Geophysical Research Abstracts
Vol. 17, EGU2015-520, 2015
EGU General Assembly 2015

Turbulence Reduces Magnetic Diffusivity in DTS Liquid Sodium Experiment

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Earth, Sun and many other astrophysical bodies produce their own magnetic field by dynamo action, where induction of magnetic field by fluid motion overcomes the Joule dissipation when the magnetic Reynolds number Rm = UL/η is large enough (U and L are characteristic velocity and length-scale and η the magnetic diffusivity). Large scale motion of a conducting medium shearing pre-existing magnetic field lines is a well known process to produce large scale magnetic field by omega-effect. However, such a process cannot sustain a self-excited dynamo and small-scale turbulent motions are usually invoked as the appropriate mechanism to dynamo action.

The contribution of turbulent fluctuations to the induction of mean magnetic field is investigated in our liquid sodium spherical Couette experiment, with an imposed magnetic field. Many measurements are used through an inversion technique to obtain a radial profile of α and β effects together with the mean flow at magnetic Reynolds number Rm = 100.
It appears that the small scale turbulent fluctuations can be modeled as a strong contribution to the magnetic diffusivity which is negative in the interior region and positive close to the outer shell.Direct numerical simulations of our experiment support these results. The lowering of the effective magnetic diffusivity by small scale fluctuations implies that turbulence can actually help to achieve self-generation of large scale magnetic fields.