ISSI Workshop on Magnetic Switchbacks in the Young Solar Wind

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Abstracts of short (contributed) presentations

Agapitov, Oleksiy

Switchback Evolution Reflected in Dynamics of the Alfvénicity and Plasma Parameters: Numerical Model and Parker Solar Probes Observations

A generation mechanism of SBs is supposed to be through magnetic reconnection between open and closed magnetic flux in the solar corona, termed interchange reconnection that leads to the injection of flux ropes (FR) into the solar wind. The interaction of FRs (merging, which leads to their transforming into SB observed in the solar wind) during their propagation with the solar wind is explored by making use of the direct observations by PSP, analytic analysis, and numerical simulations. The direct consequences of FRs' merging are (1) the resulting dominance of the axial magnetic field within SBs; (2) the observed characteristic sharp rotation of the magnetic field direction (along the geometrical SB axis) at the SB boundary; (3) intensifying the axial plasma flow; (4) increase of the proton temperature and proton temperature anisotropy inside SB; (5) increase of Alfvénicity of the perturbation inside SBs. The indirect consequence is a significant decrease of the SBs' number occurrence rate from 20 RS to 30 RS with almost independence of the occurrence rate on the heliocentric distance above 30 RS.

Akhavan-Tafti, Mojtaba

Magnetic Switchbacks Heat the Solar Corona

Magnetic switchbacks are short magnetic field reversals ubiquitously observed in the solar wind. The origin of switchbacks remains an important open science question, because of switchbacks' possible role in the heating and acceleration of the solar wind. Here, we report observations of 501 robust switchbacks, using magnetic and plasma measurements from the first eight encounters by the Parker Solar Probe. More than 46% (6%) of switchbacks are rotational (tangential; TD) discontinuities (RD), defined as magnetic discontinuities with large (small) relative normal components of magnetic field and proton velocity. Magnetic reconnection in the solar atmosphere can be a source of the observed RD-type switchbacks. It is discovered that: (1) the RD-to-TD ratio exponentially decays with increasing heliocentric distance at rate 0.06 [R_S^{-1}], and (2) TD-type switchbacks contain 64% less magnetic energy than RD-type switchbacks, suggesting that RD-type switchbacks may relax into TD-type switchbacks. It is estimated that relaxing switchbacks generated via magnetic reconnection in the solar atmosphere can transfer an additional 16% of the total reconnected magnetic energy into heating and/or accelerating the solar corona, within 11.6 [R_S] of the reconnection site, below the critical Alfvén surface.

Badman, Samuel

Establishing a consensus: The time is right for a systematic review of switchback literature

There are now five years of observations of sub-0.3 AU switchbacks and an enormous body of literature studying their properties. However, definitions of what constitutes a switchback vary and this makes cross-comparing statistical trends difficult. Specifically, definitions are made according to metrics including but not limited to maximum rotational displacement of the magnetic field (e.g. Dudok de Wit+2020, Jagarlamudi+2023) sometimes on a continuous basis and sometimes with some minimum displacement threshold e.g. a full reversal in polarity (e.g. Badman+2021) , the presence of correlated magnetic rotations and velocity spikes (equivalently high cross-helicity or alfvenicity, e.g. Kasper+2019, McManus+2020, Horbury+2020) , the indication of "switchback" topology itself via electron strahl (e.g. Kasper+2019, McManus+2020) and a sharp transition and extended switchback region (e.g. Kasper+2019, McManus+2020, Horbury+2020, Huang+2020a, Huang+2020b). Some of these definitions place switchbacks in a novel class of fluctuations never observed before, and some place them on a continuum with alfvenic fluctuations seen at 1au and beyond. I would like to propose a coordinated effort to take as many of these definitions as possible, generate resulting catalogs and determine the extent of overlap as well as identify which definitions constitute subsets of others. Further, statistical properties common to all definitions including the most restrictive should be distinguished from those which are generally true of Alfvenic fluctuations, to determine if there is a unique physical basis to near-Sun switchbacks as compared to when Alfvenic spikes are seen at larger heliocentric distances.

