USA
Raffaella D'Amicis, Institute for Space Astrophysics and Planetology, ITALY
Paulett Liewer, Caltech JPL, USA
Stuart Bale, SSL UC Berkeley, USA

We discuss the sources of the solar wind observed by Parker Solar Probe over its first 12 encounters with the Sun and relate their global properties to those of the embedded turbulence, including characteristics such as overall magnitude, Alfvenicity, prevalence of switchback structures. We then describe what we have learned thanks to PSP of the relationship of the turbulence properties to the solar wind origins, before arguing how structures such as photospheric network of supergranular cells and magnetic nodes, large-scale coronal magnetic funnels, isolated coronal holes, coronal hole boundaries, solar filament channels, pseudostreamers, helmet streamers and the nascent heliospheric current sheet contribute to the structure of the inner heliosphere. We also discuss sources of the Alfvenic slow wind at the first Solar Orbiter close perihelion in March 2022 at 0.32 AU and compare them to observations in July 2020 at 0.64 au.

Thursday, November 3: 11:20 AM - 11:45 AM
Presenter: Adhikari, Laxman

Modeling of Joint Parker Solar Probe – Metis/Solar Orbiter Observations

Laxman Adhikari, University of Alabama in Huntsville, USA
Gary Zank, University of Alabama in Huntsville, USA
Daniele Telloni, National Institute for Astrophysics-Astrophysical Observatory of Torino Via Osservatorio, Italy
Lingling Zhao, University of Alabama in Huntsville, USA

We present a first theoretical modeling of joint Parker Solar Probe (PSP) - Metis/Solar Orbiter (SolO) quadrature observations (Telloni et al. 2022b). The combined observations describe the evolution of a slow solar wind plasma parcel from the extended solar corona (3.5 − 6.3 Rsun) to the very inner heliosphere (23.2 Rsun). The Metis/SolO instrument remotely measures the solar wind speed finding a range from 96 − 201 km/s, and PSP measures the solar wind plasma in situ, observing a radial speed of 219.34 km/s. We find theoretically and observationally that the solar wind speed accelerates rapidly within 3.3 – 4 Rsun, and then increases more gradually with distance. Similarly, we find that the theoretical solar wind density is consistent with the remotely and in situ observed solar wind density. The normalized cross-helicity and normalized residual energy observed by PSP are 0.96 and -0.07, respectively, indicating that the slow solar wind is very Alfvénic. The theoretical NI/slab results are very similar to PSP measurements, which is a consequence of the highly magnetic field-aligned radial flow ensuring that PSP can measure slab fluctuations and not 2D. Finally, we calculate the theoretical 2D and slab turbulence pressure, finding that the theoretical slab pressure is very similar to that observed by PSP.

Thursday, November 3: 11:45 AM - 12:10 PM
Presenter: Terres, Michael

Parker Solar Probe Observations of Periods of Sustained Low Cross Helicity and Negative Residual Energy

Michael Terres, The University of Alabama in Huntsville, USA
Gang Li, The University of Alabama in Huntsville, USA

Turbulence is a ubiquitous process throughout the entire heliosphere and is essential to the evolution of the solar wind. MHD turbulence with zero cross helicity is considered a balance of inward and outward propagating Alfv\'{e}n waves. However, observations throughout the solar wind show a predominately outward flux of Alfv\'{e}n waves with a cross helicity near unity. We investigate the turbulent properties for periods of sustained low cross helicity (\sigma_{c} \sim 0) and negative residual energy (\sigma_{r} \sim -1) found during PSP encounters 6 through 11. Our analysis suggests periods, presumably close to the Sun, where solar wind MHD turbulence shows signs of almost equal magnitude counter-propagating Alfv\'{e}nic turbulence exists possibly under the framework of dynamic alignment.

