# Rossby Wave-Zonal Flow Turbulence in a Tangled Magnetic field

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Rossby wave-zonal flow turbulence frequently occurs in presence of a tangled stochastic magnetic field. Tangled fields that coexist with an ordered mean field play a key role in turbulence in the solar tachocline[1] and in magnetic confinement devices. The stochastic field forms an effective viscoelastic (i.e. elastic and dissipative) medium in which the Rossby waves and zonal flows evolve. Simulations[2] also show that interaction of tangled field with Rossby turbulence is multi-faceted. In particular, the magnetic fields affect the phase relation in the vorticity flux, as well as induce a Maxwell stress.

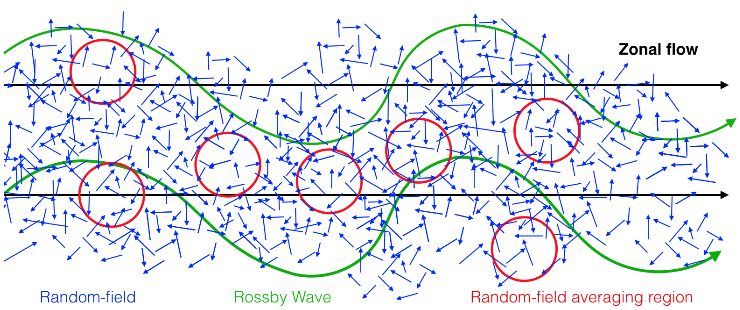


Figure 1: Rossby waves in small-scale random magnetic fields.

We are interested in how tangled small-scale stochastic magnetic fields ($B_r$) might affect the waves and the zonal flow by modifying the transport of mean potential vorticity. In order to understand the complex physics of this nonlinear system, we consider an idealized model where the scales of a the prescribed tangled fields are smaller than those of the Rossby waves. This tangled-field dominated system with high Kubo number cannot be treated by standard quasilinear theory. We developing a "double averaged"theory where we first derive the vorticity and field evolution equations by averaging over the PDF of the stochastic fields. From these evolution equations, we find the mean-field PV equation and the construct quasilinear-type expressions for the vorticity flux and stresses.

The principal results are that the random-field induced stresses damp the Rossby waves, and that the phase relation in vorticity flux is modified by the tangled field. This leads to an suppression of zonal flow– a case of stochastic vortex disruption. This effect occurs at levels of field intensities well below that of Alfvnization, where Maxwell stress balances the Reynolds stress (i.e.$\langle \widetilde{v}_\theta \widetilde{v}_r \rangle \sim \langle B_{R,\theta} B_{R,r} \rangle$). Ongoing work is focused on understanding the feedback of shears on the small scale field.

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[1] S.M. Tobias, P.H. Diamond, D.W. Hughes, *β-Plane Magnetohydrodynamic Turbulence in the Solar Tachocline.*, The Astrophysical Journal Letters, **667**, 11–116, 2007.

[2] S.M. Tobias, P.H. Diamond, D.W. Hughes, *(in preperation)*.