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Density gradient driven transport in LTX-like plasma due to Ubiquitous Mode

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Transport in toroidal plasmas is well believed to be driven by drift instabilities arising from gradients present in radial profiles of temperature and density. Temperature gradient driven instabilities such as ion temperature gradient (ITG), trapped electron mode (TEM) are usually the dominating instabilities that drive the microturbulence in burning plasmas. Consequently, these instabilities are well studied and remain a topic of current research. However, recent findings of flat temperature profiles in laboratory plasmas as reported in LTX machine (a tight aspect ratio tokamak) [1,2] are expected to provide a conducive environment for density gradient driven instabilities.

Instabilities driven by density inhomogeneities are referred to as “universal” because some finite density gradient is invariably present in any laboratory plasma system. Universal Drift Modes (UDM) and Ubiquitous Modes (UM) are two such instabilities, primarily driven by passing and trapped electrons, respectively. Both instabilities extract free energy from radial density gradients. A global parametric study of the UM has been previously conducted for tokamak plasmas [3], and more recently, nonlinear transport due to the UM has been investigated for LTX-like equilibrium [4]. However, the effects of the kinetic response of passing electrons and of temperature gradients on the UM remain unexplored.

In the present work, we investigate the role of kinetic passing electrons and the effects of temperature gradients on the Ubiquitous Mode (UM). To carry out the study, a circular equilibrium is constructed using the CHEASE code, employing profiles and parameters similar to those reported in LTX [2]. First, a linear analysis of the UM is carried out, incorporating the kinetic response of passing electrons through global electrostatic simulations using the ORB5 [5] code. This is followed by nonlinear simulations to examine the resulting turbulence and associated transport due to UM in such an equilibrium. Mode structures during the non-linear evolution are shown in Figure 1, where the turbulent phase can be observed after a brief linear phase. Subsequently, temperature profiles with small gradients—insufficient to trigger ITG modes—are considered. A comparison of the linear dispersion relation is made first, followed by a nonlinear analysis of the UM that includes the effects associated with the temperature gradient.

References

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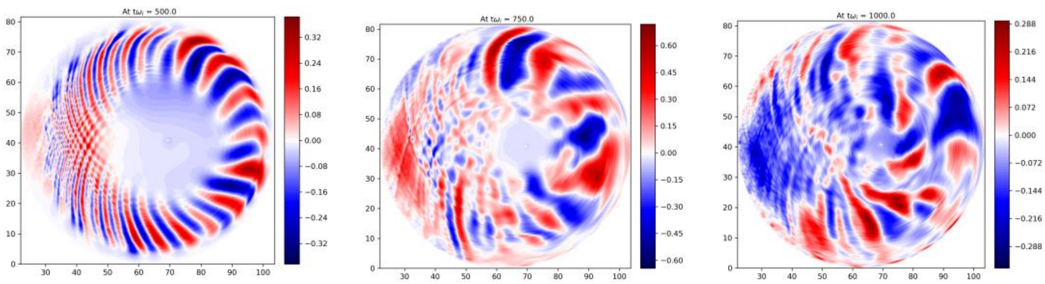

Figure 1. Mode structures of UM at different timesteps during the non-linear evolution with kinetic passing electrons.