SCHEDULE OF TALKS

Thursday, November 3: 12:10 PM - 12:35 PM
Presenter: Reisenfeld, Daniel

Advances in Mapping the Three-Dimensional Boundary of the Heliosphere

Daniel B. Reisenfeld, Los Alamos National Laboratory (LANL), USA
Maciej Bzowski, Space Research Centre of the Polish Academy of Sciences (CBK PAN), Poland
Herbert O. Funsten, LANL, USA
Jacob Heerikhuisen, University of Waikato, New Zealand
Paul H. Janzen, University of Montana, USA
Marzena A. Kubiak, CPK PAN, Poland
Asher S. Merrill, LANL, USA
David J. McComas, Princeton University, USA
David Osthus, LANL, USA
Nathan A. Schwadron, University of New Hampshire, USA
Justyna M Sokol, Southwest Research Institute, USA
Brian Weaver, LANL, USA
Eric J. Zirnstein, Princeton University, USA

We present new advances in mapping the 3D structure of the heliosphere using ENA flux observations from the Interstellar Boundary Explorer (IBEX) mission. IBEX has shown that variations in the ENA flux from the outer heliosphere are associated with the solar cycle and longer-term variations in the SW. In particular, there is a good correlation between the dynamic pressure of the outbound SW and variations in the later-observed IBEX ENA flux. The time difference between observations of the outbound SW and the heliospheric ENAs with which they correlate ranges from approximately two to six years or more, depending on ENA energy and look direction. This time difference can be used as a means of “sounding” the heliosheath, that is, finding the average distance to the ENA source region in a particular direction. Reisenfeld et al. 2021 applied this method to build for the first time a three-dimensional map of the heliosphere. We now utilize a newly developed IBEX ENA data product to increase the statistical resolution of ENA skymaps. The original map was based on dividing the sky into 56 “macro-pixels”, driven by the need to reduce the statistical uncertainties when working with smaller pixels. Inclusion of the new data product allows us to use smaller pixels, and thus form a higher-resolution 3D map of the heliosphere.

Thursday, November 3: 1:30 PM - 1:55 PM
Presenter: Swaczyna, Pawel

Temporal Evolution of Separated Energetic Neutral Atom Flux Components Observed by IBEX

Pawel Swaczyna, Department of Astrophysical Sciences, Princeton University, USA
Maher A. Dayeh, Southwest Research Institute,USA
Eric J. Zirnstein, Department of Astrophysical Sciences, Princeton University, USA
David J. McComas, Department of Astrophysical Sciences, Princeton University, USA
Herbert O. Funsten, Los Alamos National Laboratory, USA
Nathan A. Schwadron, Physics Department, Space Science Center, University of New Hampshire,USA

The maps of energetic neutral atom (ENA) flux observed by IBEX show two distinctive components: the globally distributed flux (GDF) and the IBEX ribbon. The GDF is broadly distributed over the entire sky, while the ribbon is a relatively narrow, almost circular structure. While the GDF is expected to be primarily formed in the inner heliosheath, the source of the ribbon is likely outside the heliopause. Analyses of overlapping signals are complicated because these two components change differently over time. Several separation methods have been previously developed to enable such analyses. Recently, a method using spherical harmonic (SH) decomposition was developed to estimate the GDF component. We extend this method to provide the SH representation of both components. The best-fit SH coefficients are obtained using χ^2 minimizations with additional regularization terms. The method can be applied to yearly IBEX maps and gives separate sets of SH coefficients for the ribbon, the GDF, and the sum of these components. The SH coefficients provide an alternative representation of the IBEX observations compared to the traditional pixelized maps. The SH coefficients can be easily transformed into flux averaged over any selected portions of the sky. We analyze the time series of the ribbon and GDF flux to show the difference in response to the solar cycle changes confirming different distances to the sources. We also consider the response of the ribbon in different segments around its circumference.

SCHEDULE OF TALKS

Thursday, November 3: 1:55 PM - 2:20 PM
Presenter: Kurth, William

Voyager Plasma Wave Observations and Inferred Electron Densities in the Very Local Interstellar Medium

W. S. Kurth, University of Iowa, USA
L. F. Burlaga, Leonard F. Burlaga, Inc., USA

Voyager plasma wave observations have provided the first in situ electron densities in the Very Local Interstellar Medium (VLISM) and evidence of solar transient effects in this region just beyond the heliopause. These measurements reveal a large-scale radial density gradient in a boundary layer extending approximately 10 AU or more beyond the heliopause in the general direction of the heliospheric nose. Beyond the boundary layer is an extensive region with generally increasing electron densities to about 155 AU that is dominated by increases from shocks and pressure fronts presumably originating in solar transients. The observed ratios of electron densities and magnetic field intensities across these structures are very similar to each other. We examine the occurrence of shocks as identified by electron plasma oscillation events as a function of radial distance and solar cycle. While it is reasonable to assume these effects decrease in occurrence frequency and/or amplitude as a function of distance due to dissipation, it is also the case that transient events are related to the solar cycle and that this may be an important factor in the probability of detecting shock-related effects by the Voyager spacecraft in the coming years.

