Reply to "Comment from Dr. Joseph Borovsky"

We appreciate Dr. Joseph Borovsky for the comments on our manuscript entitled "Effect of Intermittent Structures on the Spectral Index of Magnetic field in the Slow Solar Wind" [angeo-2022-28]. We have taken the suggestions fully into account. In our response, each of the suggestions is followed by the corresponding reply and revision marked in bold. Line numbers refer to the original submission. The comments have helped us to improve our manuscript and clarify the contents significantly. We are grateful for the referee's suggestions.

This is a very interesting study, but this reader was at times confused about the methodology used in the data analysis. I am asking for a revised manuscript clarifying some of the data-analysis methods.

1. Throughout the paper, please make clear that the PSD is the magnetic PSD and that the spectral index is the magnetic spectral index.

Reply: Thanks! Revised throughout the paper.

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2. It seems that the plasma data is only used to get the number density in order to put the magnetic data into Alfvén units. Can you clarify in the manuscript if that is true.

Reply: According to the suggestion, we add the following sentence in original line 76 to clarify this point: "The plasma data is used here to get the bulk velocity for data selection and to get the proton number density in order to put the magnetic data into Alfvén units. In addition, the plasma data is also used to calculate Alfvénicity for the purpose of revealing the nature of intermittent structures."

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3. There is no description in the manuscript of how the time-series data was prepared prior to performong the FFT. Was the data windowed? Was the data interval de-trended? If not, then there is an extra discontinuity in the data that adds Fourier power to the PSD. Please add a description of the time-series preparation to the manuscript.

Reply: Thanks for the suggestion! When performing the FFT on the components of magnetic field data, we use a simple rectangle window. We add a description of the time-series preparation prior to FFT in line 143 and in the caption of Figure 2, and also add a subsection and a new figure to compare the magnetic spectral index obtained from "no data preprocessing" method and "linear detrending preparation" method.

– Line 143: ".. the time series ... is Fourier transformed using the FFT method with a simple rectangle window. This method could introduce an extra

discontinuity in the data that will add Fourier power to the magnetic PSD as mentioned by Borovsky (2012) and Borovsky and Burkholder (2020). In subsection 4.4, we apply a linear detrend to the data prior to Fourier transforming following Borovsky (2012), and make a comparison between the two methods."

– Caption of Figure 2: "The gray curve corresponds to the magnetic power spectrum by performing FFT on .. magnetic field data ... with a simple rectangle window."

– 4.4 Linear detrending to data prior to FFT

When performing the FFT on the components of magnetic field data, we use a simple rectangle window (hereinafter referred to as "no data preprocessing" method). This method could introduce an extra discontinuity in the data that will add Fourier power to the magnetic PSD as mentioned by Borovsky (2012) and Borovsky and Burkholder (2020). Following Borovsky (2012), we try applying a linear detrend to each data interval prior to Fourier transforming (hereinafter referred to as "linear detrending preparation" method), and compare the result with that in Figure 6 obtained from "no data preprocessing" method.

Figure 11 presents the joint distribution of intermittency level I_{max} **and magnetic spectral index** α_B **obtained from "linear detrending preparation" method plotted in the same format as the lower panel of Figure 6. The analytical relationship** $\alpha_B = 0.4\exp(-I_{max}/5) - 2.02$ **adopted from Figure 6 is superposed on the figure as black curve for easier comparison. It is clear that when** $I_{max} > 12$**, the black curve coincides with the averaged magnetic spectral indices** α_B **(gray dots) well. However, when** $I_{max} < 12$**, the averaged magnetic spectral indices** α_B **(gray dots) obtained from "linear detrending preparation" method appear to be larger than that obtained from "no data preprocessing" method denoted by the black curve. The differences between them are about** $0.01 - 0.06$**. This is consistent with Borovsky (2012), which mentioned that the "no data preprocessing" method leads to spectral indices slightly steeper. When looking at the upper/lower quartiles, we notice that the distribution of** α_B **in a** I_{max} **bin obtained from "linear detrending preparation" method (e.g.,** $\alpha_B = -1.90^{+0.15}_{-0.14}$ **at** $I_{max} = 8.5$**) is slightly wider than that obtained from "no data preprocessing" method (e.g.,** $\alpha_B = -1.93^{+0.13}_{-0.12}$ **at** $I_{max} = 8.5$**). The wider distribution for the "linear detrending preparation" method is also consistent with Borovsky (2012). Accordingly, we suggest that when using different data preprocessing methods, the magnetic spectral index slightly changes, but our results about the trend of the magnetic spectral index** α_B **versus the intermittency level** I_{max} **and the contribution of the intermittency on the magnetic spectra are robust.**

