Geophysical Research Abstracts
Vol. 18, EGU2016-8978, 2016
EGU General Assembly 2016

Alfvén-dynamo balance and magnetic excess in MHD turbulence

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3D Magnetohydrodynamic (MHD) turbulent flows with initially magnetic and kinetic energies at equipartition spontaneously develop a magnetic excess (or residual energy), as well in numerical simulations and in the solar wind. Closure equations obtained in 1983 describe the residual spectrum as being produced by a dynamo source proportional to the total energy spectrum, balanced by a linear Alfvén damping term. A good agreement was found in 2005 with incompressible simulations; however, recent solar wind measurements disagree with these results.

The previous dynamo-Alfvén theory is generalized to a family of models, leading to simple relations between residual and total energy spectra. We want to assess these models in detail against MHD simulations and solar wind data.

The family of models is tested against compressible decaying MHD simulations with low Mach number, zero cross-helicity, zero mean magnetic field, without or with expansion terms (EBM or expanding box model).

A single dynamo-Alfvén model is found to describe correctly both solar wind scalings and compressible simulations without or with expansion. It is equivalent to the 1983-2005 closure equation but with critical balance of nonlinear turnover and linear Alfvén times, while the dynamo source term remains unchanged. The discrepancy with previous incompressible simulations is elucidated. The model predicts a linear relation between the spectral slopes of total and residual energies $m_R = -1/2 + 3/2 m_T$. Examining the solar wind data as in [**?**], our relation is found to be valid whatever the cross-helicity, even better so at high cross-helicity, with the total energy slope varying from 1.7 to 1.55. ——-