Badman, Samuel

Heating and Acceleration of the Solar Wind by Magnetic Switchbacks

It is well established that the solar wind is actively heated and accelerated after it escapes the closed-field corona. Parker Solar Probe's close proximity to the Sun enables fresh insight into these processes in newly formed solar wind. Recent observations from Parker Solar Probe reveal magnetic switchbacks, largely Alfvenic field rotations propagating as coherent patches are prevalent close to the Sun. Their substantially reduced energy content at larger heliocentric distances suggests their dissipation may be an important energy source for the solar wind. Through a spacecraft conjunction between Parker Solar Probe and Solar Orbiter, we examine the radial flow of a single stream to directly trace the evolution of a switchback patch across the inner heliosphere. We find the total energy flux dissipated from the patch is required to achieve conservation of energy between the two spacecraft. Further, we perform simple hydrodynamic modeling with a data-constrained external wave pressure force to quantify the portion of the energy flux transferred to mechanical work and find the remaining portion is substantial enough to sustain the polytropic cooling rate measured in the stream above adiabatic expansion. This implies switchbacks experience substantial non-linear damping and both drive and heat the fast solar wind. They are therefore key to understanding the solar wind's early development and heliospheric expansion.

Bale, Stuart

Do switchbacks drive an alpha dynamo in the solar wind?

I'll compare the evolution of EMF associated with switchbacks to the radial growth profile of the heliospheric magnetic field.

Bizien, Nina

Are Switchback boundaries observed by Parker Solar Probe all closed?

Our goal is to describe the boundary of switchbacks using a series of events detected during the spacecraft's first encounter with the Sun. Using FIELDS and SWEAP data, we investigate two methods, minimum variance analysis and singular value decomposition, to identify the type of discontinuities of each boundary. We find that the switchback boundaries are arc-polarized structures, with a rotation that is always contained in one plane. Most of these boundaries appear to have the same characteristics as tangential discontinuities in the context of switchbacks, with very few rotational discontinuities.

Bowen, Trevor

Mediation of Turbulent Dissipation via Cyclotron Resonance

Observations from the Parker Solar Probe mission in the inner heliosphere have shed new light on the role of ion-cyclotron waves (ICWs) in dissipating highly Alfvénic states. We show that ICWs provide a major pathway for dissipation and plasma heating in the solar wind for Alfvénic states and that in the absence of ICW, kinetic scale current sheets form. Our results support recent theoretical predictions of turbulence in the inner-heliosphere, known as the helicity-barrier, that suggest a role of cyclotron resonance in ion-scale dissipation. Taken together, these results provide important constraints for turbulent dissipation and acceleration efficiency in astrophysical plasmas.

Bowen, Trevor

Characteristics of Spherical Polarization in Alfvénic Turbulence

We characterize signatures of spherical polarization observed by PSP and their association with turbulent signatures. We demonstrate that the level of spherical polarization is associated with the spectral index of the turbulent fluctuations. We furthermore investigate distributions of rotational angles in spherically polarized turbulence. We show that the distribution of fluctuations at outer scales is consistent with random rotations of the magnetic field, while intermittency in the distribution of rotations emerges in the inertial range of scales.

Desai, Mihir

Spectral Properties of Suprathermal Ions Observed Near Perihelion of PSP encounters 6 and 10

We report observations of 100 keV/nucleon suprathermal (ST) H, He, O, and Fe ions in association with perihelia of PSP encounters 6 and 10. These specific intervals have been examined by Bale et al (2022; 2023) and interpreted in terms of interchange reconnection-driven processes that occur routinely in the solar corona and likely to be responsible for the acceleration of the fast solar wind. Here we examine the phase space densities from the solar wind energies through the ST regime and derive kappa indices to compare with predictions of models based on reconnection-driven mechanisms.