Thursday, November 3: 2:20 PM - 2:45 PM
Presenter: Brandt, Pontus

New Horizons' Planned Future Observations and the Heliophysics System Observatory

Pontus C. Brandt, Johns Hopkins APL, USA
Fran Bagenal, LASP, USA
Alan Stern, SwRI Boulder, USA
Merav Opher, Boston University, USA

New Horizons was approved for its second mission extension in April 2022 spanning FY23-24 during which the spacecraft will traverse the 54-60 au region, heading along the same ecliptic longitude as Voyager 2, but in the ecliptic plane and towards the IBEX ribbon. Given that New Horizons is projected to be able to operate well into the 2040's, the New Horizons Project Science Team is laying out Enduring Goals for the exploration of the outer heliosphere, the Termination Shock encounter, investigations well into the heliosheath and possibly even a crossing of the heliopause in about two decades from now. Therefore, the next two decades will provide, in particular critical new measurement of H+ and He+ PUIs from SWAP and PEPSSI, that Voyager 1 and 2 were not equipped to measure. The future investigations will continue to detail the evolution of the solar wind and the impact of solar transients in the outer heliosphere. Coming off the peak of Kuiper Belt dust, the Student Dust Counter (SDC) is well positioned to potentially detect interstellar dust (ISD) grains as we near the heliospheric boundary. With its relatively high sensitivity, the Alice UV camera holds promise to search for signatures of the hydrogen wall and perhaps even signatures of our neighboring interstellar clouds. The historic exploration of Pluto and Arrokoth redefined our view on our solar system (and others). As a true cross-divisional pathfinder, New Horizons is now gradually transforming into a phase revolving around heliophysics and also astrophysics, with important components of planetary science remaining. With the expected graceful "sortie" of the Voyager Interstellar Mission (VIM) in the mid-2030's, we are quickly coming up on the last opportunity to utilize the widest constellation of the Heliophysics System Observatory (HSO) including other notable missions such as IBEX and IMAP, and several others. However, this requires a higher level of coordination within the HSO framework through joint working groups and collaborations, and also data-model coordination that the SHIELD Drive Center could serve as an appropriate platform for. In this talk, we will present an overview of the future New Horizons observations focusing on heliophysics, but also astrophysics that inevitably shares some of the same science goals. We seek to discuss the implementation and utilization of the HSO to make the most of the inner-heliospheric fleet of spacecraft connected with the farthest outposts in space – Voyager and New Horizons.

Thursday, November 3: 2:45 PM - 3:10 PM
Presenter: McNutt, Ralph

The Pragmatic Interstellar Probe: Next Step to Interstellar Space

Ralph L. McNutt, Jr., Johns Hopkins Applied Physics Laboratory, USA
Robert F. Wimmer-Schweingruber, University of Kiel, GERMANY
Mike Gruntman, University of Southern California, USA
Stamatios M. Krimigis, Johns Hopkins Applied Physics Laboratory, USA and Academy of Athens, GREECE
Edmond C. Roelof, Johns Hopkins Applied Physics Laboratory, USA
Pontus C. Brandt, Johns Hopkins Applied Physics Laboratory, USA
Steven R. Vernon, Johns Hopkins Applied Physics Laboratory, USA
Michael V. Paul, Johns Hopkins Applied Physics Laboratory, USA
Robert W. Stough, NASA Marshall Space Flight Center, USA
James D. Kinnison, Johns Hopkins Applied Physics Laboratory, USA
Kathleen E. Mandt, Johns Hopkins Applied Physics Laboratory, USA
James P. Mastandrea, Johns Hopkins Applied Physics Laboratory, USA
Elena A. Provornikova, Johns Hopkins Applied Physics Laboratory, USA
Alice A. Cocoros, Johns Hopkins Applied Physics Laboratory, USA
Glen Fountain, Johns Hopkins Applied Physics Laboratory, USA
Carey M. Lisse, Johns Hopkins Applied Physics Laboratory, USA
Kirby D. Runyon, Johns Hopkins Applied Physics Laboratory, USA
And many more at many institutions

