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ORAL ABSTRACTS

Adhikari, Laxman	***Theory and Transport of Nearly Incompressible Magnetohydrodynamics Turbulence. III. Evolution of Power Anisotropy in Magnetic Field Fluctuations throughout the Heliosphere*** Laxman Adhikari, CSPAR, USA Gary Zank, CSPAR/UAH, USA Daniele Telloni, INAF, Italy Peter Hunana, CSPAR/UAH, USA Roberto Bruno, INAF-IAPS, Italy Daikou Shiota, Nagoya University/National Institute of Information and Communications Technology, Japan A theoretical model that describes the evolution of the power anisotropy in the energy-containing and inertial ranges throughout the heliosphere is developed for three possibilities: (i) no in situ sources of turbulence; (ii) stream-shear sources of 2D and slab turbulence; and (iii) a fully driven turbulence model that includes both stream- shear driving and a pickup ion source of slab turbulence. At the inner boundary (1 au), we assume that the ratios of the 2D to slab fluctuating magnetic energy variances in the energy-containing range are 80:20, 70:30, 60:40, and 55:45. For case (i), <B^2_2D>/<b^2_slab> in the energy-containing range increases monotonically throughout the heliosphere, whereas the inertial range ratio increases until ~20 au and then decreases. For case (ii), the energy-containing range ratio increases initially and then remains approximately constant and ordered beyond ~2 au, according to the inner boundary assumptions. The inertial range ratio for the 80:20 case increases with heliocentric distance, whereas for the 70:30, 60:40, and 55:45 cases, the rations increase between ~2 to ~10–20 au, and then generally decrease at larger heliocentric distances. For case (iii), the energy-containing and inertial range ratios increase initially, remain approximately constant and increase slightly, respectively, and then decrease more rapidly between ~8 and 30 au, and more gradually thereafter, approaching a ratio of ~1 at 75 au. We present preliminary results that show the power anisotropy in magnetic field fluctuations observed by Ulysses spacecraft increasing with heliocentric distance from ~1.5 to 4.5 au.
Al-Haddad, Nada	***Structure and Evolution of CMEs Through Simulations and In-situ Data Analysis*** Nada Al-Haddad, Catholic University of America, USA Teresa Nieves-Chinchilla, Catholic University of America, USA Noe Lugaz, University of New Hampshire, USA Understanding the structure of coronal mass ejections (CMEs) has been the focus of a multitude of works over the past few decades, through the analysis of in-situ and remote measurements. This work demonstrates multiple approaches to understanding the structure of CMEs: I. Through identifying a sample of 13 “simple” CMEs, and comparing several different models used to reconstruct the CME morphology. II. Through comparing synthetic multi-spacecraft in situ measurements of two structurally different CMEs, and, III. Through studying the evolution of two different simulated CMEs as they propagate in the inner heliosphere.
Asgari-Targhi, Mahboubeh	***A Comprehensive Study of Solar Wind Structure and Dynamics based on Alfven Wave Turbulence*** Mahboubeh Asgari-Targhi, Harvard-Smithsonian Center for Astrophysics, USA Adriaan A. van Ballegooijen, Harvard-Smithsonian Center for Astrophysics, USA We present a reduced magnetohydrodynamic description of an open magnetic field line at the center of a coronal hole extending along the solar rotation axis from the coronal base outward into the heliosphere. Alfven waves are generated at the coronal base and reflect as a result of variations in Alfven speed and solar wind outflow velocity at different heights. The interactions between counterpropagating waves create turbulence that heat and accelerate the solar wind. We consider two models of the solar wind. In the first model, the plasma density and Alfven speed vary smoothly with height along the modeled flux tube. However, we find that the energy dissipation rate of the turbulence is insufficient to maintain the temperature of the background atmosphere. In the second model, we introduce additional density variations along the open field that approximates the effects of compressive MHD waves in the solar wind. We find that such spatial variations in density may enhance the turbulence dissipation rates, and thereby increase the heating rate and the acceleration of the solar wind.

Bhattacharjee, Amitava	***Onset of Fast Reconnection and Turbulence Mediated by the Plasmoid Instability in the Solar Atmosphere*** Amitava Bhattacharjee, Princeton University, USA The plasmoid instability of thin current sheets has transformed our understanding of fast reconnection. We have carried out extensive analysis and computer simulation of evolving current sheets and obtained precise criteria and scaling relations for the disruption of a current sheet when the reconnection rate increases suddenly. Subsequently, the system evolves to a state of anisotropic turbulence that cannot be described by standard Goldreich-Sridhar phenomenology, nor are they simple power laws. Novel investigations of IRIS observations provide valuable tests for theory.
Boldyrev, Stanislav	***The Role of Current Sheets and Reconnection in Magnetic Plasma Turbulence*** Stanislav Boldyrev, University of Wisconsin-Madison, USA Small-scale current sheets are ubiquitous structures in magnetic plasma turbulence. They have been consistently observed in numerical simulations and predicted in analytical models. For instance, they are related to a highly intermittent nature of energy dissipation in MHD turbulence [1]. Recent studies [2,3,4] have suggested that the sheet-like structures may have a profound impact not only on the dissipation range but also on the inertial interval of magnetic plasma turbulence. In particular, they may modify the energy spectrum of turbulence and lead to a new, reconnection-mediated energy cascade [2,3,4]. We review the recent results on the nature and role of current sheets in magnetic turbulence. [1] V. Zhdankin, S. Boldyrev, C.H.K. Chen (2016), MNRAS, 457, L69 [2] N. F. Loureiro & S. Boldyrev (2017), Phys. Rev. Lett, 118, 245101 [3] S. Boldyrev & N. F. Loureiro (2017), Astrophys. J. , 844, 125 [4] N. F. Loureiro & S. Boldyrev (2017), Astrophys J. 850 182
Bourdin, Philippe-A.	***Electron Acceleration and their Thermalization in the Solar Corona and Earth's Magnetosphere*** Philippe-A. Bourdin, Space Research Institute, Austria The evolution of magnetic fields in the solar atmosphere requires magnetic reconnection and change in the global magnetic topology. In collisionless plasmas, this reconnection accelerates electrons and induces currents that eventually need to be dissipated to heat the plasma. The long-standing coronal heating riddle is tightly connected to understanding how currents may dissipate in a collisionless regime. Magneto-hydrodynamic (MHD) models need to assume the dissipation scheme in a simplistic way through a magnetic resistivity. But, in the same time, MHD models are successful to reproduce observed extreme-UV-bright loop systems in the corona. It seems obvious to treat the plasma with a particle-kinetic approach in order to be able to study magnetic-energy dissipation mechanisms. Even though, the more one studies particle trajectories, the more one looses the actual dissipation, because any particle's behavior is symmetric in time and hence reversible. We tackle this topic with a combination of a realistic coronal MHD model and a particle-in-cell simulation of anti-parallel magnetic reconnection, similar to the Earth's magnetosphere. The electron velocity distributions may be compared to actual MMS in-situ observations and allow to search for irreversible current dissipation schemes. We present a catalog of such distributions and investigate the chaotic mixing of particle trajectories responsible for the thermalization of accelerated electron populations.

Bzowski, Maciej	***Diagnosing the Local Interstellar Medium Using the Warm Breeze and IBEX Ribbon*** M. Bzowski , CBK PAN, Poland M.A. Kubiak , CBK PAN, Poland J. Heerikhuisen, University of Alabama in Huntsville, USA A. Czechowski , CBK PAN, Poland J. Grygorczuk , CBK PAN, Poland P. Swaczyna , CBK PAN, Poland E. Zirnstein, Princeton University, USA J.M. Sokół , CBK PAN, Poland The IBEX Ribbon and the Warm Breeze, two important discoveries made by Interstellar Boundary Explorer (IBEX), which originally seemed little related to each other, have turned out to provide important and consistent insight into the physical state of the Local Interstellar Medium (LISM) surrounding the heliosphere. The IBEX Ribbon, which is a large arc-like sky region of enhanced emission of energetic neutral atoms with the energies of ~0.7 keV and larger, has been shown to be (1) most likely due to the secondary ENA emission mechanism and (2) geometrically centered near the direction of a 3 µG local interstellar magnetic field (ISMF). The Warm Breeze, discovered as a population of interstellar neutral (ISN) helium other than the primary ISN He, has been shown to most likely be the secondary population of ISN He, created due to charge-exchange process between He+ ions and the primary ISN He atoms in the perturbed interstellar plasma in the outer heliosheath, as predicted by heliospheric models. Furthermore, it has been demonstrated that the inflow directions of ISN He and the Warm Breeze are co-planar with the center of the Ribbon. With that, it has been further demonstrated that combining MHD modeling of the plasma flow in the outer heliosheath with solutions of the charge-exchange production and loss balance equation along the orbits of He atoms allows to successfully simulate the signal due to the Warm Breeze and ISN He that IBEX is actually observing. Qualitatively, a good agreement has been obtained when the direction and strength of the ISMF conforming with those found from Ribbon analysis were adopted. This suggests that the Warm Breeze and Ribbon phenomena are related to each other, even though they are formed by different processes and in different regions of the outer heliosheath. The factor that makes them related to each other is the ISMF. In this contribution, we show that results of the IBEX ISN He and Warm Breeze signal synthesis technique are sensitive to the assumed ionization degree of ISN He in the LISM. The ionization state of He in this region is poorly recognized but the scarce available insight suggested that the ionization degree of He is larger than that of H. Using a fitting technique similar to that previously used to obtain the parameters of ISN He, and results of MHD heliosphere simulation precisely conforming with those used to establish the direction and strength of the ISMF, we determine the ionization degree of ISN He by fitting the simulated signal to the IBEX observations of the ISN He, collected during almost the entire interval of the mission. We find that most likely, the ionization degree of the ISN He in the LIC is significantly lower than previously thought.
Cairns, Iver	***Magnetic Reconnection at the Heliopause: Predicted Electron and Ion Bulk Heating Effects in the Plasma Depletion Layer and Outer Heliosheath*** Iver Cairns, University of Sydney, Australia Stephen Fuselier, Southwest Research Institute, USA Magnetic reconnection is a well known source of electron and ion bulk heating, as well as energetic particles, in the solar system. Examples include solar flares and reconnection at Earth's magnetopause and in Earth's magnetotail. Several authors have suggested that reconnection occurs at the heliopause. The primary focus of this paper is to predict the amount of electron and ion bulk heating for heliopause reconnection, using the empirical relations of T. Phan and colleagues between the changes in electron and ion temperature and an Alfven speed V_ARA. This Alfven speed depends on the strengths of the reconnecting magnetic fields and includes asymmetries in the magnetic fields and densities on the two inflowing sides of the reconnection region. For the undisturbed interstellar flow the predicted V_ARA ≈ 25 km/s and the predicted changes in electron and ion temperature are ΔTe ≤ 1000 K and ΔTi ≤ 6000 K. These changes are relatively small and not important for the dynamics at the heliopause. However, a plasma depletion layer (PDL) is predicted beyond the heliopause, analogous to the PDLs observed sunwards of the magnetopauses of Earth, Mercury, Jupiter, and Saturn. In the PDL, the interstellar (ISM) magnetic field lines drape over the heliopause. Plasma ions and electrons with relatively large parallel temperatures escape along the field, increasing the field strength, decreasing the plasma density, and increasing the Alfven speed. In the region of the PDL where these effects are strong, the expected field and density changes are a factor of 4 and ¼, respectively, increasing V_ARA by a factor close to 3 and the temperature changes by almost a factor of 10. Thus, heliopause reconnection in a strong PDL is predicted to increase the electron and ion temperatures by up to 10,000 K and 80,000 K, respectively, corresponding to changes by factors of order 1.5 and 11 compared to the predicted ISM temperature of 7000 K. Thus, the effects of bulk heating in heliopause reconnection regions should only be important for plasma inside or magnetically connected to the strong region of the heliopause's PDL. The effects of this heating on electrons and ions accelerated by shocks beyond the heliopause and on associated Langmuir waves will also be discussed.

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Che, Haihong	***How Nanoflares produce the Kinetic Waves and Weak Coronal Radio Bursts and Non-Thermal Electrons in the Solar Wind*** H. Che,UMCP/GSFC, USA Increasing observations suggest that the solar wind originates from the photosphere and is associated with nanoflare-like impulsive events. These observations present new theoretical challenges on how the coronal origin of solar wind affects its in situ properties and is one of the key to understand the relationship between the Sun and the heliophysics. I first review the pioneering observations that establish the connection between solar wind and nanoflares; then I discuss the recent theoretical and simulation advances, in particular on how the nonlinear dynamics of nanoflare-accelerated electrons produce the kinetic waves and radio bursts, and shape the non-thermal electron velocity distribution which is believed to be responsible for the solar wind acceleration.
Cheung, Mark	***Thermal Diagnostics of the Solar Corona with SDO/AIA*** Mark CM Cheung, Lockheed Martin Solar & Astrophysics Laboratory, USA As the science mission tasked to keep a watchful eye on the Sun, full disk observations from NASA's Solar Dynamics Observatory (SDO) will be crucial for understanding the source regions of the solar wind measured by the Parker Solar Probe and Solar Orbiter missions. In this presentation, we show how EUV images from the Atmospheric Imaging Assembly (AIA) onboard SDO can be used to quantitatively measure the thermal distribution and evolution of coronal plasma. We illustrate with examples of mapping the thermal structure of emerging active regions, probing the temperatures of coronal loops with different connectivities, and the evolution of flare plasma from chromospheric evaporation to coronal condensation.
Consolini, Giuseppe	***Topological Features of Magnetic Field Fluctuations at Kinetic Scales in the Reconnection Dissipation Region*** G. Consolini, INAF-IAPS, Italy V. Quattrociocchi, INAF-IAPS, Italy M.F. Marcucci, INAF-IAPS, Italy The magnetic reconnection is generally accompanied by large and quasi-turbulent spatio-temporal fluctuations from the MHD scales down to the kinetic ones. The discussion of the nature of such turbulent fluctuations is generally based on the analysis of its spectral and scaling features. Here, we present a preliminary characterisation of these fluctuations by the geometric invariants of the magnetic field gradient tensor at kinetic scales using data collected by MMS constellation during the crossing of the X-line/dissipation region of an already studied magnetic reconnection event [Burch et al., Science, 2016]. The analysis evidenced the presence of both tube- and sheet-like structures and essentially a vortex sheet Ohmic-dissipation. This work is funded by Italian Space Agency under Grant agreement No. ASI-INAF 2015-039-R.O. ``Missione M4 di ESA: Partecipazione italiana alla fase di assessment della missione THOR''.
Dahlin, Joel	***Implications of Self-consistent Solar Eruptions for Particle Acceleration and Turbulence*** J. T. Dahlin, UCAR, USA S. K. Antiochos, NASA/GSFC, USA C. R. DeVore, NASA/GSFC, USA The mechanism for eruptive flares/CMEs is one of the most important problems in space science. Understanding the build up and explosive energy release is vital for predicting energetic particles and turbulence in major space weather events. We recently proposed that the free energy build up leading to eruption is due to an inverse cascade of magnetic helicity injected into the corona by turbulent convective motions at the photosphere, resulting in ‘helicity condensation’ forming a filament channel. We present the first 3D MHD numerical simulations in a spherical system appropriate for studying CMEs, in which the initial state is a minimum energy potential field and the system is driven by the small-scale photospheric motions. We demonstrate that this simple, self-consistent model drives large-scale energy build up and eventual explosive energy release in the form of a coronal mass ejection with a highly complex and turbulent three-dimensional structure. We discuss implications for the acceleration, transport, and release of energetic particles in solar eruptive events. This work was supported by the NASA LWS and SR Programs.