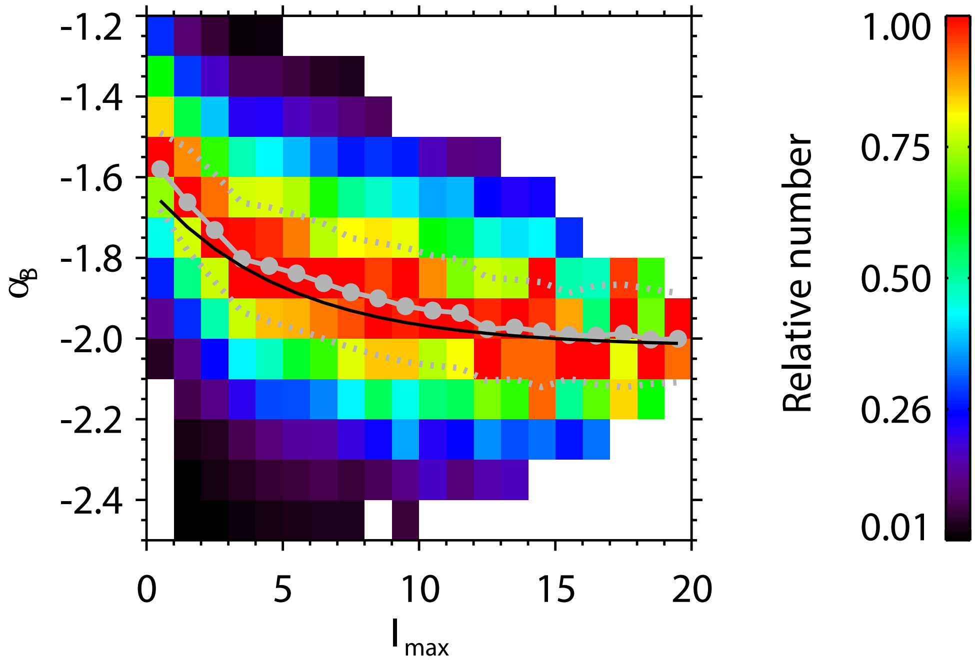

Figure 11: **Joint distribution of intermittency level I_{max} and magnetic spectral index α_B obtained from "linear detrending preparation" method plotted in the same format as the lower panel of Figure 6. The black curve is the exponential function $\alpha_B = 0.4\exp(-I_{max}/5) - 2.02$ adopted from Figure 6.**

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4. The PSDs in the figures are in units of velocity, meaning that the time series of the magnetic field in Alfven units was used in the FFT. The magnetic-field data has a resolution of 1/11 sec while the plasma data has a resolution of 3 sec. How were the values of the number density chosen to put the magnetic-field data into Alfvén units. One density value for the entire time series interval? Changing the density value every 3 seconds in the time series?

Reply: We add the following sentences to clarify about how are the values of number density chosen to put the magnetic-field data into Alfvén units.

– Original line 118: "The magnetic field data are transformed into Alfvén units (i.e., B/$\sqrt{\mu_0 m_p \langle n_p \rangle}$ with μ_0 being susceptibility, m_p being proton mass, and $\langle n_p \rangle$ being the average proton number density of the ∼5-min interval)."