Interstellar Probe is a scientific mission to capture a unified view of our heliosphere and its surroundings in interstellar space. It will capture that view using an optimized set of modern, state-of-the-art scientific instruments beginning with its launch from Earth. Throughout its journey into nearby interstellar space, Interstellar Probe will carry out investigations of (1) the processes within the heliosphere responsible for the formation of the heliospheric boundary, (2) the detailed physical processes at work in the heliosheath, (3) the global dynamics of the heliosphere, and (4) conditions in, and characteristics of, the very local interstellar medium (VLISM), including the Sun's influence therein. To study and select a menu of "appropriate" science drivers, required measurements, and example payload instruments for such a mission, both an internal Johns Hopkins Applied Physics Laboratory (APL) team and a large number of external and unpaid volunteers were assembled via a set of four annual workshops from 2018 through 2021. The "support community" assembled a consensus science traceability matrix and Working Groups crafted a notional set of remote-sensing and in situ instruments to address both a baseline heliophysics mission and an "augmented" mission with additional planetary science and astrophysics science goals. Detailed engineering and trade-off studies have shown that an interstellar probe mission supporting the science investigations can be designed, built, and launched in the near term of the 2030s. The nominal mission uses a super heavy lift launch vehicle (a Space Launch System Block 2 Cargo or commercial equivalent) with additional 3rd and 4th stages and a separated spacecraft of 860 kg carrying about 90 kg of instruments. With a close Jupiter Gravity Assist, a spacecraft launched in 2036 would exit the solar system at about twice the current speed of Voyager 1 and reach ~350 au in 50 years. Powered by two next-generation radioisotope thermoelectric generators and with a communications system designed to return data from as far as 1000 au, the next step past the Voyagers could begin. The study, including science details, instrument examples, system trades, and cost and reliability estimates, has been published online (https://interstellarprobe.jhuapl.edu), from which it can be downloaded. The 498-page report is readily available worldwide. As a large strategic mission, it is envisioned that a future NASA Science and Technology Definition Team as well as members of the upcoming Solar and Space Physics Decadal Survey could draw upon this document as a "menu" from which to select and/or reject science goals, solar-system-flyout direction, and potential instruments for a scientific payload for an Interstellar Probe that could be readied in this decade and launched within the next.

SCHEDULE OF TALKS

Thursday, November 3: 3:10 PM - 3:35 PM
Presenter: Huang, Yifan

A Numerical Model for Understanding Pickup-Ion Dynamics in the Outer Heliosphere and IBEX Observations of the ENA Ribbon

Yifan Huang, LANL, USA
Fan Guo, LANL, USA
Eric Zirnstein, Princeton University, USA
Hui Li, LANL, USA
Dan Reisenfeld, LANL, USA
Jacob Heerikhuisen, University of Waikato, New Zealand

We present a new numerical model for understanding the narrow and ribbon-like enhancement in the emission of energetic neutral atoms (ENA) coming from the outer heliosphere first discovered by the IBEX mission. We begin with a global MHD model which provides global magnetic field, plasma density and temperature, and neutral distributions in the heliosphere and local interstellar medium. The dynamics of the pickup ions is modeled by numerically solving the focused transport equation with prescribed diffusion coefficients, which includes the particle drifts and transport effects due to large-scale turbulence and micro-instabilities, such as field-line wandering and pitch-angle scattering. We determine the coefficients with test-particle simulations in magnetic field fluctuations similar to Voyager observations in the local interstellar medium. The ENA emission flux and image seen at 1 AU are calculated to enable comparisons between the simulation results and IBEX observations.

Thursday, November 3: 3:55 PM - 4:20 PM
Presenter: Strumik, Marek

Contributions of the Extra-Heliospheric Background, Solar-UV-Output Anisotropy and Multiple Scattering Effects to the Heliospheric Lyman-Alpha Glow Observed at 1 AU From the Sun

Marek Strumik, Space Research Centre PAS (CBK PAN), Poland
Maciej Bzowski, Space Research Centre PAS (CBK PAN), Poland
Marzena A. Kubiak, Space Research Centre PAS (CBK PAN), Poland
Izabela Kowalska-Leszczynska, Space Research Centre PAS (CBK PAN), Poland

Heliospheric Lyman-alpha glow is observed by a number of spaceborne instruments (e.g., Voyager/UVS, New Horizon/ALICE, Cassini/UVIS, or SOHO/SWAN) and can be used as an indirect way of probing the neutral hydrogen parameters in the heliosphere. However, since the hydrogen parameters are not measured directly, the interpretation of the Lyman-alpha measurements requires significant modeling efforts. Commonly the models take into account only some phenomena that possibly contribute to the total observed photon flux, while some other effects are neglected. In this context we discuss the latitudinal anisotropy of the solar UV output, extra-heliospheric background emissions and multiple scattering effects. For each phenomenon we provide some estimations of its contribution to the total signal measured at 1 AU as inferred from analyses of SOHO/SWAN and IUE observations and comparison of the observations with simulation results from the recently developed WawHelioGlow model.

