
Report of Referee A -- LP13596/Schaffner

This is a clearly written paper discussing new experimental results concerning intermittency in plasmas as a function of magnetic helicity level. It is of importance to several different branches of physics, including fusion and plasma physics, and solar, space and astrophysics. The experimental finding that the spectral slopes, above and below the breakpoint, are approximately invariant wrt magnetic helicity is of direct relevance to solar wind and coronal plasmas.

I recommend publication.

We thank the referee for a careful reading of our manuscript. We especially appreciate the comment: "The experimental finding that the spectral slopes, above and below the breakpoint, are approximately invariant wrt magnetic helicity is of direct relevance to solar wind and coronal plasmas." We have attempted to carefully respond to each and every point the referee has raised and have tried to clearly indicate where modifications in the text have been made.

There are a couple of points I would suggest the authors consider.

The paper would benefit from a table or listing of characteristic length and time scales, eg ion inertial length, Alfven speed, ion cyclotron freq, ion gyroradius. Although these are easy to calculate given the information in the paper, it would be instructive and convenient to have them immediately to hand.

A table has been added with pertinent parameters

On page 2 in the discussion about the wavelet power spectra, the authors note there is a breakpoint ~1MHz. Recommend adding some discussion about why a break should be anticipated at this frequency. Is it ~gyrofreqency and so separating kinetic scale effects from large scale ones? Some references would probably be appropriate.

We expect discontinuities and current sheets at all scales, but eventually thinned down to c/omega_pi, the ion inertial scale length. We expect no structures thinner than that. At densities of 10^15 cm^{-3}, c/omega_pi is 0.6 cm and given a bulk flow of 20 km/s (2 cm/us), Taylor hypothesis gives 0.35 us (3 MHz) for the smallest structures. We expect a drop-off in signal at frequencies higher than that. A comment about a dissipation break at the ion

inertial length has been added in the paragraph starting "The wavelet power spectrum of magnetic field fluctuations…" A paper discussing in more detail the implications of this breakpoint is in preparation.

Fig 2. Powerlaw fits. Perhaps add some comments about the perils of claiming powerlaws when the fitting region is less than a decade long, as it is for most of the dotted lines in Fig 2a.

Power-law fits are made to the data though for some ranges slightly less than a decade. Though this can be an issue for determining with great accuracy the scaling index, it is nevertheless useful for comparison between slopes. Moreover, the fitting technique used here, (i.e. MLE) is less prone to fitting error than a typical linear fit of logarithmic values as it incorporates the weighting of the power in the signal. A reference has been added (Dudok de Wit 2013) which discusses some of these issues of small fitting ranges.

Minor points
Additional references
To [3], recommend adding Chapman and Hnat 2007, GRL And there are several Muller and Biskamp papers which discuss intermittency and spectral slopes in 3DMHD simulations with magnetic helicity. Recommend the authors consider adding these in the intro with some brief discussion somewhere.
Muller et al 2012 PRE
Muller and Biskamp 2000 PRL
Biskamp and Muller 2000 Phys Plas

A number of these references have been added. The Muller and Biskamp 2000 PoP is of particular interest as it explores the effect on the turbulence between finite and zero helicity states, though in terms of a temporal energy decay rate rather than in energy cascade or intermittency modification. The paper is referenced in the introduction and the prospect of exploring simulations of the effect of helicity in this vein has been noted in the conclusion. Thank you to the referee for highlighting references to this work. We are also working on conducting a similar scan of helicity as is done in this manuscript using the simulation framework discussed in Schaffner PPCF 2014.

The following typos have been fixed:

"be" changed to "been"

Fig 1 caption changed from four to "all three plots"

The phrase "are generally linear in the logarithmic scaling of Figure…" has been added to the sentence starting "This region is where the frequency spectra…"

Tau has been changed to Delta t in Figure 3.