– Original line 143: "The high-resolution magnetic field data are first transformed into Alfvén units (i.e., B/$\sqrt{\mu_0 m_p \langle n_p \rangle}$ with $\langle n_p \rangle$ being the average proton number density of each interval). ... the time series of each component of the

high-resolution magnetic field data in Alfvén units is Fourier transformed ...”

– Caption of Figure 2: “The magnetic field is plotted in Alfvén units (i.e., B/$\sqrt{\mu_0 m_p \langle n_p \rangle}$ with μ_0 being susceptibility, m_p being proton mass, and $\langle n_p \rangle$ being the average proton number density of this interval). ... The gray curve corresponds to the magnetic power spectrum by performing FFT on the 1/11-s-resolution magnetic field data in Alfvén units obtained still from B/$\sqrt{\mu_0 m_p \langle n_p \rangle}$.”

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5. When putting the magnetic field into Alfvén units, if one value of number density for the entire interval is not chosen, how different is the spectral index of the magnetic field in Alfvén units versus the spectral index of the magnetic field in nT? I would worry that noise in the density measurements (particularly in the WIND 3-sec onboard moments) would spoil the spectral-index value. Can you comment on this possibility in the manuscript.

Reply: We use the ensemble average of proton number density for each selected interval when putting the magnetic field into Alfvén units. We emphasis that we use the one value of number density in the text and add the following sentences in original line 143: “When putting the magnetic field into Alfvén units, we use one value of proton number density, which corresponds to the ensemble average of proton number density $\langle n_p \rangle$ for each selected interval. By doing so, we avoid the contamination of the noise in density measurements on the magnetic spectral-index value, which would be resulted from using the density value changing every 3 seconds.”

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6. $> 42,000$ intervals were examined but only 24,886 intervals were used for the statistics. That means almost half of the intervals were rejected. Besides having a higher fitting error, were there any trends to what was rejected and what was accepted?

Reply: Besides having a higher fitting error, we also eliminated the cases during which the energy of the fluctuations is not dominated by the intermittent structure imbedded in the center of it as mentioned in original line 136. We add the following sentences in original line 296 to clarify this point: “We examine 56,398 intermittent structures preliminarily by using the criterion $|PVI_i| > 2$ ($i = x, y$, or z), with t_B and t_E being the beginning and ending instants of a structure, respectively. However, for more than half of them, the maximum I (I_{max}) during $[t_B, t_E]$ (as marked by the two vertical dotted lines in Figure 2) is not the maximum I during the corresponding plotted interval $[t_B - 150s, t_E + 150s]$ (as the whole plotted interval in Figure 2). It means that outside $[t_B, t_E]$, there exist some other structures with even higher level of intermittency during the interval $[t_B - 150s, t_E + 150s]$. We eliminate this kind of intervals, during which the energy of the fluctuations is not dominated by the intermittent structure imbedded in

the center of it. In this way, we avoid the duplicate selection of the cases, and also guarantee that both the intermittency level I_{max} and the magnetic spectral index α_B are closely related to the intermittent structure imbedded in the middle of each interval. Then we obtain 25,912 intermittent intervals. Subsequently, the cases with higher fitting error of the magnetic power spectra ($\Delta_{\alpha_B}/\alpha_B > 5\%$) are eliminated, and 24,886 intermittent intervals are reserved for the statistical analysis."

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7. When the "width" of an intermittent spot is measured (line 264 and Figure 3), what are the units? Data points at 1/11-sec resolution? Data points at 3-sec resolution? Please clarify for the reader.

Reply: Thanks for the suggestion! We clarify this point both in line 164 and in the caption of Figure 3 as following: "... present the joint distribution of their width in units of data points and ... . Here, the width in units of data points for an intermittent structure is obtained from $t_E - t_B$, during which the condition $|PVI_i| > 2$ satisfies ($i = x, y$, or z), divided by the time resolution $\Delta t = 3$ s."

References

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