Dayeh, Maher A.	***What Causes the Variability in Energetic Storm Particle (ESP) Events?*** Maher A. Dayeh, SwRI, USA Energetic storm particle (ESP) events are enhancements of >0.1 MeV/nucleon ions near 1 AU in association with the passage of interplanetary (IP) coronal mass ejections (ICME). The primary candidate for producing these enhancements is diffusive shock acceleration (DSA) at the ICME-driven IP shock. ESPs can produce significant increases in the near-Earth particulate radiation and pose severe hazards to astronauts and hardware in space. Physical parameters thought to affect ESP production include IP shock properties (e.g., speed, strength, obliquity) and upstream conditions ahead of the propagating shock (e.g., turbulence, seed population, SW conditions). Several theoretical and observational studies have attempted to relate ESP production to these drivers, however, reliable prediction of ESP properties (e.g. intensities, spectra, abundances), including their event-to-event variability, has so far proven elusive, indicating an incomplete understanding of how ICME-driven IP shocks accelerate ESPs. Using instruments onboard ACE, Wind, and STEREOs, we perform cross-correlation analysis among a large set of parameters characterizing the (i) upstream conditions, (ii) ICME properties, (iii) IP shock properties, and (iv) ESP properties and search for dominant parameters that influence ESP production and variability. Results are also examined in context of the DSA theory predictions.
Dialynas, Konstantinos	***Cassini/INCA and Voyager Measurements on the Global Heliosphere (2003-2017)*** Stamatios M. Krimigis, Applied Physics Laboratory, USA Donald, G. Mitchell, Applied Physics Laboratory, USA Robert B. Decker, Applied Physics Laboratory, USA The INCA detector on Cassini has been measuring 5.2-55 keV Energetic Neutral Atoms from the heliosphere since 2003, while the LECP instruments on Voyager-1 (>35 keV) and Voyager-2 (>28 keV) have been taking in-situ ion measurements from the heliosheath (HS) after crossing the termination shock (TS), 35deg north (2004) and 32deg south (2007) of the ecliptic plane at 94 and 84 AU, respectively. The comparison between in-situ ions and remote sensed ENAs in overlapping energy bands has led to several discoveries that revealed the dynamical profile of the heliosphere and posed new questions for future heliosphere imaging. Some of those key discoveries are briefly summarized as follows: (A) The “Belt” [1], identified as a high intensity and wide ENA region that encircles the celestial sphere in ecliptic coordinates corresponds to a “reservoir” of particles that exist within the heliosheath and the “Basins”, identified as two extended heliosphere lobes where the ENA minima occur; both constantly replenished by new particles from the solar wind [2]; (B) The interstellar magnetic field was estimated to be ~0.5 nT (<0.64 nT) [3], stronger than was assumed before in order to balance the nonthermal pickup ion pressure in the heliosheath, which was confirmed a few years later, after V1 crossed the heliopause [4]; (C) The V1 crossing of the heliopause per se was predicted within a month, implying a heliosheath thickness of LV1~27(+26, -11) AU [5], whereas the thickness along the V2 line-of-sight might be twice as thick [6]; (D) Strong intensity/pressure gradients in the anti-nose ENA measurements (tail to basin drop rate of ~2.4% per degree) [7], taken together with the fact that the pick-up ion populations, in keV range play dominant role in maintaining the pressure balance in the heliosheath, pointed to the “diamagnetic” character of the heliosheath; Recently [8], we have argued that the heliosphere forms a time-dependent roughly symmetric obstacle to the inward interstellar flow, reflecting the 11-year “breathing mode” of the global heliosphere, caused by the outward propagating changes of the solar wind through the solar cycle. Further, the heliosphere responds promptly to those changes, within ~2-3 yrs, in both the nose and anti-nose directions [9]. These results, taken together with the Voyager 1 measurements of a ~0.5 nT interstellar magnetic field, >0.09/cm3 interstellar plasma density, and increased plasma β inside the HS, preclude the formation of a strong bowshock, and strongly suggest a diamagnetic bubble-like heliosphere with few substantial tail-like features [8]. (1) Krimigis et al. (2009), Science, 326, 971; (2) Dialynas et al. (2013), ApJ, 778:40; (3) Krimigis et al. (2010), AIP Conf. Proc., 1302, 79; (4) Krimigis et al., (2013), Science, 341; (5) Krimigis et al. (2011), Nature, 474; (6) Roelof et al. (2012), AIP Conf. Proc., 1436, 239; (7) Dialynas et al. (2015), J. Phys.: Conf. Series 577; (8) Dialynas et al. (2017a), Nat. Astron., 1, 0115; (9) Dialynas et al. (2017b), J. Phys.: Conf. Ser. 900, 012005.

Du, Senbei	***Particle Acceleration in Interacting Magnetic Flux Ropes*** Senbei Du, University of Alabama in Huntsville, USA Gary P. Zank, University of Alabama in Huntsville, USA Fan Guo, Los Alamos National Laboratory, USA Xiaocan Li, Los Alamos National Laboratory, USA Magnetic flux rope structures, also known as magnetic islands when viewed in 2D, are frequently observed in space, and are often associated with the acceleration of charged particles. Previous particle-in-cell (PIC) simulations have revealed several basic mechanisms including reconnection electric fields and Fermi acceleration by contracting magnetic field lines, but detailed particle acceleration processes remain unclear. In this study, we present PIC simulations studying the particle acceleration due to magnetic flux ropes. We consider a simple 2D configuration of two-magnetic-island coalescence. An inhomogeneous out-of-plane guide field is included to ensure an initial force-free condition. Due to the presence of the guide field, only a few percent of the total magnetic energy is converted to plasma energy. Nevertheless, some electrons and protons are found to be accelerated to a few times their initial kinetic energies. We use a particle tracing technique on the high-energy particles to clarify the associated acceleration mechanisms and to quantify the acceleration rate from the simulation data. The methods we use support the development of transport theories. Our results are roughly consistent with previous PIC simulations.
Eriksson, Stefan	***On Magnetic Reconnection Exhausts in the Solar Wind and Associated Perturbations of the Out-of-Plane Magnetic Field*** Stefan Eriksson, Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, USA Giovanni Lapenta, Center for Mathematical Plasma Astrophysics, Department of Mathematics, University of Leuven, Belgium; Space Science Institute, Boulder, USA Paul A. Cassak, Department of Physics and Astronomy, West Virginia University, USA David L. Newman, Center for Integrated Plasma Studies, University of Colorado, Boulder, USA Lynn B. Wilson III, NASA Goddard Space Flight Center, USA Daniel J. Gershman, NASA Goddard Space Flight Center, USA Magnetic reconnection is a plasma physics process of tremendous importance for the dynamics of current sheets. It is the main science objective of the Magnetospheric Multiscale (MMS) satellite mission in its Earth-centered orbit, which allows for a microscopic exploration of the important ion and electron diffusion regions in the vicinity of X-lines on the basis of very high-cadence measurements of ion distributions at 150-ms and electron distributions at 30-ms. This presentation will focus on reconnection signatures across solar wind current sheets with an emphasis on the out-of-plane (BM) magnetic field. We present WIND and MMS satellite observations of bipolar BM perturbations across individual exhausts consistent with our understanding of Hall magnetic fields. We also present examples of a lesser known tripolar BM perturbation signature across exhausts and discuss a scenario in terms of reconnection-associated flux ropes on the basis of particle-in-cell simulations.
Fisk, L.A.	***Reflections on a 50-year Career as a Theoretician in Heliospheric and Solar Physics*** L.A. Fisk, University of Michigan, USA I will talk today about what I have attempted to accomplish during the two intervals in my career when I pursued research: the interval before I became a senior administrator in the early 1980s, and the interval after I returned to research in 1993. I will emphasize my belief that in order to maintain our scientific discipline as vibrant, dynamic, and worth supporting, it is essential that we always seek and welcome new concepts and paradigm shifts.
Frisch, Priscilla	***Tracing the Interaction between the Interstellar Magnetic Field and the Heliosphere using Linearly Polarized Starlight*** P. Frisch, University of Chicago, USA et al. Magnetically aligned interstellar dust grains trace the direction of the interstellar magnetic field (ISMF). The motion of the Sun through the interstellar medium sweeps up interstellar magnetic field lines. Interstellar dust grains trapped in the swept-up ISMF create a measurable linear polarization signal. We report results of new measurements of linearly polarized starlight collected to study the ISMF in the very local interstellar medium, within 15 pc. Surprisingly, the most obvious magnetic structures traced by these data reveal the configuration of the interstellar magnetic field lines draped over the heliosphere. The previously discovered dust filament in the heliosphere nose region is prominent. A new more global magnetic feature reveals magnetic field lines draping over the heliosphere. Essential new polarization data have been collected for this project using Dipol -2 mounted on telescopes in Hawaii and Australia, by HIPPI and Mini-HIPPI mounted on telescopes in Australia, and by IAGPOL on a telescope in Brazil. The results reported here represent the efforts of 23 collaborators located in Finland, Australia, Brazil, and the USA.

Fu, Xiangrong	***Parametric Decay Instability and Dissipation of Low-frequency Alfvén Waves in Low-beta Turbulent Plasmas*** Xiangrong Fu, New Mexico Consortium, USA Hui Li, Fan Guo, Xiaocan Li, Los Alamos National Laboratory, USA Vadim Roytershteyn, Space Science Institute, USA Evolution of the parametric decay instability (PDI) of a circularly polarized Aflv\'en wave in a turbulent low-beta plasma background is investigated using 3D hybrid simulations. It is shown that the turbulence reduces the growth rate of PDI as compared to the linear theory predictions, but PDI can still exist. Interestingly, the damping rate of ion acoustic mode (as the product of PDI) is also reduced as compared to the linear Vlasov predictions. Nonetheless, significant heating of ions in the direction parallel to the background magnetic field is observed due to resonant Landau damping of the ion acoustic waves. In low-beta turbulent plasmas, PDI can provide an important channel for energy dissipation of low-frequency Alfv\'en waves at a scale much larger than the ion kinetic scales, different from the traditional turbulence dissipation models.
Fuselier, Stephen	***The IBEX Ribbon at all energies and the thickness of the Inner Heliosheath*** M. A. Dayeh, Southwest Research Institute, USA E. Moebius, University of New Hampshire, USA The dominant feature in global images of 1 keV heliospheric energetic neutral atom (ENA) emissions is the IBEX Ribbon. Several processes have been proposed for creating the Ribbon. One process that shows significant promise is the so-called secondary ENA process. Solar wind ions propagating away from the Sun charge exchange, forming a neutral solar wind. This neutral solar wind propagates across the termination shock, through the inner heliosheath and across the heliopause. In the outer heliosheath, some of these neutrals charge exchange a second time, forming a 1 keV pickup ion population that, after a third charge exchange, re-enter the heliosphere as 1 keV neutrals. The Ribbon is also observed at other energies, down to 0.2 keV and above solar wind energies. In the secondary ENA process, 0.2 keV ENAs originated from 0.2 keV ions in the inner heliosheath. Similarly, ~4 keV ENAs originated from ~4 keV ions in the inner heliosheath. Thus, the ratio of the Ribbon ENA flux at 1 keV and at 0.2 keV or ~4 keV provides information on the sources of the original ion populations and ultimately on the relative sizes of the heliosphere and inner heliosheath. This work describes how the differences in the source populations lead to estimates of the thickness of the inner heliosheath. A proof-of-concept model is introduced to make these estimates.
Gary, S. Peter	***Species Entropies in the Kinetic Range of Collisionless Plasma Turbulence: Particle-in-Cell Simulations*** S. Peter Gary, Space Science Institute, USA Three-dimensional particle-in-cell simulations of the forward cascade of decaying turbulence in the relatively short-wavelength kinetic range have been carried out as initial-value problems on collisionless, homogeneous, magnetized electron-ion plasma models. The simulations have addressed both whistler turbulence at beta_i = beta_e = 0.25 and kinetic Alfvén turbulence at beta_i = beta_e = 0.50, computing the energy dissipation rates as well as the rates of entropic increase of both ions and electrons as functions of the initial dimensionless fluctuating magnetic field energy density epsilon_o on the range 0 ≤ epsilon_o ≤ 0.50. This study shows that electron and ion entropies display similar rates of increase and that all four rates of entropic increase scale approximately as epsilon_o.
Giacalone, Joe	***Diffusive Shock Acceleration of Suprathermal Ions at Strong Interplanetary Shocks and Comparison with Observations*** Joe Giacalone, Lunar and Planetary Laboratory, University of Arizona, USA David Lario, Johns Hopkins Applied Physics Laboratory, USA We compare the results of diffusive shock acceleration (DSA) theory applied to a pre-existing, upstream source of high-energy particles with high-time cadence (12 min.) ACE/SWICS and EPAM observations of proton energy spectra for a number of strong and fast interplanetary shocks. These spectra cover a wide range of energy including the thermal solar-wind peak, the suprathermal tail, and the high-energy tail. The observed pre-shock distribution in each case constrains our assumed pre-existing, initial distribution. DSA theory then gives post-shock spectra with which we compare with observations. A key free parameter is the low-energy cut-off, or injection energy, E0, in the initial distribution. In all of the events we analyzed, we find that the value of E0 which leads to the best fit of the observed post-shock spectra is well below the solar-wind (ram) kinetic energy, and, in fact, near the thermal energy, in some cases. This suggests that the high-energy protons accelerated by the shock originate from near the thermal portion of the upstream distribution. Thus, we conclude that the source of high-energy protons for the events we have analyzed are shock-accelerated thermal solar wind protons. We will also discuss implications for minor ions.

