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Erratum: “3D Anisotropy of Solar Wind Turbulence, Tubes, or Ribbons?” (2018, ApJ, 853, 85)

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Due to an error when averaging the measurements computed in each interval, the plot of the alignment angle versus perpendicular scale appearing in Figure 7 of the published article needs to be corrected. We also misprinted the definitions of these angles (but not their computation, apart from the cited error), since the absolute value appears also in the numerator of each definition, and we give the correct forms here. The averaging error affects only the angles in Equations (15) and (16), while the other angles, Equations (13) and (14), are unchanged. The proper definition for the angle between velocity and magnetic fluctuation is

$$\sin\theta_\perp^{ub} \equiv \left\langle \frac{|\delta\boldsymbol{B}_\perp \times \delta\boldsymbol{u}_\perp|}{|\delta\boldsymbol{B}_\perp||\delta\boldsymbol{u}_\perp|} \right\rangle, \tag{13}$$

where the angular brackets stand for an average on all intervals belonging to the same data set, the subscript $\perp$ indicates the component perpendicular to the local mean field, and $\delta\boldsymbol{B}$, $\delta\boldsymbol{u}$ are the magnetic and velocity fluctuations obtained from the two-point difference, i.e., for a given time lag τ the fluctuation is given by $\delta\boldsymbol{B}(\tau) \equiv \boldsymbol{B}_2(t+\tau) - \boldsymbol{B}_1(t)$ and corresponds to a scale $\ell = V_{SW}\tau$. A similar definition can be given for the alignment between the two Elsässer fields,

$$\sin\theta_\perp^{z} \equiv \left\langle \frac{|\delta z_\perp^{+} \times \delta z_\perp^{-}|}{|\delta z_\perp^{+}||\delta z_\perp^{-}|} \right\rangle, \tag{14}$$

with $\delta z^{\pm} = \delta\boldsymbol{u} \pm \delta\boldsymbol{B}/\sqrt{4\pi\rho_0}$.

Different definitions obtained by averaging separately the numerator and the denominator, in what is termed polarization intermittency (Beresnyak & Lazarian 2006), are

$$\sin\tilde{\theta}_\perp^{ub} \equiv \frac{\langle|\delta\boldsymbol{B}_\perp \times \delta\boldsymbol{u}_\perp|\rangle}{\langle|\delta\boldsymbol{B}_\perp||\delta\boldsymbol{u}_\perp|\rangle} \tag{15}$$

and, analogously,

$$\sin\tilde{\theta}_\perp^{z} \equiv \frac{\langle|\delta z_\perp^{+} \times \delta z_\perp^{-}|\rangle}{\langle|\delta z_\perp^{+}||\delta z_\perp^{-}|\rangle}. \tag{16}$$

In the corrected Figure 7, one can see that the measurements obtained by averaging the angles, Equations (13) and (14), return a shallower scale-dependence than the one obtained by averaging separately the numerator and the denominator, Equations (15) and (16), consistent with measurements in numerical simulations (Beresnyak & Lazarian 2006; Mason et al. 2006, 2008; Beresnyak & Lazarian 2009; Perez et al. 2012; Mallet et al. 2016), and thus removing a discrepancy with our analysis. Most importantly, for $k \lesssim 10^{-2}$ Mm^{-1} the correct measurements of polarization intermittency, Equations (15) and (16), in blue and black lines, show a scaling

$$\sin\theta_\perp \sim \ell_\perp^{1/4}. \tag{17}$$

Note that the scaling of polarization intermittency of magnetic and velocity fluctuations (blue line) is consistent with Boldyrev phenomenology (Boldyrev 2005, 2006), while the scaling of the polarization intermittency of Elsässer fields (black line) is steeper than the prediction of the intermittency model of Chandran et al. (2015). However, at scales smaller that 100 Mm both kinds of polarization intermittency start to increase, a behavior already noted by Podesta et al. (2009) that used *Wind* data to measure the polarization intermittency of velocity and magnetic fluctuations and found a scaling close to Equation (17) only at large scales.

Although we now have an indication of scale-dependent alignment, this is not sufficient to explain the different power-law indices observed in the perpendicular (1/2) and displacement (2/3) structure functions since the indices are found at scales where the alignment stops ($k \gtrsim 10^{-2}$ Mm^{-1} roughly corresponding to frequencies $f \gtrsim$ 4–8 10^{-3} Hz for an average solar wind speed between 400–800 km s^{-1}). The quenching of alignment at small scales is consistent with the total SF having a power-law index of 2/3, this value not requiring alignment but only a strong critical balance cascade. Whether this quenching is real or due to the contamination of instrumental noise, as suggested by previous authors (Podesta et al. 2009; Wicks et al. 2013), will be the subject of future works. The increase of the angle at small scales indicates that it is of physical origin, a confirmation possibly coming from recent measurements of cross helicity that employed *MMS* data at higher resolution (Parashar et al. 2018). Our original conclusions remain valid, namely, that the measured anisotropy in weak-expansion intervals indicates that MHD turbulence forms ribbon-like structures, but their origin cannot be attributed to the scale-dependent alignment at the base of Boldyrev phenomenology.

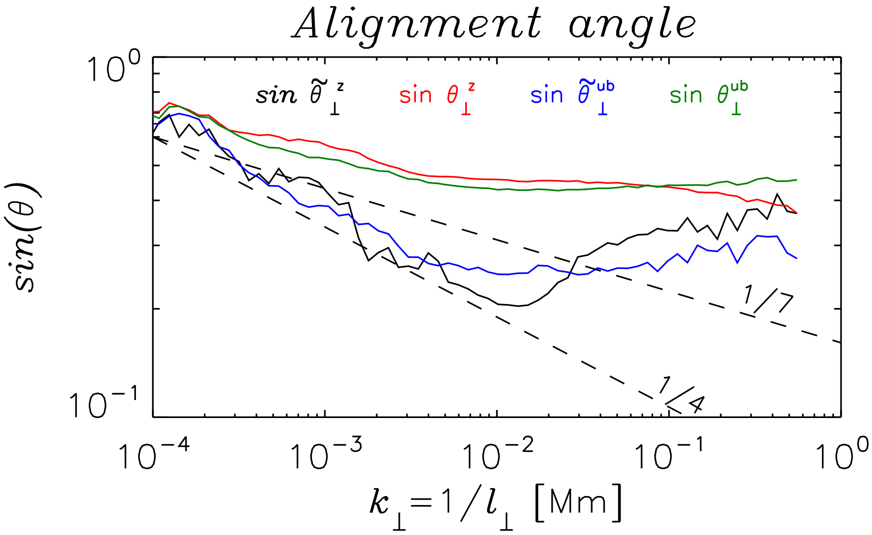

Figure 7. Measurement of the alignment angles, Equations (13)–(16), in the weak-expansion data set. The dashed lines are references for the scaling $\theta_\perp \sim \ell^\alpha$ with α indicated in the figure.

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