Drake, James

A turbulent solar wind driven by super-Alfvénic sheared flow instability

Analysis and simulations of a fast solar wind driven by interchange reconnection suggest that solar wind turbulence is dominantly driven by super-Alfvenic sheared flow and ion beam instabilities within the corona. The Parker Solar Probe (PSP) data close to the sun has revealed a bursty solar wind with a periodicity that matches the spatial periodicity of the magnetic field at the surface of the sun. This points to interchange reconnection within coronal holes as the driver of the fast wind. Because reconnection in the corona is expected to be bursty, a reconnection drive mechanism for the solar wind will be highly structured in space and time, which is consistent with PSP observations close to the sun. The bursty outflows from reconnection accelerate outward from the low corona while at the same time the local Alfven speed drops sharply because of the super-radial expansion of the magnetic field from coronal holes. The consequence is the development of sheared flows with velocity differences that greatly exceed the local Alfven speed. Simulations of this sheared flow reveal the development of strong turbulence that produces local reversals of the radial magnetic field, strong azimuthal magnetic field components and strong plasma heating. The resulting magnetic structure is reminiscent of the structure of switchbacks documented in the PSP data. The near absence of switchbacks during periods with sub-Alfvenic flow support this view of the switchback drive mechanism.

Dudok de Wit, Thierry

Switchbacks: gentle kinks or ragged field lines ?

One aspect of switchbacks that has received little attention is their self-similar structure, in the sense that there are many more small deflections of the magnetic field that the few large (and true) switchbacks. From the statistics of switchback properties we can now represent how the kinked magnetic field lines look like. They definitely do not look like gentle kinks, but rather like a ragged lines, which has direct implications on particle transport.

Fargette, Naïs

On the preferential orientation of magnetic switchbacks

In this work, we investigate the orientation of the magnetic field deflections in switchbacks to determine if they are characterised by a possible preferential orientation. We compute the deflection angles of the magnetic field relative to the theoretical Parker spiral direction for encounters 1 to 9 of the PSP mission. We model the total distribution of deflection angles we observe in the solar wind as a weighed sum of two distinct normal distributions, each corresponding to one of the population. This method allows us to quantify the properties of both the quiet solar wind and the switchback populations without setting an arbitrary threshold on the magnetic field deflection angles.

We find that the fitted switchback population presents a systematic bias in its deflections compared to the quiet solar wind population. This implies a marked preferential orientation of switchbacks in the clockwise direction in the ecliptic plane, and we discuss this result and its implications in the context of the existing switchback formation theories.

Fargette, Naïs

Magnetic reconnection in the solar wind and its interaction with switchback-like wind

Magnetic reconnection is a fundamental process in astrophysical plasma, as it enables the dissipation of energy at kinetic scales. Detecting it in-situ is therefore key to further our understanding of energy conversion in space plasma. We use a new approach to identify automatically reconnection exhausts in-situ. The method strongly relies on the Walén relation and uses Bayesian inference as well as physical considerations to detect reconnection jets in-situ. Applying the detection algorithm to one month of Solar Orbiter data at 0.7 AU, and at 0.3 AU, we show that the occurrence rate of magnetic reconnection tends to increase with radial distance. Interestingly, we show that magnetic reconnection has a much lower occurrence in highly alfvenic wind, i.e. in switchback-like solar wind, consistent with PSP observations. The reason of this decreased occurrence of reconnection in switchback patches is still being investigated and up for discussion.

Gannouni, Bahaeddine

Modelling the formation and evolution of solar wind microstreams: from coronal plumes to propagating Alfvénic velocity spikes

We investigate the origin of mesoscale structures in the solar wind called microstreams defined as enhancements in solar wind speed and temperature that last several hours. They were first clearly detected in Helios and Ulysses solar wind data and are now omnipresent in the 'young' solar wind measured by Parker Solar Probe and Solar Orbiter. These recent data reveal that microstreams transport a profusion of Alfvénic perturbations in the form of velocity spikes and magnetic switchbacks. In this study we use a very high-resolution 2.5 MHD model of the corona and the solar wind to simulate the emergence of magnetic bipoles interacting with the pre-existing ambient corona and the creation of jets that become microstreams propagating in the solar wind. Our high-resolution simulations reach sufficiently high Lundquist numbers to capture the tearing mode instability that develops in the reconnection region and produces plasmoids released with the jet into the solar wind. Our domain runs from the lower corona to 20 Rs, this allows us to track the formation process of plasmoids and their evolution into Alfvénic velocity spikes. We obtain perturbed solar wind flows lasting several hours with velocity spikes occurring at characteristic periodicities of about 19 minutes. We retrieve several properties of microstreams measured in the pristine solar wind by Parker Solar Probe, namely an increase in wind velocity of about 100 km/s during the stream's passage together with superposed velocity spikes of also about 100 km/s released into the solar wind.