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Gilbert, Holly	***Solar Orbiter: Joint Mission to Study the Sun*** Holly Gilbert, NASA Goddard Space Flight Center, USA Daniel Mueller, ESA, The Netherlands Yannis Zouganelis, ESA, The Netherlands Chris St Cyr, NASA Goddard Space Flight Center, USA This mission to explore the Sun-Heliosphere connection is the first medium-class mission of ESA's Cosmic Vision 2015-2025 program and is being jointly implemented with NASA. The dedicated payload of 10 remote-sensing and in-situ instruments will orbit the Sun as close as 0.3 A.U. and will provide measurements from the photosphere into the solar wind. The three-axis stabilized spacecraft will use Venus gravity assists to increase the orbital inclination out of the ecliptic to solar latitudes as high as 34 degrees in the extended mission. Solar Orbiter's science team has been working closely with the Parker Solar Probe (PSP) scientists to coordinate observations between these two highly-complementary missions. In addition to providing a Solar Orbiter status update, I will present the exciting new science opportunities that the synergy between Solar Orbiter and PSP offer in the search to understand the origins of the heliosphere.
Gloeckler, George	***3-D Velocity Distribution Functions measured every ten milliseconds with the Fast Imaging Solar Wind Ion Composition Spectrometer*** G. Gloeckler, University of Michigan, USA L. A. Fisk, University of Michigan, USA We have designed relatively simple and easily constructed instrument (FI-SWICS) that will measure the full 3-D velocity distribution function (VDF) of solar wind protons and solar wind alpha particles as fast as every 10 milliseconds. FI-SWICS, which uses a highly modular design, combines the SWICS ion identification system with a novel, highly symmetric Concentric Spheres electro-static deflection analyzer (CONSESA) driven by a rapidly swept (or stepped) deflection voltage (Vd < 1 kV) between an outer mechanical collimator (OMC) at ground and the inner mechanical collimator (IMC) at -Vd. The tens of centimeter size FI-SWICS is an assembly of i identical wedges of angular width $\Delta\varphi=2\pi/i$, where i is the desired number of azimuth sectors to be sampled. Each wedge has j OMC tunnels of desired polar look directions, θ_j and specified angular width $\Delta\theta_j$ with corresponding IMC tunnels. Each tunnel pair is thus an individual electrostatic analyzer (ESA) with dimensions and locations of its tunnel pair determining the geometrical factor, analyzer constant and $\Delta\varepsilon/\varepsilon$ where ε is the energy/charge of the particle. Specific wedges and tunnel pairs are uniquely identified using position-sensing detectors. With dimensional changes only, larger versions of this instrument will also measure the full 3-D VDF of suprathermal, pickup and tail ions of protons, $^4He^{++}$, $^3He^{++}$, $^4He^{+}$ and an additional ~70 heavy ion species with different mass-(mass/charge), such as O^{+6}, Fe^{+10}, etc. every few seconds to minutes. Three such FI-SWICS instruments of different dimensions on a spacecraft such as ACE would provide data that would resolve many outstanding problems concerning local particle acceleration by shocks and turbulence at 1 AU.
Goldstein, Melvyn	***Using Global Codes to Anticipate the Environment to be Encountered by the Parker Solar Probe Mission*** Melvyn L. Goldstein, University of Maryland and NASA Goddard Space Flight Center, USA Rohit Chhiber, University of Delaware, USA Arcadi V. Usmanov, University of Delaware, and NASA Goddard Space Flight Center, USA Craig E. DeForest, Southwest Research Institute, USA Tulasi N. Parashar and William H. Matthaeus, University of Delaware, USA The Parker Solar Probe (PSP) mission is scheduled for launch this summer. Its orbit will take it closer to the sun than any previous mission, providing unique and unprecedented opportunities to characterize the physical properties of the solar corona. In preparation for the passage of the spacecraft into the corona, it is important to have some indication from theory and models as to what one might expect to observe and where one might expect to observe it. In particular, one would like to have an idea as to where the various critical surfaces will be located as the solar atmosphere expands outward and evolves into the solar wind. Examples of such surfaces include where the flow first becomes supersonic and where it will become superAlfvénic. Also, the location of the transition from magnetic field dominated flow to hydrodynamic dominated flow (i.e., where the plasma beta (the ratio of thermal to magnetic pressures) becomes unity) appears to be another important structure as revealed recently in new analyses of data from the STEREO mission. We have recently used our global magnetohydrodynamic code to try to predict where these regions might be found along the PSP trajectory. The code includes several additions to the standard MHD equations, including electrons as a separate fluid (together with various approximations to the heat flux), the effects of sub-grid-scale turbulence on the flow, as well as parameterization of the Alfvén ratio and estimates of the diffusion coefficient of energetic particle propagation that can be used in conjunction with studies of solar energetic particle events.

Golla, Thejappa	***Evidence for Simultaneous Occurrence of Oscillating Two Stream and Nucleation Instabilities in a Solar Type III Burst*** G. Thejappa, University of Maryland, USA R. J. MacDowall, NASA, Goddard Space Flight Center, USA The WAVES experiment on the STEREO B spacecraft has detected a magnetic field aligned linearly polarized one dimensional Langmuir wave packet, which is unique in the sense that (1) it is the most intense wave packet ever detected in association with a type III radio burst so far, and (2) for the first time, this wave packet provides evidence for the collapsing Langmuir wave packet formed as a result of nucleation processes even when the level of ambient density fluctuations is higher than that of the ponder-motive force induced fluctuations. Further more (1) The measured normalized peak energy density and estimated wave number indicate that this wave packet probably is saturated by the supersonic modulational instability (oscillating two stream instability (OTSI)) of the strong Langmuir turbulence, (2) the peak amplitude and spatial width of this wave packet are consistent with that of the collapsing Langmuir soliton formed as a result of OTSI, (3) the characteristics of the density cavity detected in association with this wave packet indicate that probably it is created by the ponder-motive force of the wave packet, (4) the FFT spectrum of the wave packet contains the signatures of OTSI, namely, spectral peaks corresponding to beam excited Langmuir waves as well as the primary and secondary side bands and ion sound waves which satisfy the required resonance conditions, and (5) the FFT spectrum also contains harmonic peaks corresponding probably to the second and third harmonic electromagnetic waves excited as a result of wave-wave interactions as indicated by the computed bicoherence spectrum of the wave packet. The implication of these observations for theories of strong Langmuir turbulence and type III radio bursts is discussed.
Guo, Fan	***The Acceleration of Particles at the Solar Flare Termination Shock*** Fan Guo, LANL, USA Xiangliang Kong, Shandong University, China Chengcai Shen, CFA, USA Joe Giacalone, University of Arizona, USA Bin Chen, NJIT, USA Standing (but unsteady) solar flare termination shocks can develop when the high-speed reconnection outflow encounters the reconnected post flare loops and accelerates particles to high energy. We investigate the dynamical evolution of the termination shock and its electron acceleration through numerical simulations. Because of the upstream turbulence and plasmoids from the reconnection region, the shock front is likely to be turbulent and rippled at a range of spatial scales, which has a strong implication for electron acceleration. We solve the Parker transport equation for the distribution function of accelerated electrons using the plasma flow velocity and magnetic field obtained from a MHD simulation of a classic Kopp-Pneumann configuration for a two-ribbon flare. We find that the electrons are accelerated rapidly, forming a power-law distribution similar to solar flare observations. Because particles transport crossing the magnetic field is much less than that along the magnetic field, a large fraction of the accelerated electrons are trapped in the region above the top of the post-reconnection loop. These results may explain the main features of the hard X-ray observation of solar flares.

Gurnett, Don	***Measurements of the Nearby Interstellar Plasma Density with the Voyager 1 PWS*** Don Gurnett and Bill Kurth, University of Iowa, USA The plasma wave instruments on Voyagers 1 and 2 have made both remote and local (in situ) measurements of the plasma density in the nearby interstellar medium. The remote measurements started in 1983 (over 30 years ago) when both Voyagers 1 and 2 detected radio emission from interplanetary shocks that reached the heliopause and propagated into the local interstellar medium. These radio emissions were assumed to be generated at the electron plasma frequency (or its harmonic) via mode conversion from local electron plasma oscillations excited by shocks propagating outward from energetic solar events. Typically, after the shock reaches the heliopause the radio emission frequency increases with increasing time from about 1.8 to 3.5 kHz on time scales of months. This temporal increase was interpreted as indicating that the shock is propagating into a density ramp in the local interstellar medium. When Voyager 1 finally reached the heliopause in 2012 the above model was confirmed by direct in situ observations of the upstream electron plasma oscillations associated with shocks propagating into the interstellar medium. Over the now nearly five years for which such plasma oscillation events have been observed, spanning a radial distance of roughly 20 AU (Astronomical Units), the plasma density in the interstellar medium has increased from 0.06 cm(^-3) for the first such measurement in Oct.-Nov. 2012, to nearly 0.14 cm(^-3) for the latest event in Aug. 2017. Although generally consistent with the density ramp inferred from the remote radio measurements, the origin of this density ramp in the interstellar plasma medium is not yet clear. There are several current theories that will be reviewed. Nor is it clear what the plasma density profile might be on the flanks or downstream sides of the heliosphere, as there are no in situ measurements in those regions. One possible very important clue is given by the radio remote sensing spectrums made when Voyager 1 was within the heliosphere. These spectrums typically show a very sharp cutoff at 1.8 kHz and a band from about 1.8 to 2.4 kHz that appears to be radiation trapped in the heliosphere. Just how these features might be interpreted in the context of the three dimensional density structure of the heliosphere will be discussed.
Hansteen, Viggo	***The Heating of the Solar Chromosphere and Corona, What can "realistic" 3D Numerical Models teach us?*** Viggo Hansteen, Rosseland Center of Solar Physics, Institute of Theoretical Astrophysics, Norway Three-dimensional (3D) radiative MHD numerical simulations now reproduce many properties of the outer solar atmosphere. When including a domain from the convection zone into the corona, a hot chromosphere and corona are found to be self-consistently maintained and reproduce many observational diagnostics measured in the real Sun. In this talk we study a number "realistic" models, with different simulated areas, magnetic field strength and topology. We analyze the heating at both large and small scales and find that heating is episodic and highly structured in space, but occurs along loop-shaped structures, and moves along with the magnetic field. On large scales we find that the heating per particle is maximal near the transition region and that widely distributed opposite-polarity field in the photosphere leads to a greater heating scale height in the corona. On smaller scales, heating is concentrated in current sheets, the thicknesses of which are set by the numerical resolution. Some current sheets fragment in time, this process occurring more readily in the higher-resolution models leading to spatially highly intermittent heating.
Higginson, Aleida	***Modeling the Complex and Dynamic Magnetic Field Governing SEP Propagation*** A. K. Higginson, University of Michigan, USA S. K. Antiochos, NASA/GSFC, USA C. R. DeVore, NASA/GSFC, USA B. J. Lynch, University of California, Berkeley, USA P. F. Wyper, Durham University, United Kingdom Particle transport in the heliosphere remains an unsolved problem across energy regimes. One of the most important discoveries of the STEREO mission is that impulsive Solar Energetic Particle (SEP) events frequently exhibit large longitudinal spread in the heliosphere, up to 100 degrees or more. It has been assumed that in order to observe these 3He-rich events, the spacecraft must be magnetically connected to the acceleration region, but how that region connects to such a large swath of the heliosphere remains a mystery. Theory predicts that the magnetic topology of coronal holes should produce a complex and highly dynamic web of separatrices (or S-Web) that thread the heliosphere, and recent simulations have shown that this complex, dynamic connectivity of the heliospheric magnetic field can establish heliospheric magnetic-field connections that range far in latitude and longitude. Here we show that these connections may play a larger role in the dissemination of SEPs than previously recognized. We compute, for the first time, the dynamics of the S-Web when the photospheric driver is applied over a large portion of the solar surface compared to the scale of the driving, and demonstrate that for commonly-observed coronal magnetic topologies small regions near the Sun can connect to giant arcs in the heliosphere that span tens of degrees in both latitude and longitude. We discuss the implications of the S-Web model for the propagation of SEPs and their distribution in the heliosphere. We will make predictions for Solar Orbiter and Parker Solar Probe and discuss future work that will be essential for interpreting these new measurements and illuminating the transport mechanisms of wide-spread impulsive SEP events.