According to the estimations, the solar-UV-output anisotropy (polar darkening) of the order of 15% may cause the helioglow signal to change by 20-30% in polar regions. Extra-heliospheric-background estimates are shown to depend on the characteristics of the measuring instrument, e.g., its spectral sensitivity or the field of view. For a spectrally-broad photometer like, e.g., SOHO/SWAN, the extra-heliospheric background amounts to 5-10% of the helioglow magnitude when averaged over the entire sky, but locally this contribution can be of the order of 20%. Comparison of WawHelioGlow modeling results with SOHO/SWAN observations suggests that some effects commonly attributed to multiple scattering can be explained by latitude-dependent ionization rate related to realistic solar wind structure.

Thursday, November 3: 4:20 PM - 4:45 PM
Presenter: Isenberg, Phil

Turbulence Driving by Interstellar Pickup Ions in the Outer Solar Wind

Philip A. Isenberg, University of New Hampshire, USA
Bernard J. Vasquez, University of New Hampshire, USA
Charles W. Smith, University of New Hampshire, USA

Interstellar neutral atoms slowly drifting into the heliosphere become ionized in the supersonic solar wind, where they temporarily form unstable ring-beam distributions about the magnetic field. These newly ionized pickup ions (PUIs) scatter toward a more stable isotropy, self-consistently generating quasi-parallel-propagating ion cyclotron (IC) waves. These fluctuations contribute to and drive the turbulent cascade in the outer solar wind. Evidence of this driven cascade is found in the anomalous heating of the core solar wind protons, most visible beyond 40 AU, and the slow decay of the turbulent fluctuations. Attempts to quantify this driving found that the single quasilinear interaction with IC waves alone, resulting in so-called “bispherical” distributions, provided far too much energy transfer from the particles to the waves/turbulence and predicted proton temperatures in excess of those observed. An additional wave-particle process was invoked, serving to moderate the PUI scattering to the bispherical distribution, but no further studies have been made on this process.

We point out here that the turbulent cascade itself can provide the moderating interaction on the newly-ionized PUIs through the dissipative energization of these particles. On the slow time scale of evolution in the distant solar wind, these turbulent interactions can influence the PUIs during the isotropization process, resulting in reduced IC generation and consequently weaker turbulent driving. We demonstrate the operation of this moderation with an idealized computational model.

A particularly interesting feature of this scenario is that this coupled system can be self-regulating. That is, a change in the background turbulent intensity will cause a compensating change in the level of IC scattering of newly-ionized PUIs. The modified scattering will, in turn, adjust the level of energy transfer back to the turbulent driving, so as to counteract the previous change in intensity.

Thursday, November 3: 4:45 PM - 5:10 PM
Presenter: Huang, Zhenguang

Modeling the Solar Wind During Different Phases of the Last Solar Cycle

Gabor Toth, University of Michigan, USA
Nishtha Sachdeva, University of Michigan, USA
Lulu Zhao, University of Michigan, USA
Bartholomeus van der Holst, University of Michigan, USA
Igor Sokolov, University of Michigan, USA
Ward Manchester, University of Michigan, USA
Tamas Gombosi, University of Michigan, USA

We describe our first attempt to systematically simulate the solar wind during different phases of the last solar cycle with the Alfvén Wave Solar atmosphere Model (AWSoM) developed at the University of Michigan. Key to this study is the determination of the optimal values of one of the most important input parameter of the model, the Poynting flux, which prescribes the energy flux passing through the chromospheric boundary of the model in form of Alfvén wave turbulence. It is found that the optimal value of the Poynting flux parameter is correlated with: 1) the open magnetic flux with the linear correlation coefficient of 0.913; 2) the area of the open magnetic field regions with the linear correlation coefficient of 0.946. These highly linear correlations could shed light on understanding how Alfvén wave turbulence accelerates the solar wind during different phases of the solar cycle and estimating the Poynting flux parameter for real-time solar wind predictions with AWSoM.