Horbury, Tim

Switchback Deflections Beyond the Early Parker Solar Probe Encounters

Switchbacks are Aflvénic fluctuations in the solar wind, which exhibit large rotations in the magnetic field direction. Observations from Parker Solar Probe's (PSP's) first two solar encounters have formed the basis for many of the described switchback properties and generation mechanisms. However, this early data may not be representative of the typical near-Sun solar wind, biasing our current understanding of these phenomena. One defining switchback property is the direction in which the magnetic fields deflects as the spacecraft samples them. During the first solar encounter, this was primarily in the tangential direction for the longest switchbacks, which has since been discussed as evidence, and a testable prediction, of several switchback generation methods. In this study, we re-examine the deflection direction of switchbacks during the first eight PSP encounters to confirm the existence of a systematic deflection direction. We first identify switchbacks exceeding a threshold deflection in the magnetic field and confirm a previous finding that they are arc-polarized. In agreement with earlier results from PSP's first encounter, we find that groups of longer switchbacks tend to deflect in the same direction for several hours. However, in contrast to earlier studies, we find that there is no unique direction for these deflections, although several solar encounters showed a non-uniform distribution in deflection direction with a slight preference for the tangential direction. This result suggests a systematic magnetic configuration for switchback generation, which is consistent with interchange reconnection as a source mechanism, although this new evidence does not rule out other mechanisms, such as the expansion of wave modes.

Horbury, Tim

Evolution of switchbacks into microstreams and broadband turbulence

Radial line-ups between Parker and Solar Orbiter allow us to study how switchbacks evolve towards 1 AU. We present one such example and show that the switchback patches evolve into large scale fluctuations which might provide a driver for MHD turbulence.

Huang, Nengyi

Observation of Mini-Filament Eruption As Possible Source of Small Scale Turbulence in Solar Wind

The omnipresence of transient fluctuations in the solar wind, such as switchbacks (SBs) and small-scale magnetic flux ropes (SMFRs) have been well observed by the in-situ observation of Parker Solar Probe (PSP), yet their sources are not clear. Possible candidates fall into two categories: solar origin and in-situ generation in the solar wind. Among the solar-origin scenarios, small-scale activities (such as ejections and eruptions) in coronal hole (CH) regions, where solar wind originates, are suggested as candidates. Using full-disk extreme ultraviolet images from Atmospheric Imaging Assembly on board Solar Dynamic Observatory, we identify small-scale ejections in CH regions during PSP Encounters and statistically studied the occurrence of coronal ejections and mini-filament and suggested the small-scale ejections from the solar surface to be possible candidates of the SMFRs. Meanwhile, in the calculated source region of solar wind probed by PSP, we observed the mini-filament eruptions corresponding to the coronal ejections using high-resolution observations from Goode Solar Telescope (GST) and studied such ejections from the chromosphere to the corona.

Karpen, Judy

New Evidence on the Origin of Solar Wind Switchbacks

We investigated periodicities in the radial speed at PSP during Encounter 10, when the mission dove toward a small region of a coronal hole. In tandem, we analyzed time series of the emission intensities of jetlets at the base of plumes magnetically connected to PSP. We found the same periods in both data sets. These and other observed characteristics indicate that quasiperiodic jets powered by interchange reconnection at plume bases and larger bright points are the most likely solar sources of the switchbacks.