Ho, George	***Measurements of Suprathermal Ions in the inner Heliosphere from Solar Orbiter and Solar Probe Plus*** Glenn Mason, Johns Hopkins University Applied Physics Laboratory, USA Particles that have energies of a few times the solar wind plasma energy up to 100s of keV/q are called suprathermal particles. Recent studies have revealed that these particles may a significant role as seed particles for further acceleration to higher energies. This may occur either close to the Sun in solar energetic particle (SEP) events, but also locally at 1 AU in energetic storm particle events, or even outside 1 AU as ions accelerated in Corotating Interaction Regions. The origin of these suprathermal particles is largely unknown at this time. Possible sources include: 1) suprathermal tails of the fast and slow speed solar wind; 2) interstellar and "inner source" pick-up ions; 3) remnant material from both gradual and impulsive SEP events; and 4) remnants from CIRs and CME-driven shocks. The constituents of this suprathermal ion reservoir are therefore expected to vary in time and space. It is therefore important to make high-time resolution measurements of the composition and spectra of this particle population in the inner heliosphere to better characterize its origins and role as a seed population in particle acceleration processes. Because of the vastly different mass-per-charge ratios of the various possible origins of suprathermal ions, we expect to see distinct difference and radial dependencies in their abundances in low-energy accelerated particles in the inner heliosphere. Here we describe the measurements that we will be making on both Solar Orbiter and Solar Probe Plus that will make significant contributions to the understanding of the particle population in this largely unexplored energy range.
Hu, Qiang	***Small-scale Magnetic Flux Ropes in the Solar Wind: Identification and Characterizations*** Qiang Hu, and Jinlei Zheng, Department of Space Science/CSPAR, The University of Alabama in Huntsville, USA We present a unique observational analysis of the small-scale coherent magnetic flux rope structures in the solar wind at 1 AU. Such structures with duration between 9 and 361 minutes are identified from Wind in situ spacecraft measurements through the Grad-Shafranov (GS) reconstruction method. The GS method employs the plane GS equation which characterizes two and a half dimensional magnetic structures in quasi-static equilibria. We describe in detail an automated algorithm for identifying small-scale magnetic flux ropes from in situ time-series data. We present the statistical results associated with the events identified from Wind spacecraft measurements during 1996-2016. The event occurrence counts are on the order of 3500 per year on average and have a clear solar-cycle dependence. In particular, we show a power-law distribution of the wall-to-wall time corresponding well to the inertial range solar wind turbulence, which agrees with relevant observations and numerical simulation results of magnetohydrodynamic (MHD) turbulence. We also provide the axial current density distribution of the flux rope cores from the GS-based quantitative characterization, which yields a non-Gaussian probability density function consistent with the MHD simulation results. Therefore we conclude that we have provided additional evidence for the self-generation of small-scale magnetic flux ropes via MHD turbulence, based on the unique GS-based observational analysis and the extensive database.
Hu, Junxiang	***Modeling Particle Acceleration and Transport using iPATH: Further Development and Applications*** Junxiang Hu, CSPAR/University of Alabama in Huntsville, USA Gang Li, CSPAR/University of Alabama in Huntsville, USA Shuai Fu, CSPAR/University of Alabama in Huntsville, USA Gary Zank, CSPAR/University of Alabama in Huntsville, USA The improved Particle Acceleration and Transport in Heliosphere (iPATH, [Hu et al. 2017]) model simulates particle acceleration at a CME-driven shock based on diffusive shock acceleration (DSA) mechanism in a 2D domain. Transport of the accelerated particles is followed using the backward stochastic differential equation method. Both parallel and perpendicular diffusion are considered in the transport process. Numerous improvements have been implemented into the iPATH model recently, including a closer inner boundary, a refined shock detection method, and an attempt to model the energetic storm particles (ESP) phase. Results from iPATH model, such as time-intensity profiles, particle spectra and anisotropies, will be applied to study the longitudinal and radial spreads of gradual SEP events.

Hunana, Peter	***New Closures for more Precise Modeling of Landau Damping in the Fluid Framework*** Peter Hunana, CSPAR University of Alabama in Huntsville, USA Gary P. Zank, CSPAR University of Alabama in Huntsville, USA Monica Laurenza, Institute for Space Physics and Planetology (INAF-IAPS), Italy Anna Tenerani, University of California, USA Gary M. Webb, CSPAR University of Alabama in Huntsville, USA Melvyn L. Goldstein, Space Science Institute, USA Marco Velli, University of California, USA Laxman Adhikari, CSPAR University of Alabama in Huntsville, USA Incorporation of kinetic effects such as Landau damping into the fluid framework was pioneered by Hammett and Perkins PRL 1990, by obtaining closures of the fluid hierarchy, where the gyrotropic heat flux fluctuations or the deviation of the 4th-order gyrotropic fluid moment, are expressed through a lower-order fluid moments. To obtain a closure of a fluid model expanded around a bi-Maxwellian distribution function, the usual plasma dispersion function that appears in kinetic theory or the associated plasma response function, have to be approximated with a suitable Pade approximant. Such closures are rare to find, and the original closures of Hammett and Perkins are often employed. Here we present several more closures that describe Landau damping in the fluid framework with better precision than prior models.
Jian, Lan	***Electromagnetic Cyclotron Waves in the Inner Heliosphere: Observations and Wave Dispersion Analysis*** L. K. Jian, University of Maryland, NASA/GSFC, , USA M. Stevens, Harvard Smithsonian Center for Astrophysics, USA S. P. Gary, Space Science Institute, USA T. Broiles, Space Science Institute, USA P. S. Moya, University of Chile, Chile A. F. Viñas, NASA/GSFC, USA J. C. Kasper, University of Michigan, USA Using high-cadence magnetic field data from the Helios, MESSENGER, STEREO, and Wind missions, we have observed the strong narrow-band electromagnetic waves near the proton cyclotron frequency (fpc) in the solar wind (excluding the intervals around shocks) from 0.3 to 1 AU, some can last more than one hour. They are transverse and near-circularly polarized, and propagate in directions quasi-parallel or anti-parallel to the magnetic field. The wave frequency is a few times of fpc in the spacecraft frame and a fraction of fpc in the plasma frame after removing the Doppler shift effect. These waves are left-hand (LH) or right-hand (RH) polarized in the spacecraft frame with otherwise similar characteristics except LH ones appear more often and have higher wave power. Intrinsically they can be LH polarized Alfven-cyclotron waves or RH polarized magnetosonic waves. Using the wide spatial coverage from one year of STEREO observation, we have excluded the interstellar pickup ions, cometary or planetary pickup ions as the major sources of these waves. Using well-calibrated plasma data from the Wind mission, we have found a mixture of temperature anisotropies for core protons, beam protons, and alpha particles, as well as proton beam drift are often associated with the selected events of extensive waves. The wave dispersion analysis using these ion parameters indicates these waves are likely to be associated with unstable Alfven-cyclotron anisotropy instability or ion beam instability, and suggests there is a mixture of Alfven-cyclotron waves and magnetosonic waves in the solar wind.
Jokipii, Jack	***Physics of the ISM Plasma as it Flows Around the Heliosphere*** J. R. Jokipii and Joe Giacalone, University of Arizona, USA We discuss the physical properties of the interstellar plasma as it flows around the heliopause.We point out that the isotropization time scale for the thermal plasma particles is significantly less than the flow time scale. Therefore, their distribution must be nearly isotropic in the fluid frame. This is in contrast to recent suggestions that the plasma is significantly anisotropic and unstable to plasma instabilities. The nearly isotropic plasma therefore behaves approximately as an ideal MHD fluid. This implies, among other things, a plasma depletion layer in the heliosheath caused by the usual MHD forces. .

Klein, Kristopher	***How Unstable is the Solar Wind? Evaluating in situ Observations using Nyquist's Criterion*** Kristopher G Klein, University of Michigan, USA Justin Kasper, University of Michigan, USA Michael Stevens, Smithsonian Astrophysical Observatory, USA Lan Jian, University of Maryland, USA Instabilities play an important role in the regulation of dynamic behavior of collisionless plasma systems and are the focus of significant ongoing work within the plasma, space, solar, and astrophysics communities. Most studies of stability in systems such as the solar wind focus on the parametric behavior of specific unstable modes or a single free-energy source. We employ for the first time on a statistical set of random solar wind intervals a method that determines a system's stability considering all modeled sources of free energy, known as Nyquist's instability criterion. We find a surprising result, that a majority of the intervals are unstable, in contrast to previous results that typically identify only a few percent of observed intervals as capable of supporting unstable modes. While most of these modes grow more slowly than ion-kinetic timescales, many grow sufficiently quickly to be relevant to inertial-range turbulence and transport processes. We also discuss initial applications of this method to other systems of interest. The abundance of unstable modes in the solar wind may have important implications for the dynamics of the solar wind as well as a variety of other collisionless plasma systems.
Kota, Jozsef	***On the Anisotropies of Anomalous and Galactic Cosmic Rays Observed by Voyagers in the Heliosheath and beyond the Heliopause*** Jozsef Kota, University of Arizona, USA The Voyager team reported on an anisotropy of 0.5-35 MeV/n anomalous cosmic rays observed during the Magroll operations of Voyager-2 in the heliosheath (Cummings et al, 2017). The inferred streaming of ACRs directed toward the nose of the termination shock (TS), and was not present at low energies. This is in qualitative agreement with models predicting higher ACR intensities toward the flanks and tail of the TS (McComas & Schwadron, 2006; Kota & Jokipii, 2004, 2008). We present model simulations to constrain the acceleration mechanism and estimate the ratio of perpendicular and parallel diffusion coefficients. We also discuss some implications of the episodic depletion of galactic cosmic rays near perpendicular pitch angles observed by Voyager-1 beyond the Heliopause.
Landi, Enrico	***Diagnostics and Empirical Modeling of Heating and Cooling of CME Plasmas from Remote Sensing and in-situ Observations*** Enrico Landi, University of Michigan, USA Manan Kocher, University of Michigan, USA Yeimy Rivera, University of Michigan, USA Susan Lepri, University of Michigan, USA In this talk I will describe measurements of the thermal evolution of CME plasmas in the inner solar corona as determined from remote sensing observations from STEREO, SDO and Hinode, and from in-situ measurements from ACE/SWICS. I will describe the diagnostic techniques that we used, the results that we obtained on a few different CMEs we applied them to, and discuss the new possibilities offered by the upcoming Parker Solar Probe and Solar Orbiter missions.
Lario, David	***Flat Proton Spectra Large Solar Energetic Particle Events*** D. Lario, R.B. Decker, E.C. Roelof, The Johns Hopkins University, Applied Physics Laboratory, USA L. Berger, R. F. Wimmer-Schweingruber, Institute for Experimental and Applied Physics (IEAP), Christian-Albrechts-University of Kiel, Germany J. Giacalone, University of Arizona, USA L. Wilson III, A.-F. Viñas, NASA Goddard Space Flight Center, USA We present Solar Energetic Particle (SEP) events observed at 1 AU from the Sun for which the proton energy spectra at energies between ~50 keV and ~1 MeV flatten during a period of at least ~12 hours prior to the passage of the associated interplanetary shock. The flattening of the proton energy spectra occurs when the source of the particles (presumably the traveling interplanetary shock) is approaching the spacecraft and particle intensities are still continuously increasing. The arrival of the shock is then characterized by a softening of the spectra, where low-energy proton intensities show a more pronounced enhancement than the high-energy proton intensities. The observation of these flat spectra raises the question of whether they extend to lower proton energies (i.e. below ~50 keV). As energy decreases, proton energy spectra may (1) progressively increase until reaching thermal energies, (2) remain flat but discontinuously increase when reaching the thermal energy domain, or (3) roll over and evolve as an independent population separated from the thermal population. Complementary data from instruments such as ACE/SWICS and Wind/3DP/PESA-High allow us to extend the proton energy spectra to lower energies. We present data from these instruments and discuss how the suprathermal proton population evolves as the shock approaches the spacecraft and whether there is an actual discontinuity between thermal and energetic particle populations. This research is partially supported by the NASA HGI program.

Le, Ari	***Energization and Transport in 3D Kinetic Simulations of MMS Magnetopause Reconnection Site Encounters with Varying Guide Fields*** Ari Le, LANL, USA Bill Daughton, LANL, USA Obi Ohia, LANL, USA Li-Jen Chen, NASA/UMD, USA Yi-Hsin Liu, Dartmouth, USA We present 3D fully kinetic simulations of asymmetric reconnection with plasma parameters matching MMS magnetopause diffusion region crossings with varying guide fields of ~0.1 [Burch et al., Science (2016)], ~0.4 [Chen et al. JGR (2017)], and ~1 [Burch and Phan, GRL (2016] of the reconnecting sheath field. Strong diamagnetic drifts across the magnetopause current sheet drive lower-hybrid drift instabilities (LHDI) over a range of wavelengths [Daughton, PoP (2003); Roytershteyn et al., PRL (2012)] that develop into a turbulent state. Magnetic field tracing diagnostics are employed to characterize the turbulent magnetic geometry and to evaluate the global reconnection rate. The contributions to Ohm's law are evaluated field line by field line, including time-averaged diagnostics that allow the quantification of anomalous resistivity and viscosity. We examine how fluctuating electric fields and chaotic magnetic field lines contribute to particle mixing across the separatrix, and we characterize the accelerated electron distributions that form under varying magnetic shear or guide field. The LHDI turbulence at the magnetospheric separatrix is found to strongly enhance transport and parallel electron heating in 3D compared to 2D, particularly along the magnetospheric separatrix [Le et al., GRL (2017)]. The PIC simulation results are compared to MMS observations.
le Roux, Jakobus	***Investigation of Different Dynamic Small-scale Flux-rope Acceleration Scenarios near Earth*** Jakobus A. le Roux, University of Alabama in Huntsville, USA Gary P. Zank, University of Alabama in Huntsville, USA Gary M. Webb, University of Alabama in Huntsville, USA Olga V. Khabarova, IZMIRAN, Russia Recent observations near 1 AU suggest that dynamic small-scale flux-rope structures are a much more common occurrence than previously thought (Zheng et al. 2018), coinciding often with enhanced energetic particle fluxes (e.g., Zank et al. 2015; Khabarova and Zank 2017). In response we recently developed a system of coupled equations involving a kinetic focused transport equation with Fokker-Planck scattering coefficients for energetic charged particles coupled to a MHD turbulence transport equation for coherent, quasi-2D magnetic island structures based on NI MHD turbulence theory (Zank et al. 2017). The coupled equations can be used to model the self-consistent acceleration of suprathermal charged particles interacting with and traversing numerous dynamic (contracting and merging) quasi-2D small-scale flux ropes with cross-sectional sizes belonging to the inertial range for particles with gyro radii smaller than the flux-rope size (quasi-trapping of particles in these structures). Both coherent and stochastic energetic particle acceleration rate expressions were derived for four small-scale flux-rope acceleration scenarios present in focused transport theory. Estimated test-particle suprathermal proton acceleration rates for the different flux-rope acceleration scenarios in the supersonic solar wind near 1 AU will be compared and discussed. Dynamic flux-rope induced energetic particle pitch-angle scattering and stochastic acceleration rates will also be compared to the corresponding rates for parallel propagating Alfvén waves.