The sentence, "it is reasonable to think mechanisms are at play here as well" has been changed to "…reasonable to think similar mechanisms are at play…"

Symbols for vector potential, volume and ion temperature have been explicitly defined.

Thank you again to the referee for a careful analysis and for recommending publication pending some corrections and modifications. We believe the changes we have made and presented here will be sufficient for meeting your expectations for publication.

Report of Referee B -- LP13596/Schaffner

The manuscript "Observation of turbulent intermittency scaling with magnetic helicity in an MHD plasma wind-tunnel" by D.A. Schaffner, A. Wan, and M.R. Brown is a study of the change in the statistics of magnetic field fluctuations as helicity is injected into a spheromak. Evidence is shown that the distribution function from B-dot probes becomes flatter as the time scale over which the second order time derivative is computed is reduced, and this flatness increases with increasing injected helicity. The authors also show a similar trend with the flatness of the ion temperature. In contrast, they show no clear trend in the plasma parameters or the linear spectra of B-dot with helicity. They conclude this provides some evidence for a connection between intermittency and reconnection.

We thank the referee for a careful reading of our manuscript and for the many constructive comments and suggestions. We especially appreciate the points which ask to improve the clarity of our explanations. We have attempted to carefully respond to each and every point the referee has raised and have tried to clearly indicate where modifications in the text have been made.

I have the following remarks:
1. The authors do not show "Evidence for the role of current sheets and reconnection sites in the generation of this intermittency is provided..."

While the particular statement at issue may be considered too strong, we do believe that there is a connection between the presence of reconnection sites and the observation of intermittent magnetic signal and that this manuscript presents such evidence. The observation of ion temperature bursts and modification of soft X-ray signal, while circumstantial, can be viewed as evidence for the presence of reconnection layers. In other reconnection scenarios at SSX, we have certainly observed ion temperature and soft X-ray bursts associated with identified reconnection events (see Brown PoP 2012 and Brown ApJ Letters 2002). Meanwhile, the presence of fat tails in the probability distribution function of increments quantified by the flatness measurement is viewed to be a common signature of current sheets especially in light of the many MHD simulation results referenced. Thus, we feel that correlation of these trends as presented in Figure 4 make for a valid hypothesis of the connection between reconnection sites and the intermittency.

2. The authors assume that the value of injected helicity in Eq. (2) is sufficient to characterise each helicity state present. Those familiar with Taylor's relaxation theory (such as this reviewer) may be led to the conclusion that the field is Beltrami, and the plasma fully relaxed. The reader then becomes confused when reading "Note that since the magnetic energy values are *determined during the process of relaxation, there is no expectation of a relationship between this energy and the helicity as would be expected in a fully relaxed Taylor state." I think it would help the reader to add on the first page the sentence " During the injection phase the plasma evolves towards a fully relaxed Taylor state."*

The twisted plume (Taylor double helix) *is* evolving and it is the concomitant turbulence that we study. Full relaxation (if ever achieved) occurs very late in the discharge. Once the Taylor state is at minimum energy, there is no more free energy to drive MHD turbulence. The line "As the plasma evolves toward a fully-relaxed Taylor state during the injection phase, the resulting turbulent magnetic field and plasma fluctuations of this transition process are measured," has been added in the paragraph beginning, "This paper presents the results…" on the first page.

3. The sentence "Figure 1 demonstrates that modifying the gun flux has little affect on the total energy content or the bulk plasma properties", is inconsistent with the previous text which that the average magnetic field / density increases/decreases with increasing Φ, then saturates.

The main point of Figure 1 is that beyond a threshold helicity—in this case, about 1x10^$^{-5}$ mWb^2—the change in gun flux, and consequently the change in helicity, does not show a significant effect on the bulk plasma properties such as density and mean magnetic field. However, it is clear that the initial sentence is somewhat confusing so it has been modified to read, "Overall, Figure 1 demonstrates that modifying the gun flux has little affect on the total energy content or the bulk plasma properties once a threshold helicity has been surpassed."