SCHEDULE OF TALKS

Friday, November 4: 8:00 AM - 8:25 AM
Presenter: Li, Gang

On the Meandering Nature of the Solar Wind Magnetic Field

Gang Li, UAHuntsville, USA
Nicolas Bian, UAHuntsville, USA

To the first approximation, the solar wind magnetic field can be approximated by the Parker spiral which is the consequence of a constant radial solar wind speed. Turbulence in the solar wind, however, lead to distortions of the ideal Parker field and results in a meandering field line. Various sources contribute to the meandering of the field line. These include a time-varying and/or a non-radial solar wind velocity, a turbulent motion of the footpoint on the source surface, as well as in-situ tubulent motion of solar wind parcels in the direction perpendicular to the large-scale mean field. We discuss the effect of the turbulent motion of the footpoint and in-situ solar wind parcel on the meandering field line in this work. We propose that in both processes the displacement of solar wind parcels can be described by a Langevin model and the root mean square displacement is controlled by a time scale tau, which can be related to the power of solar wind MHD turbulence. The resulting IMF path length is computed and shown to be finite, as compared to the case of a random walk model in the seminal work of Jokipii and Parker.

Friday, November 4: 8:25 AM - 8:50 AM
Presenter: Yuen, Ka Ho

Origin of Magnetically Elongated Cold Neutral Media in Multiphase Interstellar Media

Ka Ho Yuen, LANL, USA
Ka Wai Ho, UW Madison, USA
Alex Lazarian , UW Madison, USA

The atomic hydrogen cold neutral media (HI-CNM) is one of the most popular and important astrophysical observables that came to the researchers' eyes in the last decade. Observations like HP4PI (Kalberla et.al 2015), GALFA (Peek et.al 2018), THOR-HI (Beuther et.al 2016, Wang et.al 2020), FAST (e.g. Li et.al 2021) have advanced our understanding of CNM, including its spatial distribution (Kalberla et.al 2016,18), relation to magnetic field (Heilis & Troland 2003, Clark et.al 2015) and its connection to underlying molecular phase (Kritsuk et.al 2017). CNM is ubiquitous in interstellar media (ISM), spanning from high latitude (Clark et.al 2015, Kalberla & Haud 2016) to the galactic plane (Solar et.al 2020), and being highly filamentary with filament aligned along the magnetic field direction (Clark et.al 2015, Yuen & Lazarian 2017a, Lazarian & Yuen 2018a). The observed parallel HI filaments generally have a very high aspect ratio, from 30-400 (Clark et.al 2015, Clark et.al 2014, Soler et. al 2020,2021), and are proposed to be associated to cold features (Clark et.al 2019, Peek & Clark 2019). Given the ubiquity of these long, cold and thin filaments on the full sky (~0.1pc thick, Kalberla et.al 2020, 2021), there must be a universal mechanism favoring long CNM to form. One of the most common explanations is the equally ubiquitous magnetized turbulence (Yuen et.al 2022b) shaped the multiphase media according to the Goldreich-Sridhar scaling (GS95, 1995, see also Lazarian & Vishniac 1999, Xu et.al 2019). This scaling predicts filaments in the isothermal MHD turbulence could be scaled as \propto M_A^(-4/3), and could left imprint to the observed velocity channel maps (Yuen et.al 2021). However, recent work (Yuen et.al 2022a) suggests that high density cold features under GS95 are significantly longer than what is expected in observations.
In this talk, we recognize a new type of instability due to the non-trivial nature of the pressure force in the unstable phase via theoretical and numerical efforts We provide a new estimation of the average CNM filament aspect ratio with the consideration of force balances at the phase boundary, which is roughly 5-20 in common CNM environment. By performing multiphase numerical simulations with realistic heating and cooling, we show that most of the cold filaments are less filamentary than what usually predicted via MHD turbulence theory or inferred from observations: (1) The average length of CNM filament is roughly 1/2 of that in isothermal MHD turbulence with similar turbulence conditions. (2) Filaments that are longer than the expected length are subjected to instability and fragmentate into smaller segments. (3) Anisotropic features observed in HI emission maps with aspect ratio of ~100 are unlikely to be cold density features, but warmer, thermally unstable features.