Lembege, Bertrand	***Interactions of Two Supercritical Perpendicular Collisionless Shocks: Full Particle Simulations*** B. Lembege, LATMOS, France Y. MA, University of Wuhan, China Shock collisions are often invoked in the interaction of interplanetary shocks or during the impulsive phase of solar flares to explain the heating and particle acceleration arising from a large number of localized regions. Such collisions have been mainly analyzed with stationary shocks (Cargill, 1991). However, 1D and 2D numerous PIC (Particle in Cell) - and later on hybrid- numerical simulations have clearly evidenced that the front of individual supercritical perpendicular/quasi-perpendicular shocks may be strongly nonstationary. Different source mechanisms have been identified as being responsible for this nonstationary behavior. One well recognized process is the so called ”self-reformation” mainly driven by the accumulation of reflected ions over a foot distance from the ramp. In the present work, interactions between two supercritical perpendicular shocks are analyzed by using 1D full particle-in-cell simulations where space charge and induced effects, and nonstationary effects driven by this cyclic self-reformation are fully and self-consistently included. At the location of the shock fronts interaction (in short SFI), strong local B fields build up associated to large magnetic pressure effects (accumulation of inter-penetrating ions). This accumulation is due to the local interaction (co-rotation) of individual ion vortices (signatures of individual self-reforming shock) which takes place before ion phase mixing establishes. Then, local new shock fronts build up and separate each other after the SFI. Key results show that (a) shocks cross each other (instead of being reflected) so that each incident shock keeps in propagating within the downstream region of the other one, (b) each well organized self-reforming shock (before the SFI) may be replaced by a very turbulent shock (after the SFI) where the self-reformation totally disappears, according to the concerned shock regime, and (iii) the shocks interaction reveals to be a local efficient and relatively quick acceleration process for ions of the upstream edge of the self-reforming fronts. Extensively, these results have been also analyzed for different initial upstream conditions.
Li, Hui	***Particle Energization in Different Turbulent Environments*** Hui Li, LANL, USA Xiaocan Li,LANL, USA Fan Guo, LANL, USA Magnetohydrodynamic (MHD) turbulence and magnetic reconnection are ubiquitous in astrophysical environments. Particle energization often arises in such environments, such as solar coronal heating, flares and gamma-rays from accretion disk coronae. Recent theoretical and numerical studies have highlighted the role of dynamic current sheets, including their formation and associated reconnection processes, which in turn are postulated to strongly impact the turbulence dynamics as well as particle energization processes. Here, we present 3D kinetic simulations of two limiting cases: one is driven by the evolution a large-scale unstable current sheet, and the other is driven by energy injection in a uniform magnetic field background. These systems are large enough that turbulence is fully developed. Whereas some turbulence properties are similar between these two cases, we highlight the differences in particle energization processes arising from these turbulent systems. In particular, we differentiate the relative role of large-scale flows versus the turbulent flows in producing particle energization. This is crucial for determining the efficiency of particle acceleration in different turbulence environments.
Li, Xiaocan	***The Roles Of Fluid Compression And Shear In Particle Acceleration During Magnetic Reconnection*** Xiaocan Li, Los Alamos National Lab, USA Fan Guo, Los Alamos National Lab, USA Hui Li, Los Alamos National Lab, USA Joachim Birn, Space Science Institute, USA Particle acceleration in space and astrophysical reconnection sites is an important unsolved problem in studies of magnetic reconnection. Earlier kinetic simulations have identified several acceleration mechanisms that are associated with particle drift motions. Here, we show that, for sufficient large systems, the energization processes due to particle drift motions can be described as fluid compression and shear, and that the shear energization is proportional to the pressure anisotropy of energetic particles. By analyzing results from fully kinetic simulations, we show that the compression energization dominates the acceleration of high-energy particles in reconnection with a weak guide field, and the compression and shear effects are comparable when the guide field is 50% of the reconnecting component. Based on this result, we then study the large-scale reconnection acceleration by solving the Parker's transport equation in a background reconnection flow provided by MHD simulations. Due to the compression effect, particles are accelerated to high energies and develop power-law energy distributions. The power-law index and maximum energy depend on guide-field strength and diffusion model. This study clarifies the nature of particle acceleration in reconnection layer, and may be important to understand particle energization during solar flares.

Linsky, Jeffrey	***The Local Interstellar medium along the Lines of Sight to Stars with Exoplanets, the Trajectories of the Voyager Spacecraft, and the Path Traveled by the Historic Sun*** Jeffrey L. Linsky, University of Colorado, USA Eric Edelman, Wesleyan University, USA Seth Redfield, Wesleyan University, USA Brian Wood, Naval Research Laboratory, USA Hans Muller, Dartmouth College, USA Julia Zachary, Wesleyan University, USA Hunter Vannier, Wesleyan University, USA We will present a progress report on three projects underway to determine the physical properties of the local interstellar medium (LISM). The observations consist of high-resolution HST spectra of stars located within 100 pc of the Sun. We will report on the properties of LISM gas located along the lines of sight to nearby stars known to host exoplanets. These lines of sight pass through the Local Interstellar Cloud and other clouds of partially ionized gas near the Sun. We will also describe the properties of interstellar gas that the two Voyager spacecraft will traverse as they leave the heliosphere. Finally we will give a progress report on our program to measure the interstellar gas properties along the direction that the historic Sun has traversed
Livadiotis, George	***Kappa Distributions: Thermodynamical Origin and Generation in Space Plasmas*** George Livadiotis, Southwest Research Institute, USA We report on new developments on the origin of kappa distributions in space plasmas. In the 1st part, we show that: (a) the zeroth law of thermodynamics can be used to derive the most generalized form of particle distributions which are assigned with a temperature; (b) under space plasma conditions, this functional form is reduced to the known scheme of kappa distributions; (c) temperature and kappa are two independent parameters spanning the 2-D abstract space of thermodynamics. In the 2nd part, we present: (a) the characterization of mechanisms that generate kappa distributions; (b) three fundamental plasma conditions that can generate kappa distributions in space plasmas; (c) applications of these findings to solar wind plasma at ~1au.
Lugaz, Noé	***Interplanetary Shocks in Unusual Conditions and their Effects*** Noé Lugaz, University of New Hampshire, USA Reka M. Winslow, University of New Hampshire, USA Charles J. Farrugia, University of New Hampshire, USA Charles W. Smith, University of New Hampshire, USA Nathan A. Schwadron, University of New Hampshire, USA Magnetic ejecta associated with coronal mass ejections (CMEs) are often preceded by dense sheaths and, when their speed is significantly faster than that of the solar wind, by fast-mode shocks. When they pass over spacecraft, they are sometimes associated with energetic storm particle (ESP) events. In addition, the majority of long-duration periods of strong southward magnetic fields at Earth are preceded by a fast forward shock wave. We focus here on the causes and consequences of shocks propagating through unusual upstream conditions, and highlight cases where in situ measurements by ACE and/or Wind can shed light on unusual properties and characteristics. We specifically discuss instances of: 1) slow CME-driven shocks and their association with ESP events, and 2) shocks measured at 1 AU as propagating inside a previous CME and their geo-effects.

Manchester, Ward	***CME-Turbulence Interaction with 3-Temperature Plasma Instabilities*** Chip Manchester, University of Michigan, USA Bart van der Holst, University of Michigan, USA We examine the interaction between Alfven wave turbulence, kinetic instabilities and temperature anisotropies in the environment of a fast coronal mass ejection (CME). The impact of a fast CME on the solar corona causes turbulent energy, thermal energy and dissipative heating to increase by orders of magnitude, and produces conditions suitable for a host of kinetic instabilities. We study these CME-induced effects with the recently developed Alfven Wave Solar Model, with which we are able to self-consistently simulate the turbulent energy transport and dissipation as well as isotropic electron heating and anisotropic proton heating. Furthermore, the model also offers the capability to address the effects of fire hose, mirror mode, and cyclotron instabilities on proton/electron energy partitioning, all in a global-scale numerical simulation. We find the turbulent energy greatly enhanced in the CME sheath with strong wave reflection at the shock, which leads to wave dissipation rates increasing by more than a factor of 100. In contrast, wave energy is greatly diminished by adiabatic expansion in the flux rope. Finally, we find proton temperature anisotropies are limited by kinetic instabilities to a level consistent with solar wind observations.
Matsukiyo, Shuichi	***Microstructure of Heliospheric Boundary and Implication for the Origin of Compressible Turbulence in VLISM*** Shuichi Matsukiyo, Kyushu Univ., JPN Tomoki Noumi, Kyushu Univ., JPN Haruichi Washimi, CSPAR, USA Tohru Hada, Kyushu Univ., JPN Gary Zank, CSPAR, USA Microstructure of heliospheric boundary is investigated by using full PIC (Particle-In-Cell) simulations. Both the termination shock and the heliopause are simultaneously reproduced by using the PIC simulation, although system size is very limited and a strong assumption of one-dimensionality is imposed. Spatial scale of the heliopause increases as the angle between the heliopause normal and interstellar magnetic field becomes oblique. The downstream of the termination shock, the region between the termination shock and the heliopause, contains large amplitude magnetic as well as density fluctuations. The VLISM region also contains some fluctuations in magnetic field and density. We investigated the origin and the characteristics of those fluctuations. The density fluctuations show partly positive and partly negative correlations with the magnetic fluctuations in the downstream of the termination shock. The positively correlated fluctuations are produced in the shock front through the self-reformation process, while the negatively correlated ones are generated through mirror instability. On the other hand, the fluctuations in the VLISM show only positive correlation between magnetic and density fluctuations. Further, the fluctuations propagate from the heliopause to the VLISM, which implies that those fluctuations are originated from the heliosphere.
Matthaeus, William	***How do Weakly Collisional Plasmas Dissipate Energy?*** William H Matthaeus, University of Delaware, USA Alexandros Chasapis, University of Delaware, USA Yan Yang, Peking University, China Tulasi Parashar, University of Delaware, USA Sergio Servidio, Universita della Calabria, Italy Turbulence cascade transfers energy from large scale to small scale but what happens once kinetic scales are reached? In a collisional medium, viscosity and resistivity remove fluctuation energy in favor of heat. In the weakly collisional solar wind, (or corona, m-sheath, etc.), the sequence of events must be different. Heating occurs, but through what mechanisms? In standard approaches, dissipation occurs though linear wave modes or instabilities and one seeks to identify them. A complementary view is that cascade leads to several channels of energy conversion, interchange and spatial rearrangement that collectively leads to production of internal energy. Channels may be described using compressible MHD & multispecies Vlasov Maxwell formulations. Key steps are: Conservative rearrangement of energy in space; Parallel incompressible and compressible cascades – conservative rearrangement in scale; conservative rearrangement in space, electromagnetic work on particles that drives flows, both macroscopic and microscopic; and pressure-stress interactions, both compressive and shear-like, that produces internal energy. Ultimately a velocity space cascade leads to enhanced collisions. This is a continuation of last year's presentation, and once again, recent examples will be given from MHD, kinetic simulations and MMS observations.

Mazelle, Christian	***Neutrals – Foreshock Electron Impact Ionization at Mars*** Mazelle, C., IRAP / CNRS - UPS -CNES - University of Toulouse, France K. Meziane, Department of Physics / University of New Brunswick, Canada D. L. Mitchell, Space Sciences Laboratory / University of California Berkeley, USA P. Garnier, IRAP / CNRS - UPS -CNES University of Toulouse, France J. R. Espley, NASA Goddard Space Center, USA A. Hamza, Department of Physics / University of New Brunswick, Canada J. S. Halekas, Department of Physics and Astronomy, University of Iowa, USA B. M. Jakosky, Laboratory for Atmospheric and Space Physics, University of Colorado Boulder, USA Backstreaming electrons emanating from the bow shock of Mars observed by MAVEN/SWEA show a flux fall off with the distance from the shock. This feature is not observed at the terrestrial foreshock. The flux decay is observed only for electron energy E >~29 eV. A recent study indicates that Mars foreshock electrons are produced at the shock in a mirror reflection of a portion of the solar wind electrons. In this context and given that the electrons are sufficiently energetic to not be affected by the IMF fluctuations, the observed flux decrease appears problematic. We have investigated the possibility that the flux fall off with distance results from the impact of backstreaming electrons with Mars exospheric neutral hydrogen. We have demonstrated that the flux attenuation is consistent with the electron-atomic hydrogen impact cross-section for a large range of energy. A better agreement is obtained for energy where the impact cross section is the highest. One important consequence is that foreshock electrons can play an important role in the production of pickup ions at Mars far exosphere.
Mazur, Joe	***The Inner Van Allen Radiation Belt*** J. Mazur, The Aerospace Corporation,USA T. P. O'Brien, The Aerospace Corporation, USA M. D. Looper, The Aerospace Corporation, USA The Earth's Inner Van Allen Radiation belt contains trapped ions and electrons that originate from a variety of sources. The primary source for trapped protons above ~100 MeV is from the decay of neutrons created from the collisions of cosmic ray primaries with the upper atmosphere. The outer edge of the Inner Belt region can also harbor other samples of matter to include solar energetic particles and anomalous cosmic rays. An astounding variety of astrophysical processes lead to a diverse collection of trapped energetic particles that resides within ~12,000 km of the Earth's surface. We will briefly review the current thinking about the Inner Belt with a focus on proton observations from the Van Allen Probes spacecraft. Since launch in August 2012 we have examined the Inner Belt in more detail than ever done before. Prior to the Van Allen Probes, most of our information about the protons above ~50 MeV came from low--Earth orbit and higher--altitude satellites that operated near the beginning of the space age. In addition to the physical characterization of its current state, we will provide insights into the practical applications of the knowledge that we have gained from a near--comprehensive mapping of this nearby and intense radiation environment.
McComas, David	***Interstellar Pickup Ions to ~40 AU and Our Evolving Heliosphere from IBEX*** D.J. McComas, Princeton University, USA On behalf of the entire IBEX and New Horizons/SWAP Teams, Princeton University, USA This talk summarizes two major observational developments in the study of the outer heliosphere. The first are new observation of interstellar H+ and He+ pickup ions from ~20-40 AU from the solar wind (SWAP) instrument on New Horizons. The data show that by 20 AU, these pickup ions already provide the dominant internal pressure in the solar wind and that this pressure is increasing with distance. We extrapolate the trends to the termination shock and find pickup H+ to core solar wind pressure of ~350; this pressure is so large that it represents a significant fraction (~0.16) of the solar wind dynamic pressure at the termination shock. The other major progress is new ENA observations from IBEX showing the response of the outer heliosphere to a large, persistent enhancement in solar wind output and dynamic pressure in the second half of 2014. Staring in 2017, IBEX observes a strong enhancement in the ENAs returning from the closest regions of the inner heliosheath, which indicates that our heliosphere is re-expanding. The coming years should see significant changes in anomalous cosmic rays, galactic cosmic radiation, and the filtration of interstellar neutral atoms into the inner heliosphere.

