Critical Balance and Solar Wind Turbulence

Sean Oughton
Department of Mathematics, University of Waikato, New Zealand
e-mail: sean.oughton@waikato.ac.nz

At scales larger than about the proton gyroradius the solar wind is often treated using magnetohydrodynamics (MHD), with the velocity, density, and magnetic fields being important quantities. Observations at distances from 0.1--130 au indicate that these quantities fluctuate, with both turbulent and wavelike aspects seen [1]. For *critical balance* models of turbulence it is argued that the dynamics acts to induce approximate (numerical) equality of two physically and conceptually distinct timescales in the system: a relevant wave timescale and the turbulence nonlinear timescale [2–5]. This assumption enables some simplifications in modelling of turbulence.

We review the main assumptions of critical balance phenomenologies and examine how well they apply to the MHD-scale solar wind. This will include discussion of points of agreement and disagreement between critical balance models and solar wind observations, such as anisotropy of spectral slopes, variance anisotropy, and the role and impact of a (local-)mean magnetic field.

[1] R. Bruno and V. Carbone. The solar wind as a turbulence laboratory. Living Rev. Solar Phys., 10, 2013.
[2] P. Goldreich and S. Sridhar. Toward a theory of interstellar turbulence: II. Strong Alfvenic turbulence. Astrophys. J., 438:763–775, 1995.
[3] S. V. Nazarenko and A. A. Schekochihin. Critical balance in magnetohydrodynamic, rotating and stratified turbulence: Towards a universal scaling conjecture. J. Fluid Mech., 677:134–153, 2011.
[4] S. Oughton and W. H. Matthaeus. Critical balance and the physics of magnetohydrodynamic turbulence. Astrophys. J., 897, 2020.
[5] P. W. Terry. Theory of critical balance in plasma turbulence. Phys. Plasmas, 25:092301, 2018.