Geophysical Research Abstracts
Vol. 15, EGU2013-4682-1, 2013
EGU General Assembly 2013
© Author(s) 2013. CC Attribution 3.0 License.

The solar wind as a turbulence laboratory- some new quantitative points of contact between theory and solar wind observations

Bogdan Hnat (1), Sandra Chapman (1,3), Giga Gogoberidze (2,1), Khurom Kiyani (1), Kareem Osman (1), and Andrew Turner (1)

(1) University of Warwick, Centre for Fusion, Space and Astrophysics, Physics Dept., Coventry CV4 7AL, United Kingdom (s.c.chapman@warwick.ac.uk, +44 2476 692016), (2) Dept. of Physics, University of Calabria, Italy, (3) University of Tromso, Dept. of Mathematics and Statistics, Norway

Single point observations of the high Reynolds number solar wind flow, suitable for the study of turbulence, are on timescales from below ion kinetic scales up to days, providing extensive datasets for the study of plasma turbulence. Central to the concept of using the solar wind as a test laboratory for plasma turbulence are methods that allow direct quantitative comparison between the predictions of theory and simulation, and the observations. Critically, theoretical predictions, and data analysis methods, must come together in a manner in which uncertainties can be well understood, and thus different theoretical scenarios be distinguished unambiguously. Scaling is a key prediction of theories of infinite range turbulence. Its full characterization requires the scaling exponents of all the moments of the probability density of fluctuations as a function of scale. In practice, only the first few moments are accessible. Comparisons with theory often focus on the second moment scaling, that is, the exponent of the power spectral density (PSD). We focus on what can be learned from two key properties of turbulent fluctuations: components of the tensor power spectral density, and the functional form and scaling of the non- Gaussian pdf of fluctuations.

Solar wind plasma turbulence is anisotropic due to the presence of a background field, so that in general the power spectral density (or correlation) tensor is needed to characterise the turbulence. We focus on the ratios of the PSD tensor terms which are sensitive to the scaling exponent, providing a method for direct observational tests of theories. The reduced PSD tensor accessed by single spacecraft measurements yields ratios of perpendicular terms which we show are robust to uncertainties. In the MHD inertial range of turbulence in the solar wind, these can clearly distinguish turbulence theories as we discuss[1]. They also offer insights into the physics below the ion kinetic scales where a further scaling range suggests a kinetic range turbulence.

Ideal fluid turbulence is characterized by non-Gaussian distributions of fluctuations which become progressively ’fat-tailed’; on smaller scales, and which exhibit a multifractal scale invariance, a behaviour also seen in the MHD inertial range of turbulence in the solar wind. We show that below the ion kinetic scales there is instead a cross-over to a quantitatively distinct global scale invariance[2] and discuss the implications for the physics of kinetic range turbulence.

[1] A. J. Turner, G. Gogoberidze, S. C. Chapman, Nonaxisymmetric anisotropy of solar wind turbulence as a direct test for models of magnetohydrodynamic turbulence, Phys. Rev. Lett., 108, 085001, (2012)

[2] Kiyani, K. S. C. Chapman, F. Sahraoui, B. Hnat, O. Fauvarque, Yu. V. Khotyaintsev, Enhanced magnetic compressibility and isotropic scale-invariance at sub-ion Larmor scales in solar wind turbulence, Ap. J., 763, 10, (2013)