Larosa, Andrea

The relation between Switchbacks and Turbulence

We investigate the relation between turbulence and magnetic field switchbacks in the inner heliosphere below 0.5 AU in a distance and scale dependent manner. The analysis is performed by studying the evolution of the magnetic field vector increments and the corresponding rotation distributions, which contain the switchbacks. We find that the rotation distributions evolve in a scale dependent fashion, having the same shape at small scales independent of the radial distance, contrary to at larger scales where the shape evolves with distance. The increments are shown to evolve towards a log-normal shape with increasing radial distance, even though the log-normal fit works quite well at all distances especially at small scales. The rotation distributions are shown to evolve towards the Zhdankin et al. (2012) rotation model moving away from the Sun. The magnetic switchbacks do not appear at any distance as a clear separate population. Our results suggest a scenario in which the evolution of the rotation distributions, including switchbacks, is primarily the result of the expansion driven growth of the fluctuations, which are reshaped into a log-normal distribution by the solar wind turbulence.

Lionello, Roberto

Switchbacks in Time-Dependent MHD Calculations

The photospheric flux is continuously evolving and causing multifarious topological restructuring of the coronal magnetic field. In the past, we modeled the formation and evolution of coronal jets using a 3D MHD code coupled with 3D MHD flux-emergence simulations (Lionello et al., 2016). There is evidence that disturbances from jets can reach PSP's location, where they may appear as switchbacks (Tenerati et al., 2020). However, our simulations did not produce full switchbacks because of the fully radial background field that hindered their formation. Time-dependent calculation of the corona do not suffer from this limitation. We have calculated the response of the corona to flux evolution of the photospheric magnetic flux, including differential rotation and meridional flows. We have identified dipped in magnetic field lines associated with the current sheet and with pseudostreamers (Lionello et al., 2023).

Mackay, Duncan

Formation and Evolution of Erupting Flux Ropes and the Origin of Switchbacks

Data-driven simulations of the solar corona will be presented both for local active region scales and global scales using the Magneto-frictional method. The formation and subsequent eruption of flux ropes will be studied along with identification of magnetic configurations consistent with Switchbacks in the low solar corona. Ideas for future research will be presented.

Malara, Francesco

Propagation of energetic particles in magnetic switchbacks

The aim of this investigation is exploring the influence of solar wind magnetic switchbacks (SB) on the propagation of charged particles within a range of energy typical of solar energetic particles. We use a simplified 1D model to represent the magnetic reversal. By means of test particle simulations, beams of mono-energetic particles are injected upstream of the SB with various initial energy, pitch- and gyro-phase angles. Particle dynamics is highly affected by the ratio between the particle gyroradius and the size of the SB, with multiple pitch-angle scatterings occurring when the particle gyroradius is of the order of the SB size. Further, particle motion is extremely sensitive to the initial conditions, implying a transition to chaos; for some parameters of the system, a large share of particles is reflected backwards upstream as they interact with the SB. An extension to a 2D model is also presented and discussed.

Mallet, Alfred

Analytic solutions for large-amplitude Alfvén waves

I will present some recent analytic work on large-amplitude Alfven waves: (1) in an expanding medium like the solar wind; and (2) with the addition of two-fluid effects. Unlike in MHD, in both cases, small compressive components of the wave appear, which have important effects on the evolution of the waves. I will critically compare these solutions to the observed switchbacks.

Matteini, Lorenzo

Spherical polarisation and switchbacks in the expanding solar wind: hybrid simulations

I'll briefly discuss some recent results from 2D expanding box simulations of Alfvénic fluctuations in the solar wind. We find that spherical polarisation (constant B) naturally emerges with distance as dB/B increases for expansion. This leads to the formation of local polarity reversals consistent with switchbacks. I'll discuss consequences of the generation and evolution of spherical polarisation on the scaling of the dB_R fluctuations. These results suggest that the observed scaling of 1/f fluctuations and switchbacks is consistent with the constraint imposed by spherical polarisation with distance and it's well captured in the regime of our simplified simulations.

Matthaeus, William

Review of shear effects in MHD and in solar wind

A brief review will cover (1) MHD simulation results that describe nonlinear shear evolution in the presence of a large scale magnetic field; (2) empirical evidence based on SW observations that points towards shear driving of turbulent evolution; and (3) results from non-WKB turbulence transport that indicate similar effects of shear.