SCHEDULE OF TALKS

Friday, November 4: 8:50 AM - 9:15 AM
Presenter: Donders, Nicolas

Why Developing a Full-sun UV Spectrograph Sounding Rocket is Difficult but Necessary

Nicolas Donders, The University of Alabama in Huntsville, USA
Gary Zank, The University of Alabama in Huntsville, USA
Amy Winebarger, NASA MSFC, USA
Genevieve Vigil, NASA MSFC, USA
Charles Kankelborg, Montana State University, USA
Larry Paxton, Johns Hopkins University Applied Physics Laboratory, USA

For a conference focused on a 20-year perspective of where we have been and where we are going, this talk will highlight specifically why we need a sounding rocket to lead the way in obtaining high-resolution UV spectroscopy of our sun-as-a-star. The currently available data is either sparse or at a much lower resolution when compared with Hubble (HST) spectra of other stars. Because of this, we cannot say with certainty if our Sun's variability is typical. This limitation is hindering our quest to place our Sun in its rightful place on our star charts. Ultraviolet light is a key component in determining this. Elements such as Hydrogen and Iron have strong emission lines here, and from them, we can determine many things about the star from which they originate. The width of these spectral features can tell us about the relative plasma activity on the surface of the star, the abundance of those elements, and the temperatures. This has been done with many instruments that have a very narrow field of view and/or narrow bandwidth. The only way to directly compare our Sun's UV "fingerprint" with other stars is to take an image in the same manner HST does: as a point source object. Our team has aimed to develop a sounding rocket capable of doing just that. Along the way, the many challenges we face are producing many solutions. A unique take on the traditional Rowland circle spectrograph will allow us to cover a large range of UV spectra with minimal moving parts. A novel in-situ gain calibration technique will be used to obtain the high level of radiometric accuracy desired. Naturally, complications arise when one takes UV measurements as the instrument flies out of the earth's atmosphere and back into it. Though it may be minor, the absorbed UV spectra from the atmosphere will have to be accounted for. In preparing for this, we have stumbled across a way in which those "telluric" absorption lines may prove useful for spectral calibration purposes. In addition, raw data from previous sounding rocket missions may have hidden within them useful information for the atmospheric-physics community. In this talk, we will highlight the unique calibration problems and solutions we have faced, and how those are of greater importance to the greater heliophysics and atmospheric communities. With these amazing developments at hand, the future of heliophysics instrumentation is looking bright.

Friday, November 4: 9:15 AM - 10:05 AM
Presenter: Goldstein, Melvin

N/A

N/A

N/A

Che, Haihong	***The Formation of Electron Outflow Jets with Power-law Energy Distribution in Guide-field Magnetic Reconnection*** H. Che, University of Alabama in Huntsville, USA G.P. Zank University of Alabama in Huntsville, USA A.O. Benz, FHNW & ETH, Switzerland B. Tang, University of Alabama in Huntsville, USA C. Crawford, University of Alabama in Huntsville, USA Observationally, electron beams with power-law energy spectra are commonly associated with solar flares. Previous studies have found that during magnetic reconnection (MR) with a guide field Bg larger than 0.1 times the asymptotic field B0, electron beams are unable to develop due to the strong deflection caused by the guide field. Using particle-in-cell simulations we show that in force-free reconnection, the development of an electron Kelvin– Helmholtz instability (EKHI) can suppress the Hall effect and produce a flute-like outflow exhaust, in which both electrons and ions are nearly frozen-in with the magnetic field. The coupling of a continuously growing electron velocity shear and E × B drift drive the electrons out of magnetic vortices and results in collimated jets with a power-law energy spectrum in the elongated exhaust. The spatial density of electron jets is comparable to the background and is highly inhomogeneous, signifying on asymmetric density structure in guide field reconnection.
Kim, Tae	***Ranking the ADAPT-WSA Coronal Model Ensemble Using Observations of Interplanetary Scintillation in the Inner Heliosphere*** Tae Kim, UAH, USA Random fluctuation in intensity of the radio waves from distant, compact astronomical sources is called interplanetary scintillation (IPS). The solar wind outflow speed can be directly estimated from multi-site IPS observations, such as the ISEE three-station array in Japan, as a weighted line-of-sight (LOS) averages using the time lag for maximum cross-correlation of the spectra as a LOS-integrated value under weak scattering assumption. On the other hand, the Wang-Sheeley-Arge (WSA) model approximates the global magnetic field and the ambient solar wind outflow speed above the corona using photospheric magnetic maps, for example, from the Air Force Data Assimilative Photospheric flux Transport (ADAPT) model. The WSA model is widely used by the space weather community for operation and research, with validation primarily against near-ecliptic, single-point data. Hence, it would be interesting to see how the ADAPT-WSA ensemble velocities compare with the IPS velocities in the 3D inner heliosphere, particularly away from Earth, where such comparisons are reasonable. For IPS lines of sight mostly through the undisturbed, ambient solar wind, the IPS velocity can be approximately attributed to the point nearest to the Sun along the LOS and easily mapped to the WSA outer boundary for direct comparison. The results show that IPS data can be a valuable tool for validating/ranking the ADAPT-WSA ensemble in the 3D inner heliosphere, particularly away from Earth or the ecliptic plane, where most of the model validation/ranking is currently performed against single-point probe data.

