Complexity project

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Title: Non-linear waves, vortices and solitons in two-dimensional plasma turbulence models.

Description:

Turbulence in plasma, its origin and interaction with coherent structures, is one of the most challenging aspects of physics operating far from equilibrium. It is also a topic of practical importance. For example, turbulent transport in magnetically confined fusion plasma is a central problem for future long-pulse fusion reactors, since it relates directly to global confinement properties. Experimental results clearly indicate that turbulent transport in plasmas is dominated by filamentary plasma structures. The generation mechanisms of these filaments are not well understood, but their dynamics can be modelled using reduced numerical models in two dimensions.

In this project, we will examine generic class of mathematical models, such as two-fluid based Charney-Hasegawa-Mima (CHM) equation, which lead to the generation and propagation of long-lived structures. Various extensions of the original CHM model will be considered, for example, scalar non-linearity leading to KdV formulation will be studied. Specifically, we will employ existing, finite difference numerical models to study 1D and 2D solitons, monopole and dipole vortices (for example, Larichev-Reznik modons), including those embedded in a sheared field of a zonal flow. Those will be used for analysis of MAST data set, in particular we will search for signatures of such nonlinear coherent structures in tokamak plasma turbulence. Stability analysis of these models should provide a range of useful predictions, such as estimate of sizes of the ejected structures and their velocities, as well as the dependence of these quantities on bilk plasma parameters. These predictions can be compared with data from MAST (Mega Amp Spherical Tokamak).