Matthaeus, William

Radial variation of occurence of (full) switchbacks

The statistical survey of Pecora et al, ApJ, 929, L10 (2022) is reviewed. A significant finding is that the rate of occurrence of SBs falls off sharply approaching the Sun near 0.2 au (40 Re) and rises gently from 0.2 au outward.

Matthaeus, William

Shear driving model can generate SBs and observed flocculation

The model of Ruffolo et al, ApJ 902, 94 (2020) provides a mechanism for explaining in situ generation of switchbacks while also accounting for the observed transition from "striation" to "flocculation" as observed in imaging (DeForest et al, ApJ, 828, 66 (2016). The mechanism is expected to operate principally outside the Alfven critical region, which itself may be of complex morphology.

Panasenco, Olga

Photospheric and coronal sources of different types of solar wind and transients

Initial Parker Solar Probe results have shown that slow Alfvénic solar wind intervals appear to be a frequent, if not standard, component of the nascent solar wind inside 0.5 AU. In addition to the strong presence of Alfvénic fluctuations propagating away from the Sun, such intervals also display the huge oscillations known as switchbacks, where the Alfvénic fluctuation is accompanied by a fold in the radial magnetic field and a corresponding forward propagating radial jet. Switchbacks often come in patches, separated by short intervals depleted with fluctuations, and periods without switchbacks may also show a striking quiescence, with the magnetic field remaining mostly radial and very small amplitude velocity and magnetic field fluctuations. These observations pose a series of questions on the origins of the solar wind and the role of coronal structure, as well as of the evolution of fluctuations within the solar wind. This paper explores the origins of different solar wind streams.

Patsourakos, Spiros

Assessing the Solar Origin of Switchbacks Using Energetics

The origin of switchbacks is currently intensely debated and could be either solar or in-situ. We hereby use energetics to scrutinize the solar of switchbacks. To this we perform simplified estimates of the energy content of switchbacks and confront them with the energetics of small-scale solar transients such as brightenings and jets of various magnitudes.

Raouafi, Nour E.

Magnetic Reconnection as the Driver of the Solar Wind

We present EUV solar observations showing evidence for omnipresent jetting activity driven by small-scale magnetic reconnection at the base of the solar corona. We argue that the physical mechanism that heats and drives the solar wind at its source is ubiquitous magnetic reconnection in the form of small-scale jetting activity (a.k.a. jetlets). This jetting activity, like the solar wind and the heating of the coronal plasma, is ubiquitous regardless of the solar cycle phase. Each event arises from small-scale reconnection of opposite-polarity magnetic fields producing a short-lived jet of hot plasma and Alfvén waves into the corona. The discrete nature of these jetlet events leads to intermittent outflows from the corona, which homogenize as they propagate away from the Sun and form the solar wind. This discovery establishes the importance of small-scale magnetic reconnection in solar and stellar atmospheres in understanding ubiquitous phenomena such as coronal heating and solar wind acceleration. Based on previous analyses linking the switchbacks to the magnetic network, we also argue that these new observations might provide the link between the magnetic activity at the base of the corona and the switchback solar wind phenomenon. These new observations need to be put in the bigger picture of the role of magnetic reconnection and the diverse form of jetting in the solar atmosphere.

Réville, Victor

Timescales of periodic jets released by interchange reconnection

Among the possible origin of switchbacks is interchange reconnection in the low corona. We perform numerical simulation showing that flux emergence creates periodic releases of plasma jets that could later on become switchbacks. In our simulations, the periodicity of these events is related to the Alfvén time L/vA, and is relatively stable when increasing the emergence rate or amplitude. This could be tested in particular orbital configurations of Parker Solar Probe or Solar Orbiter. We also test this prediction using remote sensing data of bright point emergence in coronal holes.