Medvedev, Mikhail	***Quasi-nonlinear Approach to the Weibel instability*** M. V. Medvedev, KU and MIT, USA Astrophysical and high-energy-density laboratory plasmas often have large-amplitude, sub-Larmor-scale electromagnetic fluctuations excited by various kinetic-streaming or anisotropy-driven instabilities. The Weibel (or the filamentation) instability is particularly important because it can rapidly generate strong magnetic fields, even in the absence of seed fields. Particles propagating in collisionless plasmas with such small-scale magnetic fields undergo stochastic deflections similar to Coulomb collisions, with the magnetic pitch-angle diffusion coefficient representing the effective "collision" frequency. We show that this effect of the plasma "quasi-collisionality" can strongly affect the growth rate and evolution of the Weibel instability in the deeply nonlinear regime. This result is especially important for understanding cosmic-ray-driven turbulence in an upstream region of a collisionless shock of a gamma-ray burst or a supernova. We demonstrate that the quasi-collisions caused by the fields generated in the upstream suppress the instability slightly but can never shut it down completely. This confirms the assumptions made in the self-similar model of the collisionless foreshock. (This work is support via grant DE-SC0016368)
Mostafavi, Parisa	***The Structure of Very Local Interstellar Shock Waves*** Parisa Mostafavi, University of Alabama in Huntsville, USA Gary Zank, University of Alabama in Huntsville, USA Voyager 1 has made in situ measurements of the very local interstellar medium (VLISM) by crossing the heliopause (HP) since August 2012, and its magnetometer has detected several shock waves in the VLISM. Interplanetary shocks propagate through the supersonic solar wind and then through the inner heliosheath after colliding with the heliospheric termination shock (HTS). Interplanetary shock waves can be transmitted through the inner heliosheath and then across the HP into the VLISM. The first in situ VLISM shock observed by Voyager 1 was remarkably broad and had properties different than shocks inside the heliosphere (Burlaga et al. (2013)). We present a model of the 2012 VLISM shock, which was observed to be a weak, quasi-perpendicular, low magnetosonic Mach number, low beta, and subcritical shock. Although the heliosphere is a collisionless environment, we use the Chandrasekhar function and show that the VLISM is collisional with respect to the thermal plasma since the electron and proton collisional mean free paths are relatively small. The thermal collisions introduce dissipation terms such as heat conduction and viscosity into the system. We show that the VLISM shock is determined by thermal proton-proton collisions, which is the dominant thermal collisional term. VLISM pickup ions (PUIs) that are generated by secondary charge exchange do not introduce a significant pressure nor dissipation through the shock transition meaning the VLISM shock is not mediated by PUIs but by the magnetic field and thermal gas only. Weak VLISM shocks are not controlled by wave-particle interactions and therefore are controlled by thermal particle collisions. As a result, we find that the weak VLISM shock is very broad with a thickness of about 0.12 AU, corresponding to the characteristic thermal heat conduction scale length.
Nakanotani, Masaru	***Electron Acceleration in a Shock-Shock interaction: 1D full PIC simulation*** Masaru Nakanotani, Kyushu Univ., Japan Shuichi Matsukiyo, Kyushu Univ., Japan Tohru Hada, Kyushu Univ., Japan Collisionless shock waves play a crucial role in producing high energy particles (cosmic rays) in space. While most of the past studies about particle acceleration assume the presence of a single shock, in space two shocks frequently come close to or even collide with each other. Only the work done by using hybrid simulation was reported by Cargill et al. [1986], in which they focus on a collision of two supercritical shocks and the resultant ion acceleration. While hybrid simulations can resolve ion-scale physics, electron-scale physics and an electron acceleration cannot be investigated. We expect similarly that electron acceleration can also occur in shock-shock collision. To investigate the electron acceleration process in a shock-shock collision, we perform one-dimensional full particle-in-cell (PIC) simulations. In the simulation energetic electrons are observed between the two approaching shocks before colliding. These energetic electrons are efficiently accelerated through multiple reflections at the two shocks (Fermi acceleration). The reflected electrons create a temperature anisotropy and excite large amplitude waves upstream via the electron fire hose instability. The large amplitude waves can scatter the energetic electrons in pitch angle so that some of them gain large pitch angles and are easily reflected when they encounter the shocks subsequently. The reflected electrons can sustain, or probably even strengthen, them.

Oka, Mitsuo	***Electron Acceleration at Earth's Bow Shock: MMS Observation*** Mitsuo Oka, UC Berkeley, USA The MMS team Electrons are accelerated to non-thermal energies at shocks in space and astrophysical environments. While different mechanisms of electron acceleration have been proposed, it remains unclear how non-thermal electrons are produced out of the thermal plasma pool. Here, we report detection of two different types of whistler waves associated with electron acceleration at Earth's quasi-perpendicular bow shock. For the higher frequency parallel-propagating whistler waves, we found evidence of pitch-angle scattering of non-thermal (0.5 - 2 keV) electrons by the cyclotron resonance. For the lower frequency oblique whistler waves, the resonance conditions were not satisfied and but the amplitudes were large. Thus, we suggest that a non-resonant interaction by the lower frequency whistler waves, in addition to the scattering by higher frequency whistler waves, played a role in electron acceleration.
Plunkett, Simon	***Imaging the Solar Wind with Parker Solar Probe and Solar Orbiter*** Simon P. Plunkett, U.S. Naval Research Laboratory, USA The Parker Solar Probe (PSP) and Solar Orbiter (SO) missions will include visible light heliospheric imagers that will provide unprecedented high-resolution images of the solar corona and the heliosphere over wide fields of view in the region of space where the solar wind is born. PSP will fly closer to the Sun than any spacecraft has ever gone, with a closest approach inside 10 solar radii. Solar Orbiter will fly within 60 solar radii from the Sun, and will provide a new perspective from an orbit out of the ecliptic plane. The Wide Field Imager for Solar Probe (WISPR) and the Solar Orbiter Heliospheric Imager (SoloHI) instruments will conduct observing programs designed to answer fundamental questions about the source regions of the solar wind, and the mechanisms by which the wind is heated and accelerated. These observations will include synoptic images at a constant cadence to follow the outflowing plasma from the Sun and connect the remote sensing observations to in-situ measurements of the wind, and high-cadence images with a restricted field of view around specific regions of interest to determine the roles of turbulence and wave energy dissipation in heating and accelerating the wind. In this talk, we will present details of the planned WISPR and SoloHI observations and will discuss the coordinated science objectives that can be addressed using these observations and related modeling efforts.
Potgieter, Marius	***The Physics of Cosmic Ray Modulation*** Marius Potgieter, North-West University, South Africa A review will be presented on the progress made in understanding the physics of the solar modulation of cosmic rays over five decades, focusing on highlighting and celebrating the contributions that Len Fisk made to this discipline.
Provornikova, Elena	***Where in the Solar Atmosphere Do Suprathermal Particles Originate?*** Elena Provornikova, GMU/NRL, USA (John) Martin Laming, NRL, USA Vyacheslav Lukin, NSF, USA Leonard Strachan, NRL, USA Yuan-Kuen Ko, NRL, USA Samuel Tun Beltran, NRL, USA Recent theoretical and observational studies suggest that for the acceleration of solar energetic particles (SEPs) at CME shocks in the solar corona, the presence of suprathermal particle populations in the way of a shock is a critical factor. For injection into diffusive shock acceleration at oblique shocks close to the Sun where Alfven Mach number is low, a hard energy spectrum of the suprathermal population is required (lower k in kappa-distribution). We explore where such particles can be produced in the solar corona. Our recent studies suggest that magnetic reconnection at coronal magnetic nulls is a possible origin where ions can be accelerated by Fermi mechanism in current sheets. We present resistive MHD simulations of the reconnection process in the solar coronal plasma showing the formation of strong plasma compressions. We show analytically that waves produced by plasmoid-dominated reconnection are efficiently reflected in low-beta plasma. These are the favorable conditions for the first-order Fermi particle acceleration in reconnection current sheets with a resulting hard energy spectra, as the spectral index depends on the compression ratio in a reconnection region. This study will complement the future observational program of UltraViolet Spectro-Coronograph Pathfinder (UVSC) – the first experiment to detect suprathermal particles in the solar corona to be launched in Spring 2019.

Qin, Gang	***A Nonlinear Theory of Charged Particle Parallel Diffusion*** Gang Qin, School of Science, Harbin Institute of Technology, China Junfang Wang, School of Science, Harbin Institute of Technology, China A nonlinear theory of the parallel diffusion of charged particles based on the NLGC theory (Matthaeus et al, 2003) and UNLT theory (Shalchi 2010) is obtained. The new diffusion theory is approximately reformed so we can get the analytical expression. After Nondimensionalization the new parallel diffusion coefficient by employing the same approach to perpendicular diffusion coefficient as Shachi in 2015, the parallel transport regimes corresponding to different limits are obtained.
Ratkiewicz, Romana	***Considerations on the Method of Solving the Modeling Dilemma of the Heliosphere*** Romana Ratkiewicz, Institute of Aviation, Poland Global properties of the interaction of the solar wind with the interstellar medium are vastly separated in both space and time from the detailed kinetic microphysics that governs the transport and dissipation of momentum, energy, and magnetic fields. The system is highly nonlinear and it is difficult to reconcile a rigorous numerical approach with nonlinearities when we respect the hierarchy of scales. In this talk reflections on the method of solving this dilemma are presented.
Raymond, John	***Sungrazing Comets as Probes of the Inner Solar Wind*** John C. Raymond, CfA, USA C. Downs, Predictive Sciences, USA M. Knight, UMD, USA K. Battams, NRL, USA S. Giordano, Osservatorio di Palermo, Italy and R. Rosati Sungrazing comets can be used to study the physical conditions in the solar wind and inner corona. They have the advantage over most remote-sensing observations that the inferred plasma parameters pertain to the points along the comet trajectory rather than averages along the line of sight. This talk considers UVCS observations of Comet C/2011 W3 (Lovejoy) at 2 to 10 solar radii.
Richardson, John	***Voyager Plasma Observations in the Heliosheath*** John Richardson, MIT, USA Voyager Team, JPL, USA Voyager 2 has been in the heliosheath for 10.5 years and travelled 32 AU outward since it crossed the termination shock. We present the most recent data. The radial speed of the solar wind continues to slowly decline with distance. The magnitude the speed has not yet shown a clear decline. The density fluctuates on the scales of months by a factor of two and these changes are correlated with changes in low-energy particle intensities. Flow angles have remained fairly constant for the past several years. Pressure increases occur about once per year, with the most recent at the end of 2017 and beginning of 2018.
Roth, Ilan	***Structure of Coronal Fields - Predictions and Implications for Parker Solar Probe*** Ilan Roth, UC Berkeley, USA The observational evidence of braided solar magnetic fields opens a new venue for interpretation of various solar and interplanetary phenomena. Direct imaging of the coronal fields at frequencies corresponding to atomic transition of hot (~1MK) plasma reveals their braiding structure, while solar wind measurements of magnetized plasma parcels with distinct orientation, large field deviation and intermittent fading of energetic flare ions suggest that coronal braided field may have been carried by the solar wind to 1AU. We use the interconnection between the mathematical braids and knots and apply it to the topologically non-trivial magnetized structures and their dynamics, from solar corona to the interplanetary medium. The analysis of braided magnetic modifications results in conjectures regarding (i) their stability under oscillations and successive appearance and decay of magnetic loops, (ii) reconfiguration and destruction of braided structures and (iii) their evolution into the solar wind. It is anticipated that the resulting conjectures regarding the formation of knotted magnetic configurations, their stable oscillations or eruptions will add to the understanding of solar physical processes when the Solar Probe Plus enters the inner heliosphere.

Rouillard, Alexis	***Properties of Coronal Shocks During Intense SEP Events and FERMI-LAT γ-ray Events*** Alexis Rouillard, IRAP, France Illya Plotnikov, Princeton University, USA Gerald Share, NRL, USA Alexandr Afanasiev, University of Turku, Finland Rami Vainio, University of Turku, Finland Thanasis Kouloumvakos, IRAP, France We study the spatial and temporal evolution of coronal shock properties inferred from observations to see if they could be the source of the particles producing the γ-rays and the strongest Solar Energetic Particles (SEPs) measured in situ. Greater than 100 Mev γ-rays measured in the minutes to hours following solar flares suggest that high-energy particles interacting in the solar atmosphere can be stored and/or accelerated for long time periods. In the γ-ray study we concentrated on events observed during occulted solar flares. We used a 3D triangulation technique, based on remote-sensing observations to model the expansion of the CME shocks from above the solar surface to the upper corona. Coupling the expansion model to various models of the coronal magnetic field allowed us to derive the time-dependent distribution of shock Mach numbers and the magnetic connection of particles produced by the shock to the solar surface visible from Earth. The reconstructed shock fronts for three γ-ray events became magnetically connected to the visible solar surface after the start of the flare and just before the onset of the >100 MeV γ-ray emission. The shock surface at these connections also exhibited supercritical Mach numbers required for significant particle energization. The strongest γ-ray emissions occurred when the flanks of the shocks were connected in a quasi-perpendicular geometry to the field lines reaching the visible surface. Multipoint, in situ, measurements of SEPs were consistent with the production of these particles by the same shock processes responsible for the γ-rays. Using the observationally-derived shock properties as input parameters to a time-dependent diffusive-shock acceleration model we show that during the 17 May 2012 GLE event particles could have been accelerated by the shock to several hundreds of MeVs within minutes of the CME onset.
Salem, Chadi	***Wave-mode Identification in Kinetic-scale Turbulence in the Solar Wind at High Beta*** Chadi Salem, University of California Berkeley, USA John Bonnell, University of California Berkeley, USA Elizabeth Hanson, University of California Berkeley, USA Kristopher Klein, University of Michigan, USA Catherine Lacombe, Observatoire de Paris-Meudon, France Daniel Verscharen, University College of London, UK We present here an analysis of kinetic-scale electromagnetic fluctuations in the solar wind based on data analysis from ARTEMIS spacecraft. We focus on an interval characterized by a high plasma beta. We compute parameters such as the electric to magnetic field ratio, the magnetic compressibility, magnetic helicity, and other relevant quantities in order to diagnose the nature of the fluctuations at those scales between the ion and electron cyclotron frequencies, extracting information on the dominant modes composing the fluctuations. We also use the linear Vlasov-Maxwell solver, PLUME, to determine the various relevant modes of the plasma with parameters from the observed solar wind intervals. We discuss the results and the relevant modes as well as the differences between low and high beta regimes.

