Complexity of magnetic field turbulence at reconnection exhausts in the solar wind at 1 AU

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Magnetic reconnection is a complex process in which magnetic energy is converted to kinetic and thermal energy. The solar wind is a natural laboratory for the study of magnetic reconnection. The power spectrum of magnetic field fluctuations in the interplanetary solar wind displays an inertial subrange with power-law scaling and spectral index nearly –5/3, which is indicative of a turbulent state. The magnetic field turbulence displays intermittency evidenced by non-Gaussian probability distribution functions, departure from self-similarity, multifractality, and amplitude-phase synchronization among scales. Intermittency is due to the presence of coherent structures which dominate the statistics of fluctuations at small scales. Coherent structures have been shown to be responsible for low values of the Fourier power spectral entropy in numerical simulations of a three-dimensional compressible MHD intermittent dynamo, and in numerical simulations of a three-dimensional incompressible MHD simulations of a Keplerian shear low.

We apply the Jensen-Shannon (J-S) complexity-entropy index to magnetic field data of four reconnection exhausts detected in the solar wind at 1 AU. Three events are related to the passage of an interplanetary coronal mass ejection, and one event is related to a rope-rope magnetic reconnection event. The interplanetary magnetic field is projected into the LMN coordinates by applying the hybrid minimum variance analysis. The inertial subrange of the magnetic field components in the LMN coordinates is identified by computing the compensated power spectral density. The J-S index indicates that the three components of the magnetic field display entropy and complexity values similar to stochastic fluctuations. However, we show that a high degree of intermittency is related to a lower degree of entropy and a higher degree of complexity. We also show that, for all four events, the L component of the magnetic field displays lower entropy and higher complexity than the M and N components. These results show that coherent structures can be responsible for decreasing entropy and increasing complexity in the interplanetary magnetic-field turbulence.

References:

[1] A. C.-L. Chian and R. A. Miranda, Ann. Geophys. **27**, 1789 (2009).

[2] R. A. Miranda, A. C.-L. Chian and E. L. Rempel, Adv. Space Res. **51**, 1893 (2013)

[3] R. A. Miranda. J. A. Valdivia, A. C.-L. Chian and P. R. Muñoz, Astrophys. J., submitted (2021)