Kinetic water-bag model of global drift waves and ITG instabilities in cylindrical geometry - Spectral method

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Ion temperature gradient (ITG) instabilities and collisional drift waves are studied using a linear Vlasov water-bag model [1] for ions and a fluid equation for electrons. The water-bag (WB) concept uses Liouville's invariance to reduce the phase space dimension of the gyrokinetic model. The interesting property of the WB distribution function is the absolute time invariance of the bag heights. The evolution of the system is entirely determined by the evolution of the bag contours in the phase space, the distribution function f remains equal to a constant between two contours.

A new efficient spectral method inspired from fluid dynamics studies [2] allows a fast solving of the global linear problem in cylindrical geometry. The comparison between the linear ITG instability properties thus computed and the ones given by the COLUMBIA experiment [3], shows a qualitative agreement [4]. Moreover the transition between collisional drift waves and ion temperature gradient (ITG) instabilities is studied theoretically as a function of the ion temperature profile.

Another illustration of the spectral method is given by the study of drift waves in the fluid limit of the water-bag model, i.e., in a 2-fluid model. Experiments in MIRABELLE have shown a bifurcation scenario between waves with different azimuthal wavenumber m [5]. The control parameter is the potential of an internal metallic tube in the experiments, the electron drift along the axis of the cylinder in the model. By increasing this parameter, we find bifurcations from azimuthal modes $m = 5$ to $m = 1$. The linear properties of the model agree well with the experimental observations.

References

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