Schlickeiser, Reinhard	***Magnetization of the Early Universe by Dark Aperiodic Fluctuations*** R. Schlickeiser, Ruhr-University Bochum, Germany O. Kolberg, Ruhr-University Bochum, Germany P. H. Yoon, University of Maryland, USA During the past myon and prior electron-positron annihilation epoch of the early universe the electron-positron pair number density was very high as the pairs were in thermal equilibrium with the intense superluminal photons at temperatures $k_BT>1$ MeV. With classical plasma fluctuation theory it is shown that these pairs generate random electric and magnetic fields in the form of collective damped aperiodic fluctuations with very high tera-Gauss strengths on spatial scales greater than $L\simeq 10^{-10}$(1 MeV$/k_BT)$ cm with 100 percent volume filling factor. The associated field decay with time by damping is compensated by their perpetually reexcitation due to the spontaneous emission by the pairs to maintain a lasting fluctuation level. Transverse aperiodic fluctuations exist as 4th collective eigenmode in any unmagnetized isotropic fully-ionized plasmas besides the well-known transverse superluminal electromagnetic waves, longitudinal subluminal electrostatic waves and longitudinal ion sound waves. These aperiodic fluctuations can be regarded as the stable counterpart of the well-established Weibel (1959) and filamentation (Fried 1959) instability. We also address observational consequences and the fate of the aperiodic fluctuations at the later nonrelativistic ($k_BT<1$ MeV) phase of the universe when the electron-positron pairs have annihilated into photons, so that the universe consists of neutrons and a nonrelativistic electron-proton plasma, surviving due to baryon asymmetry, with number densities $n_m=10^{-9}n_{\gamma }$.
Schwadron, Nathan	***Effects of Solar Activity on the Local Interstellar Magnetic Field Observed by Voyager 1 and IBEX*** N. A. Schwadron, University of New Hampshire, USA D. J. McComas, Princeton University, USA Interstellar Boundary Explorer (IBEX) observations have shown enhanced energetic neutral atom (ENA) emission from a narrow, circular ribbon likely centered on the direction of the magnetic field in local interstellar medium (LISM). IBEX observations are compared to Voyager 1's direct observations of the magnetic field in the LISM, which reveals structured changes shown here to be driven by pressure fluctuations transmitted across the heliopause boundary separating the LISM from the shocked solar wind beyond the termination shock. The changes in the local interstellar magnetic field observed by Voyager 1 occurred in years 2015 and 2016 when the most powerful coronal mass ejections released from the Sun over the last 11-year solar cycle arrived in the outer heliosphere. These events propagated over more than two years through the solar system, ultimately pounding the heliopause and causing transient deviations of the magnetic fields detected by Voyager 1 in the LISM. Thus, we identify the response in pressure variations at Voyager 1 in the LISM to the activity of major solar events several years earlier, during the most active period of the last solar maximum.
Shay, Michael	***Magnetic Reconnection during Turbulence and the Role it Plays in Dissipation and Heating*** M. A. Shay, University of Delaware, USA C. C. Haggerty, University of Chicago, USA W. H. Mattheus, University of Delaware, USA T. N. Parashar, University of Delaware, USA M. Wan, South Univ. of Science and Technology of China, China P. Wu, Queens University, Ireland Magnetic reconnection is a ubiquitous plasma phenomenon that has been observed in turbulent plasma systems. It is an important part of the turbulent dynamics and heating of space, laboratory and astrophysical plasmas, and is believed to play a role in heating both the solar corona and the solar wind. Recent simulation and observational studies have detailed how magnetic reconnection heats plasma and this work has developed to the point where it can be applied to larger and more complex plasma systems. First, we will lay out a framework for applying reconnection heating predictions to turbulent systems, and show initial results for testing this framework using fully kinetic PIC simulations. Second, we will examine the statistics of magnetic reconnection in these kinetic simulations of turbulence. By statistics, we mean the number of x-lines, the spread of reconnection rates, and how these quantities vary in time. Initial results indicate that the distribution of reconnection rates is broader than the MHD counterpart, and the average value is approximately 0.1. There is significant variation in the the statistics of x-lines as the simulations progress, however. Finally, we will examine how the reconnection statistics and heating vary with plasma parameters and turbulence conditions.

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ORAL ABSTRACTS

Slavin, Jonathan	***Heating the Local Interstellar Cloud*** Jonathan Slavin, Harvard-Smithsonian Center for Astrophysics, USA The Local Interstellar Cloud (LIC) is the region of the interstellar medium (ISM) that surrounds and helps to shape the heliosphere. Observations of energetic neutral He atoms by the IBEX mission and Voyager have constrained the temperature of the LIC to be roughly 7500 K. This temperature is consistent with that derived from absorption line measurements toward nearby stars. Such observations also indicate that the LIC is partially ionized with elemental abundances consistent with a moderate level of depletion onto dust grains as might occur for low density ISM that has been subject to a shock that partially destroyed the dust. The temperature of the cloud is not unusal for the warm ionized medium in the ISM, but it is less ionized than typical. Also, the radiation field is expected to be less intense and harder than for typical warm ionized medium. Modeling the ionization and heating of the LIC allows for solutions that match the observations but the situation could be considerably more complex than the steady state solutions presented previously. We discuss the various processes that may be important for heating the LIC as well as new magneto-hydrodynamical calculations of the evolution of the local ISM.
Smith, Charles	***Correlation Scales of the Turbulent Cascade at 1 AU*** Charles W. Smith, University of New Hampshire, USA Bernard J. Vasquez, University of New Hampshire, USA Jesse T. Coburn, Universita della Calabria, Italy Miriam A. Forman, State University of New York at Stony Brook, USA Julia E. Stawarz, Imperial College London, United Kingdon The common view of the turbulent cascade as derived from the early theories of Kolmogorov and through many of the most recent treatments is based on a computation of the average energy cascade. This means there is an attempt to provide a description of the time- or ensemble-average of the dynamics. These theories provide a view of turbulence as a continuous, steady transport of energy between the spatial scales. The notable exception to this view is the recognition that intermittency plays a role in the dynamics, but that role is not well understood. Our most recent applications of third-moment theory to solar wind observations have revealed a highly variable cascade that only fits the above theories in so far as the time- or ensemble-average of the estimates produces a positive cascade from large to small scales that agrees with local proton heating. In this new analysis we analyze the spatial scales for the variation of the energy cascade associated with inertial range dynamics. We find that the cascade dynamics decorrelate on the scale of interest: the cascade dynamics associated with fluctuations seen at 30-min in spacecraft data decorrelate in less than 30 minutes of data while the dynamics associated with fluctuations seen at 5-min decorrelate in less than 5 minutes of data. This suggests a significant lack of scale-spanning, coherent dynamics and a highly unsteady cascade where the turbulence consists of independent local dynamics that transport energy at a greater rate than conventional theory predicts only to agree with that theory after an ensemble average is taken.
Sokol, Justyna	***Solar Modulation of Interstellar Neutral Gas Species Inside the Heliosphere*** Justyna M. Sokol, Maciej Bzowski, Marzena A. Kubiak, Izabela Kowalska-Leszczynska Space Research Centre Polish Academy of Sciences (CBK PAN), Poland The solar wind plasma, which flows outward from the Sun, creates a cavity in the local interstellar medium known as a heliosphere. The boundary regions of the heliosphere, where the interstellar medium interacts with the solar medium, are a valuable source of information about both the interstellar environment around the Sun and the heliosphere itself. These can be studied directly or indirectly. Missions like Voyagers or New Horizons provide the information by in-situ measurements at far distances from the Sun. Missions deep inside the Solar System provide either in situ sampling of interstellar neutral (ISN) gas particles that have penetrated close to the Sun or remote-sensing of distant regions via particles that are a results of the interaction, like energetic neutral atoms (ENAs) or pick-up ions (PUIs). In this study we focus on the solar modulation of ISN gas and its derivative particles inside the heliosphere. The ISN gas that has entered freely inside the heliosphere becomes gradually modulated by the solar output within a few astronomical units from the Sun. It is ionized by the solar wind particles (via charge exchange with solar wind protons or impact by solar wind electrons) and solar extreme ultraviolet radiation. Additionally, in the case of ISN H and D, it is altered by the solar resonant radiation pressure in the Lyman-alpha line. Both solar wind plasma and solar EUV radiation evolve with the solar activity. We show an overview of the solar modulation of the ISN Hydrogen, Helium, Oxygen, Neon, and Deuterium at the solar distances up to 5 au. In the study we use the so-called hot model of ISN gas distribution in the heliosphere with an observation-based model of ionization factors. We present the distribution of density of the ISN gas as well as expected distribution of the PUIs created by interaction between the ISN gas and the solar output and their modulation with the solar activity. Additionally, we discuss the most preferable locations in space and moments during the solar activity cycle to observe the PUIs of different ISN gas species.

Sterling, Alphonse	***Solar Coronal Jets, and the Jet-CME Connection*** Alphonse Sterling, NASA/MSFC, USA Coronal jets are transient, long and relatively narrow features (typical values: lifetimes: 10 min; lengths: 50,000-100,000 km, widths: 10,000 km) seen in EUV and X-rays that shoot out from the solar surface and into the corona. While it is clear that these jets are magnetically driven, the details of the process has recently been updated. Previously it was suspected that the jets were a consequence of magnetic flux emergence interacting with ambient coronal fields. New evidence however indicates that often the direct driver of the jets is erupting fields, often carrying cool material ("minifilaments"), that undergoes interchange reconnection with preexisting field (Sterling et al. 2015, Nature). More recent work indicates that the trigger for eruption of the minifilaments is frequently cancelation of photospheric magnetic fields at the base of the minifilaments. These erupting minifilaments are analogous to the better-known larger-scale filament eruptions that produce solar flares and, frequently, coronal mass ejections (CMEs). A subject of coronal jets drives narrow "white-light jets," which are very narrow CME-like features, and apparently a few jets can even drive bonafide (although relatively weak) CMEs. In this presentation we will summarize these recent findings. This work was supported by funding from NASA Heliophysics, and the MSFC Hinode project.
Swaczyna, Pawel	***Modeling the Evolution of the IBEX Ribbon's Position due to the Solar Cycle Variation of the Solar Wind Structure*** Pawel Swaczyna, Space Research Centre PAS, Poland Maciej Bzowski, Space Research Centre PAS, Poland Justyna M. Sokol, Space Research Centre PAS, Poland We model the evolution of the position of the IBEX ribbon in the sky during the solar cycle using a semi-analytic model of the secondary Energetic Neutral Atom (ENA) mechanism. In this mechanism, the position of the IBEX ribbon marks regions in the sky where the interstellar magnetic field draped around the heliosphere is approximately perpendicular to the line-of-sight. However, the positions of the IBEX ribbon in different energy steps, revealed by the centers of circles or ellipses fitted to the ribbon circumference, show a monotonic shift by ~10° within the IBEX-Hi energy range. We recently showed that accounting for the helio-latitudinal structure of the solar wind can explain this shift. It is because the solar wind structure is also reflected in ENAs forming the neutralized supersonic solar wind, which is the main component of the primary ENA flux input to the secondary ENA mechanism. Here, we extend our modeling to include time-evolution of the solar wind during the solar cycle. We account for the time-delay between the solar wind emission and the observation of the secondary ENAs. We find that the resulting positions of the centers of the ribbon evolve accordingly. The model positions of the centers of ribbon's circles change by up to ~2° during the solar cycle. The smallest changes are expected for the energy step of 1.7 keV, i.e., for the energy where the expected flux of the supersonic solar wind is the most uniform in heliographic latitude. The modeled amplitudes of the ribbon center variation are larger for higher and lower energies.
Tang, Bofeng	***Numerical Modeling of Electron Transport in Whistler Turbulence*** B. Tang, University of Alabama in Huntsville, USA G. P. Zank, University of Alabama in Huntsville, USA V. Kolobov,CFD Research Corporation, USA The electron distribution function in the solar wind deviates from an equilibrium Maxwellian distribution, and is comprised of a Maxwellian core, a suprathermal halo, a field-aligned component strahl, and a higher energy superhalo. Charged particle Coulomb collisions are ineffective in relaxing such a velocity distribution beyond a few solar radii. Therefore wave-particle interactions need to be considered. We introduce a wave-particle interaction term into the kinetic equation that describes the interaction of electrons with whistler waves (Kim et al 2015), as well particle collision terms. The kinetic equation has a form of an advection-diffusion-like equation in which the advection and diffusion coefficients describe the scattering and drag of electrons in whistler turbulence. We have developed a reliable numerical method to solve a full form of the advection-diffusion-like kinetic equation. Some preliminary applications of our numerical method to the solar wind electron problem will be presented.

TenBarge, Jason	***Diagnosing Heating and Energy Transfer in Collisionless Kinetic Plasmas*** Jason TenBarge, Princeton University, USA James Juno, University of Maryland, USA Turbulence in a magnetized plasma is a primary mechanism responsible for transforming energy at large injection scales into small-scale motions, which are ultimately dissipated as heat in systems such as the solar corona, wind, and other astrophysical objects. Identifying the mechanisms responsible for the transfer of energy from the fields to the particles and the eventual heating that occurs has been a long standing problem, and several novel diagnostics have recently been introduced to the community to address this problem. We will present a discussion of two of these diagnostics: the field particle correlation and the “deviatoric” stress. Through a combination of fully kinetic Eulerian Vlasov-Maxwell, hybrid kinetic particle-in-cell, and gyrokinetic simulations of Landau damped waves, shocks, and turbulence, we will present analyses and comparisons of these two diagnostics. At present, it appears that both diagnostics provide unique access to particle energization information but neither approach provides a complete picture.
Terasawa, Toshio	***From the Heliosphere to Pulsar Magnetospheres, and Beyond*** Toshio Terasawa, RIKEN, Japan The famous serendipitous discovery of radio pulsars, rapidly rotating neutron stars, was made during the pioneering work of interplanetary scintillation by Prof. Hewish. On the theoretical side, the concept of magnetospheres based of the studies of planetary magnetospheres in the heliosphere was the key to understand the physics of pulsars. As such, there has been close interplay between the heliospheric and pulsar studies. In this review, I will talk about several topics of pulsar magnetospheres in which I myself was involved. In addition I will touch on the latest enigma about 'fast radio bursts', which show some resemblances to pulsars' emission but are believed to occur at cosmological distance in extreme physical environments.
van Ballegooijen, Adriaan	***The Heating of Coronal Loops in Solar Active Regions*** A. A. van Ballegooijen, Center for Astrophysics, USA M. Asgari-Targhi, Center for Astrophysics, USA The active region corona is believed to be heated by magnetohydrodynamic (MHD) waves or other magnetic disturbances that propagate into the corona from the convection zone below. However, the details of energy transport and dissipation are not well understood. In this talk we review two popular mechanisms: Alfven waves and braided magnetic fields. We present results from recent modeling of magnetic disturbances in coronal loops using a reduced MHD model. Waves are launched from a collection of kilogauss flux tubes in the photosphere at the two ends of the loop, and we investigate how the waves from neighboring flux tubes interact in the chromosphere and corona. We find that Alfven wave turbulence can produce enough heat to maintain a peak temperature of about 2.5 MK with only small deviations from the potential field. The heating rates vary strongly in space and time, but the heating events are not strong enough to produce the observed higher temperature loops. An alternative magnetic braiding model is considered in which the coronal field lines are subject to slow random footpoint motions, but we find that such long period motions produce much less heating than the shorter period waves launched within the flux tubes. We discuss several possibilities for resolving the problem of producing sufficiently hot loops in active regions.
van der Holst, Bart	***Validation of a Three Temperature, Alfvenic Turbulence Solar Wind Model*** Bart van der Holst, University of Michigan, USA Judit Szente, University of Michigan, USA Chip Manchester, University of Michigan, USA We present the Alfven Wave Solar atmosphere Model (AWSoM): a global model for the corona and inner heliosphere. The coronal heating and solar wind acceleration are addressed with low-frequency Alfven wave turbulence. The partial wave reflection by the Alfven speed gradients is taken into account. The resulting counter-propagating waves lead to nonlinear turbulent cascade. This model includes three temperatures: electron temperature and anisotropic proton temperatures, while the firehose, mirror, and ion cyclotron instabilities due to the developing temperature anisotropy are addressed. The model performance is demonstrated via a validation study using WIND/ACE data, spectra, as well as line-of-sight EUV images.