4. Can the authors comment on why the breakpoint in the slope of Fig. 2 appears at 1MHz for all values of Φ? I note Figure 2(a) also needs a legend for the fitted lines.

We expect discontinuities and current sheets at all scales, but eventually thinned down to c/omega_pi, the ion inertial scale length. We expect no structures thinner than that. At densities of 10^15 cm^{-3}, c/omega_pi is 0.6 cm and given a bulk flow of 20 km/s (2 cm/us), Taylor hypothesis gives 0.35 us (3 MHz) for the smallest structures. We expect a drop-off in signal at frequencies higher than that. Moreover, since we suspect the break-point is related to ion inertial scale it is anticipated that the breakpoint would occur in approximately the same region since the density is generally constant for the different helicity states. A comment about a dissipation break at the ion inertial length has been added in the paragraph starting "The wavelet power spectrum of magnetic field fluctuations…". The lines in Figure 2(a) are mainly there to help show what on range the power-law fits are being made. A better description of the fitted lines has been added to the caption rather than a legend in order to avoid overcrowding the plot.

5. In Fig, 3 there is some confusion with the choice of notation. I suspect the authors meant Δt, not τ.

Use of tau has been changed to Delta t

6. It is hard to resolve different cases in Fig. 4(a), and I suggest a symbol be used that allows each point to identified.

Different markers have been added to highlight Br, Bt, and Bz.

7. While it may be a standard result in turbulence literature, I suspect it is not clear to much of the broader PRL readership why intermittency is related to the flatness of the distribution function. A reference would help readers outside the field.

The references mentioned in the first paragraph (Greco08,Greco09,Wan09,Servidio11b) discuss this connection in detail though this sentence has been added to the first paragraph for clarity: "This intermittency, or `fat tails' of a probability distribution, indicates large excursions from a mean which suggests the presence of coherent structures rather than purely Gaussian fluctuations."

8. The authors should comment on the impact of restricting the frequency/time scale in analysis of Fig. 4(a). More importantly, the authors should add error estimates to Fig. 4(a) to capture the spread of flatness values with timescale in Fig. 3(b). My point is that the flatness vs. τ curves in Fig. 3(b) do not have the same shape for different Φ values. Neglecting the error estimates in Fig. 4(a) assumes they do have the same shape.

The time range chosen for the average values presented in Figure 4a was made to correspond to the range in frequency space where spectral scaling was approximately power-law-like. Since we were most interested in a global effect, we chose this full range rather than looking at separate ranges (i.e. separately before and after the breakpoint). A more detailed analysis of how the flatness varies depending on scale is in progress. To better reflect the inevitable spread in values by taking a broader point of view, standard deviations of the averages for each helicity state were calculated and are represented in Figure 4a as error bars. A comment regarding them is added to the caption of Figure 4.

9. Other than demonstrating the need to use higher order tools to compute evidence of intermittency, I do not understand the physical significance that "there is a change to the intermittent character of Bdot fluctuations as a function of injected helicity while simultaneously showing little to no change in the turbulent frequency-domain power". Is there one?

High helicity plumes have excess "twist" that needs to be relaxed. Or maybe another way to say it: the energy-to-helicity ratio (related to lambda) is mismatched from the final, relaxed state. More dynamics have to ensue to transport the state from initial turbulent to final relaxed. Though it is not entirely clear that this is exactly what is occurring, it is interesting to speculate that the relaxation process generates a similar turbulent process (reflected in the

spectra) despite starting at differing levels of "twistedness". The increase in intermittency would then seem to reflect a change in the magnetic structure of the plasma but in such a way that the cascade of energy to smaller scales is maintained at the same rate.

I support publication of the manuscript in PRL providing the authors satisfactorily address my remarks.

Thank you again to the referee for a careful analysis and for recommending publication pending the address of your remarks. We believe the changes we have made and presented here will be sufficient for meeting your expectations for publication.