Merrill, Asher	***Optimizing the Time-Correlation Method for Determining the Heliopause Distance*** Asher Merrill, Los Alamos National Laboratory, USA Dan Reisenfeld, Los Alamos National Laboratory, USA Paul Janzen, University of Montana, USA Reisenfeld et al. 2021 demonstrates a novel method of measuring the shape of the heliosphere by time-correlating variations in the heliosheath-originating energetic neutral atom (ENA) flux measured by the Interstellar Boundary Explorer (IBEX) with variations in the outbound solar wind dynamic pressure. The time delay observed in the ENA flux arriving from a particular direction in the sky can be used to calculate the average distance in that direction to the region in which charge exchange of the solar wind occurs and from which the ENAs measured by IBEX eventually return. Reisenfeld et al. 2021 determines the lag-time of the ENA flux by maximizing a cross-correlation of the summed partial-pressures of ENAs in each of IBEX's electrostatic analyzer (ESA) steps with the outbound solar wind dynamic pressure, but this method is not able to rigorously calculate uncertainties for the distance in each direction. We improve on this technique by implementing a bootstrap method for each directional pixel to derive a distribution of possible heliopause distances. The distribution is built in the following manner: the available ENA pressure data, as used in Reisenfeld et al. 2021, is sampled with replacement. A chi-squared metric is then calculated for each choice of heliopause distance. The choice of distance that minimizes the chi-squared metric is then added to the distribution. This is repeated until doubling the number of samplings does not change the mean of the distribution by more than 1%. The mean value of the heliopause distance and its uncertainty are read from this distribution. The result is a more robust determination of the distance to the heliopause with a more quantifiable uncertainty.
Murtas, Giulia	***Numerical Studies of Instability-driven Reconnection in Chromospheric Partially Ionized Plasmas*** Giulia Murtas, LANL, USA Instability-driven fast magnetic reconnection plays a fundamental role in generating explosive dynamics and heating in solar plasmas. However, relatively little is known about how fast reconnection develops in the solar chromosphere, where the plasma is partially ionized. In this talk I will discuss the effects of partial ionization on the onset of magnetic reconnection through 2.5D numerical simulations of plasmoid coalescence and 3D simulations of kink instability of flux ropes in both a single fluid magnetohydrodynamic (MHD) model and a two-fluid model of a partially ionized plasma (PIP). Partial ionization alters the dynamics of the coalescence instability: plasmoid coalescence is faster in PIP than MHD at the same bulk density, due to the faster thinning of the current sheet and the onset of secondary plasmoid dynamics, which can form in the PIP model in linearly stable conditions. Collisional ionization and recombination slow down the coalescence, stabilize current sheets and suppress non-linear dynamics, with turbulent reconnection occurring in limited cases: bursts of ionization lead to the formation of thicker current sheets, even when radiative losses are included to cool the system. Although the reconnection time scale is longer with the inclusion of ionization and recombination, reconnection in PIP is still faster than in MHD. In 3D simulations, results show that partial ionization leads to a faster onset of the non-linear phase of the kink instability. The magnetic energy lost with reconnection is distributed in a different way between MHD and PIP cases, with a larger increase of the internal energy associated to partial ionization. The temperature of PIP cases increases faster due to the frictional heating resulting from the two-fluid dynamics. These studies prove that the chromospheric dynamics can be faster and more explosive than fully ionized environments, due to the interaction between charges and neutral elements in the plasma mixture. Violent effects and changes in the stability of features such as plasmoids are a direct consequence of partial ionization and could explain the fast reconnection behind the formation of several phenomena observed in the chromosphere.

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