Rouillard, Alexis

On the link between small EUV brightpoints and bursts of magnetic switchbacks

In this work, we analyze the occurrence rate of velocity spikes and the microstream structures as probed by the Proton-Alpha Sensor (PAS) on Solar Orbiter (SolO) during its fifth encounter. We identify the characteristic periodicity of spike occurrence. We use various magnetic models of the solar atmosphere to locate the magnetic origin of the velocity spikes and microstream structures on the solar surface. We find that the footpoints of the magnetic lines are located at the boundary of a coronal hole, where the imaging instruments onboard the Solar Dynamics Observatory (SDO) record many ultraviolet brightening, which also varies periodically. We proceed to compare the time series of small bright points' counts and the cumulative magnetic flux linked with these bursts of luminosity against the in-situ velocity spikes. Remarkably, a robust positive correlation emerges from this analysis. From this, we conjecture that the localized emergence of small-scale magnetic flux within coronal holes fuels interchange reconnection—a process visible as slight brightness augmentations and outward fluctuations or jets.

Ruffolo, David

Common properties of switchbacks and Kelvin-Helmholtz structures?

We consider similarities and differences between properties of switchbacks in the super-Alfvenic solar wind (because none have been observed in the sub-Alfvenic solar wind) and documented properties of Kelvin-Helmholtz structures in observations and computer simulations.

Shi, Chen

Generation of magnetic switchbacks by jets: MHD simulation

Following the work by Landi et al., 2006, we conduct 3D MHD simulations to study the generation of magnetic switchbacks by velocity jets. The initial condition consists of an upward velocity jet on top of upward propagating shear Alfvén wave. We carry out a parametric survey and analyze the effects of jet speed, wave length, wave amplitude and plasma beta, etc on the generation of switchbacks.

Shoda, Munehito

Generation of magnetic switchbacks: expanding wave, interchange reconnection, or hybrid

I will share insights obtained from direct numerical calculations concerning the formation mechanisms of magnetic switchbacks. Expanding Alfven waves naturally generate switchbacks, and the efficiency of this process becomes more pronounced as the value of the local Poynting flux increases. On the other hand, when compared to observations from the Parker Solar Probe (PSP), the Alfven wave model tends to produce fewer magnetic switchbacks. This suggests that explosive events in the corona could be a significant contributing factor.

Sorriso-Valvo, Luca

Statistical signature of switchbacks in the turbulent fluctuations

The presence of switchbacks in solar wind samples enhances the energy transfer rate of the turbulent cascade. Statistical analysis of solar wind turbulence in the proximity of the Sun shows the emergence of a characteristic scale that can be associated to the sharp magnetic field and velocity fluctuations, including switchbacks.

Squire, Jonathan

Switchback asymmetries induced by the Parker spiral

As the mean-magnetic-field and radial directions start to differ due to the Parker spiral, an initially isotropic population of switchbacks can develop asymmetries. I will discuss some basic theoretical predictions, explaining why these effects can lead to a higher prevalence tangentially directed fluctuations with a skewed distribution of magnetic-field rotations.

Sterling, Alphonse

A Concept for Switchbacks from Solar Jets

Solar coronal jets are long and narrow (50,000 x 10,000 km) transient (tens of minutes) geyser-like outflows seen in high-resolution, high-cadence coronal movies. Recent studies show that many, if not most or all, such jets result from eruptions of small-scale cool-material filaments ("minifilaments"). The erupting magnetic field carrying the minifilament material would produce the jet through magnetic reconnections both among the field of the erupting minifilament, and between the erupting-minifilament field and surrounding coronal field. Other recent studies show that the minifilament field (likely in the form of a flux rope) often is built and triggered to erupt though canceling photospheric fields. Jets often display a spinning motion as they evolve, and this could result from twist put on the minifilament flux rope by reconnection of the canceling photospheric field, where that twist is released in the jet-producing reconnection with the coronal field when the minifilament erupts. That twist would propagate along open coronal field, forming an outward-propagating Alfvenic pulse. Due to the drop-off of Alfven velocity, that twist would steepen with distance from the Sun, perhaps forming switchback-like disturbances detected by PSP and other satellites. Further studies show that the coronal-jet-producing mechanism likely also occurs on size scales smaller than jets, including the "jetlet" size scale (base width 4000 km), and perhaps down to the spicule size scale (widths few hundred km). The smaller features are much more numerous than jets; if they are indeed produced by the coronal-jet mechanism, then the entire distribution of jet-like events leaving the Sun is a candidate to explain some portion of the observed switchback population.