Viall, Nicholeen	***The Formation of the Slow Solar Wind and the Ground State Space Weather*** Nicholeen Viall, NASA/GSFC, USA Larry Kepko, NASA/GSFC, USA Spiro Antiochos, NASA/GSFC, USA Angelos Vourlidas, JHU/APL, USA Sue Lepri, University of Michigan, USA Aleida Higginson, University of Michigan, USA Jon Linker, Predictive Science Inc., USA We present an analysis of mesoscale solar wind structures and show that they are tracers of slow solar wind formation. We analyze remote white light observations of the young solar wind, just after it is released into the Heliosphere, and we analyze in situ L1 measurements to reveal an important connection between the dynamics of the corona and of the solar wind. We show observations of quasi-periodic plasma release into the heliosphere occurring throughout the corona - including regions away from the helmet streamer and heliospheric current sheet. Our results have critical implications for the magnetic topology involved in slow solar wind formation and magnetic reconnection dynamics. We conclude that magnetic reconnection is an inherent aspect of slow solar wind formation. It produces ubiquitous mesoscale plasma structures throughout the slow solar wind. Though much smaller than coronal mass ejections or co-rotating interaction regions, the mesoscale slow solar wind structures are ever-present, and constantly impact the magnetosphere. The slow solar wind and embedded structures are therefore the ground state space weather- both a driver of smaller-scale, but ubiquitous geospace dynamics, as well as the medium through which large solar storms propagate.
Wang, Linghua	***The Electron Acceleration by ICME-driven Shocks at 1 AU*** Linghua Wang, Peking University, China We present two case studies of the in situ electron acceleration at the 11 February 2000 shock and the 22 July 2004 shock with the strongest electron flux enhancement at 40 keV across the shock, respectively, among all the quasi-perpendicular and quasi-parallel ICME-driven shocks observed by the WIND 3DP instrument from 1995 through 2014 at 1 AU. We find that for this quasi-perpendicular (quasi-parallel) shock on 11 February 2000 (22 July 2004), the shocked electron differential fluxes at ~0.4-50 keV in the downstream generally fit well to a double-power-law spectrum, J ~ E^{-beta}, with an index of beta ~ 3.15 (4.0) at energies below a break at ~3 keV (~1 keV) and of beta ~ 2.65 (2.6) at energies above. For both shock events, the downstream electron spectral indices appear to be similar for all pitch angles, significantly larger than the index prediction by diffusive shock acceleration. In addition, the downstream electron pitch-angle distributions show the anisotropic beams in the anti-sunward traveling direction, while the ratio of the downstream over ambient fluxes appears to peak near 90 deg pitch angles, at all energies of ~0.4-50 keV. These results suggest that in both shocks, shock drift acceleration likely plays an important role in accelerating electrons in situ at 1 AU. Such ICME-driven shocks could contribute to the formation of solar wind halo electrons at energies <~2 keV, as well as the production of solar wind superhalo electrons at energies >~2 keV, in interplanetary space.
Weidl, Martin	***The Resonant Right-Hand Instability in the Large Plasma Device*** Martin S. Weidl, UCLA, USA Peter V. Heuer, UCLA, USA Robert S. Dorst, UCLA, USA Derek B. Schaeffer, UCLA/PPPL, USA Carmen G. Constantin, UCLA, USA Christoph Niemann, UCLA, USA Dan Winske, LANL, USA Parallel collisionless shocks like the Earth's bow shock are formed when two ion-beam instabilities non-linearly interact, the non-resonant instability (NRI) and the resonant right-hand instability (RHI). A detailed understanding of how these instabilities saturate is therefore indispensable in order to model the behavior of astrophysical environments such as planetary bow shocks or supernova-remnant shocks. Our efforts to create a parallel collisionless shock in a laboratory experiment have yielded high-resolution measurements of the RHI inside the 17-meter LAPD plasma. After an overview of the three theoretical parameter regimes for parallel ion-beam instabilites and their respective saturation mechanisms, we present the growth and propagation of the RHI at LAPD.

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ORAL ABSTRACTS

Wiedenbeck, Mark	***Fractionation Patterns in Impulsive SEP Events Above ~5 MeV/nuc*** M. E. Wiedenbeck, JPL/Caltech, USA C. M. S. Cohen, Caltech, USA R. A. Leske, Caltech, USA Extensive measurements over the past four decades established that composition in impulsive solar energetic particle events is typically characterized by orders of magnitude enhancements of 3He/4He relative to the solar wind value and by elemental abundance enhancements that increase monotonically with increasing atomic number, Z. The Fe/O ratio is commonly ~10x the value found in the solar wind. At the 7th AIAC, Wiedenbeck et al. (AIP CP1039, 149, 2008) reported composition observations above ~5 MeV/nuc in some of the largest impulsive SEP events of solar cycle 23. Those observations showed a number of clear, systematic deviations from the general monotonic dependence on Z. We are now extending that earlier study to include events from solar cycle 24. We will report the compositional trends observed in these new data and compare with the earlier work.
Wood, Brian	***The Solar Wind When the Sun was Young*** Brian E. Wood, Naval Research Laboratory, USA I will discuss the question of what the solar wind was like in the distant past, and how the solar wind and its analogs around other coronal stars evolve with time. This issue has become increasingly important with the discovery of thousands of exoplanets around nearby stars, many of which orbit very close to their parent stars and are therefore presumably exposed to winds much stronger than that seen by Earth simply due to close proximity. It is commonly assumed that when the Sun was young and more coronally active the solar wind would have been correspondingly stronger, and perhaps dominated by CMEs associated with flares that would have been much more frequent and energetic. Very strong winds and/or frequent CME shocks could potentially destroy or at least diminish the habitability of planets, either through atmospheric erosion or through the generation of harmful SEP radiation. However, constraints on stellar winds from astrospheric Lyman-alpha absorption suggest that young and active stars actually do not have strong winds or frequent massive CMEs. In particular, the 500 Myr old young solar analog Pi1 UMa and the notoriously active flare star EV Lac are not found to have strong winds, regardless of whether these stars' winds are quiescent or CME-dominated. The Sun itself has recently provided evidence that the flare-CME connection can fail, as the largest active region in the past 20 years (AR12192 from 2014 October) produced many strong flares but few CMEs.
Zank, Gary	***Theory and Transport of Nearly Incompressible Magnetohydrodynamic Turbulence in the Solar Corona*** G.P. Zank, University of Alabama in Huntsville, USA L. Adhikari, University of Alabama in Huntsville, USA P. Hunana, University of Alabama in Huntsville, USA S.K. Tiwari, Lockheed Martin Solar and Astrophysics Laboratory, USA R. Moore, University of Alabama in Huntsville, USA D. Shiota, Nagoya University, Japan R. Bruno, INAF-IAPS Instituto di Astrofisica e Planetologia Spaziali, Italy D. Telloni, INAF - Astrophysical Observatory of Torino, Italy A new model describing the transport and evolution of turbulence in the quiet solar corona is described. In the low plasma beta environment, transverse photospheric convective fluid motions drive predominantly quasi-2D (non-propagating) turbulence in the mixed polarity “magnetic carpet,” together with a minority slab (Alfvenic) component. We use a simplified sub-Alfvenic flow velocity profile to solve transport equations describing the evolution and dissipation of turbulence from 1 - 15 Rs (including the Alfven surface). Typical coronal base parameters are used, although one model uses correlation lengths derived observationally by Abramenko et al. 2013, and the other assumes values 10 times larger. The model predicts that 1) the majority quasi-2D turbulence evolves from a balanced state at the coronal base to an imbalanced state, with outward fluctuations dominating, at and beyond the Alfven surface, i.e., inward turbulent fluctuations are dissipated preferentially; 2) the initially imbalanced slab component remains imbalanced throughout the solar corona, being dominated by outwardly propagating Alfven waves, and wave reflection is weak; 3) quasi-2D turbulence becomes increasingly magnetized, and beyond ~6 Rs, the kinetic energy is mainly in slab fluctuations; 4) there is no accumulation of inward energy at the Alfven surface; 5) inertial range quasi-2D rather than slab fluctuations are preferentially dissipated within ~3 Rs, and 6) turbulent dissipation of quasi-2D fluctuations is sufficient to heat the corona to temperatures ~2 million degrees K within 2 Rs, consistent with observations that suggest the fast solar wind is accelerated most efficiently between ~2 - 4 Rs.

Zhao, Lingling	***Influence of Solar Activity on Turbulence Properties and Cosmic Ray Mean Free Path*** L.-L. Zhao, University of Alabama in Huntsville, USA L. Adhikari, University of Alabama in Huntsville, USA G. P. Zank, University of Alabama in Huntsville, USA Q. Hu, University of Alabama in Huntsville, USA X. S. Feng, National Space Science Center, Chinese Academy of Sciences, China The solar cycle dependence of various turbulence quantities and cosmic ray (CR) mean free path at 1 au is investigated by using OMNI 1 minute resolution data over 22 years. We calculate magnetic field turbulence energy and correlation lengths for both the inwardly directed HMF and outwardly directed HMF. Based on these observed turbulence quantities, we study the influence of solar activity on CR parallel and perpendicular diffusion using QLT and NLGC theory, respectively. The radial and rigidity dependence of CR mean free path is also evaluated on the basis of a recently developed 2D and slab turbulence model using nearly incompressible theory. We find that in the ecliptic plane at 1 au (1) the fluctuating magnetic energy, residual energy, and the corresponding correlation functions all have an obvious solar cycle dependence; (2) the correlation length for magnetic fluctuations does not show significant solar cycle variation; (3) high levels of turbulent fluctuations will increase CR perpendicular diffusion and decrease parallel diffusion; (4) beyond ~10 au, pickup-ion-driven turbulence is the most important factor in determining the various mean free path since stream interaction weaken with increasing heliocentric distance; (5) the rigidity dependence of the parallel mean free path is proportional to P^0.33 from 10 to 1000 MV. In contrast, the perpendicular mean free path is weakly influenced by CR rigidity.
Zharkova, Valentina	***Particle Acceleration in 3D Current Sheets with Multiple O and X Null Points*** V.V. Zharkova and Q.Xia, Northumbria University, UK We investigate particle acceleration in 3D RCSs containing multiple O and X-null points. The inclusion of multiple O-null points, or magnetic islands, combined with different dynamics (coalescent or squashed islands) reveals the following points: a) acceleration of protons and electrons in the current sheet with multiple X nullpoints, or magnetic islands associated with O-nulls with a strong guiding field remain asymmetric towards the midplane; b) both types of particles mainly gain energy either in a vicinity of X-null points or inside O-null points, depending on the initial energy of particles; c) particles can escape O-null points, or magnetic islands, only through the neighbouring X-null points; d) as result, electron clouds are formed about the X-nullpoints betweenO-nullpoints; e) eparticles can gain relativistic energy in a single O-nullpoint; and f) particles escape from an RCS along the midplane. The energy gains in coalescent O-nullpoints are smaller than from the squashed ones. Electrons are shown to form clouds about X-nullpoints between the O-nullpoints. Particle acceleration signatures in 3D current sheets with multiple X and O-null points are probed with observational features in the solar corona and heliosphere.
Zirnstein, Eric	***The Role of Pickup Ion Dynamics Outside of the Heliopause in the Limit of Weak Pitch Angle Scattering: Implications for the Source of the IBEX Ribbon*** E. J. Zirnstein, Princeton University, USA J. Heerikhuisen, University of Alabama in Huntsville, USA M. A. Dayeh, Southwest Research Institute, USA We present a new model of the Interstellar Boundary Explorer (IBEX) ribbon based on the secondary energetic neutral atom (ENA) mechanism, under the assumption that there is negligible pitch angle scattering of pickup ions (PUIs) outside the heliopause. Using the results of an MHD-plasma/kinetic-neutral simulation of the heliosphere, we generate PUIs in the outer heliosheath, solve their transport using guiding center theory, and compute ribbon ENA fluxes at 1 AU. We implement several aspects of the PUI dynamics, including (1) parallel motion along the local interstellar magnetic field (ISMF), (2) advective transport with the interstellar plasma, (3) the mirror force acting on PUIs propagating along the ISMF, and (4) betatron acceleration of PUIs as they are advected within an increasing magnetic field towards the heliopause. We find that ENA fluxes at 1 AU are reduced when PUIs are allowed to move along the ISMF, and ENA fluxes are reduced even more by the inclusion of the mirror force, which pushes particles away from IBEX lines-of-sight. Inclusion of advection and betatron acceleration do not result in any significant change in the ribbon. Interestingly, the mirror force reduces the ENA fluxes from the inner edge of the ribbon more than its outer edge, effectively reducing the ribbon’s width by about 6 deg. and increasing its radius projected on the sky. This is caused by the asymmetric draping of the ISMF around the heliopause, such that ENAs from the ribbon’s inner edge originate closer to the heliopause, where the mirror force is strongest.