Suen, Gabriel Ho Hin

Magnetic reconnection as an erosion mechanism for magnetic switchbacks

Magnetic switchbacks are a prevalent feature of the near-Sun solar wind but are less frequently observed at 1 au and beyond, suggesting that these structures erode as they propagate away from the Sun. The specific mechanisms at play have not been identified so far. Using examples of reconnecting switchbacks observed at PSP and SolO, we propose a scenario through which reconnection can erode a switchback and estimate the timescales over which this process occurs. We find that the erosion timescales of the switchbacks are much shorter than the expansion timescale of the solar wind, ranging from a few minutes to a few hours. Furthermore, we find that the spatial scale of these switchbacks would be considerably larger than is typically observed in the inner heliosphere if the onset of reconnection occurs close to Sun. Thus, our results suggest that the complete erosion of the observed switchbacks occurs well before they reach 1 au, and that the onset of reconnection must occur during transport in the solar wind in the cases considered here. If typical, these results show that reconnection can contribute to the erosion of switchbacks and may explain the relative rarity of switchback observations at 1 au.

Tripathi, Durgesh

Heating of corona in QS and CHs and formation of near Sun switchbacks

Using the spectroscopic observations from the interface regions imaging spectrometer (IRIS), we propose a unified model of the heating of the corona in QS and Coronal holes that naturally provides evidence of the formation of switchbacks in the near sun environment.

Velli, Marco

Generation of switchbacks via shears

We revisit the idea that switchbacks are produced by the shear of circularly polarized Alfvén waves via transversely varying radial wave propagation velocity. We establish the necessary and sufficient conditions and show that the mechanism works in a realistic solar wind scenario. We also show that the theoretical predictions are in excellent agreement with observations, and the high amplitude radial oscillations are strongly correlated with the shear of the wave speed. The correlation coefficient is around 0.3 to 0.5 for both encounters 1 and 12

Verniero, Jaye

Evolution of SPAN-I measured proton velocity distribution functions through switchbacks

The Solar Probe ANalyzer for Ions (SPAN-I) is an electrostatic analyzer onboard Parker Solar Probe with a field-of-view (FOV) partially obscured by the thermal protection shield. As such, only partial velocity distribution functions (VDF) are available, which requires extra caution for interpretation. We demonstrate the evolution of VDFs through switchback intervals of both sufficient and insufficient FOV. We speculate on the effect of switchbacks on proton temperature enhancements.

Verniero, Jaye

The geometry of switchbacks

Characterizing energy storage and release in dynamical systems may be achieved by understanding their topological complexity. We present an exploratory data analysis technique based on hyper-dimensional coordinate system transformations. This new geometrical perspective may yield an optimal basis for signal extraction. We discuss preliminary findings applied to switchbacks with Parker Solar Probe magnetometer data.

Watkins, Nicholas

When is a 1/f spectrum not a power spectrum ? Revisiting Mandelbrot's 1967 switching model

A key assumption behind practical use of power spectra is that a single measured time series can estimate a property that is defined for an ensemble. However Mandelbrot's 1967 paper "Some noises with 1/f spectrum: a bridge between direct current and white noise" dealt with systems where this assumption is broken. I will build on a couple of posters [Watkins, Poster P45, Session 06, Shine, 2018; Watkins, SH43B-3697, Fall AGU, 2018] and my paper [Watkins EPJB, 90, 241, 2017] to quickly explain while this "old" work is both timeless and timely for solar wind physics.

Wyper, Peter

The development of switchbacks from the evolution of non-linear torsional Alfvénic waves

In this short talk I'll show some preliminary results of simulations where non-linear torsional Alfvenic waves develop into switchbacks as they propagate into a 3D solar wind solution. The perturbation launching the waves is designed to produce waves similar to those launched by jets and tearing induced plasmoids.