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Nonlinear electrostatic trapping effects on turbulence, transport and anomalous resistivity

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In the context of turbulent transport in hot and dilute plasmas, we draw attention to the ubiquitous phenomenon of collective particle trapping by coherent electrostatic fluctuations [1]. These coherent structures, which resemble vortices in phase-space, exhibit complex dynamics [2,3,4]. They escape the realm of nonlinear theories that rely on linear waves and their nonlinear extension (mode coupling, weak and strong turbulence theories). It is therefore crucial to develop a nonlinear kinetic description of phase-space turbulence [5].

In this paper, we report on numerical experiments of ion-acoustic instability. We show that nonlinear electrostatic trapping has deep impacts on stability [6,7], transport, turbulent heating and anomalous resistivity. In particular, phase-space turbulence is much more efficient than linear waves for driving subcritical instabilities. Fig.1 shows the evolution of electron phase-space in subcritical (linearly stable) ion-acoustic turbulence. An initial electron hole drives an instability nonlinearly, by stirring the phase-space in its wake. Transport is due to the ballistic propagation of many holes. On a much longer time-scale, we observe a self-organization into a non-thermal equilibrium. These results, and their extension to magnetized plasmas [8,9], have broad implications for fusion plasma physics.

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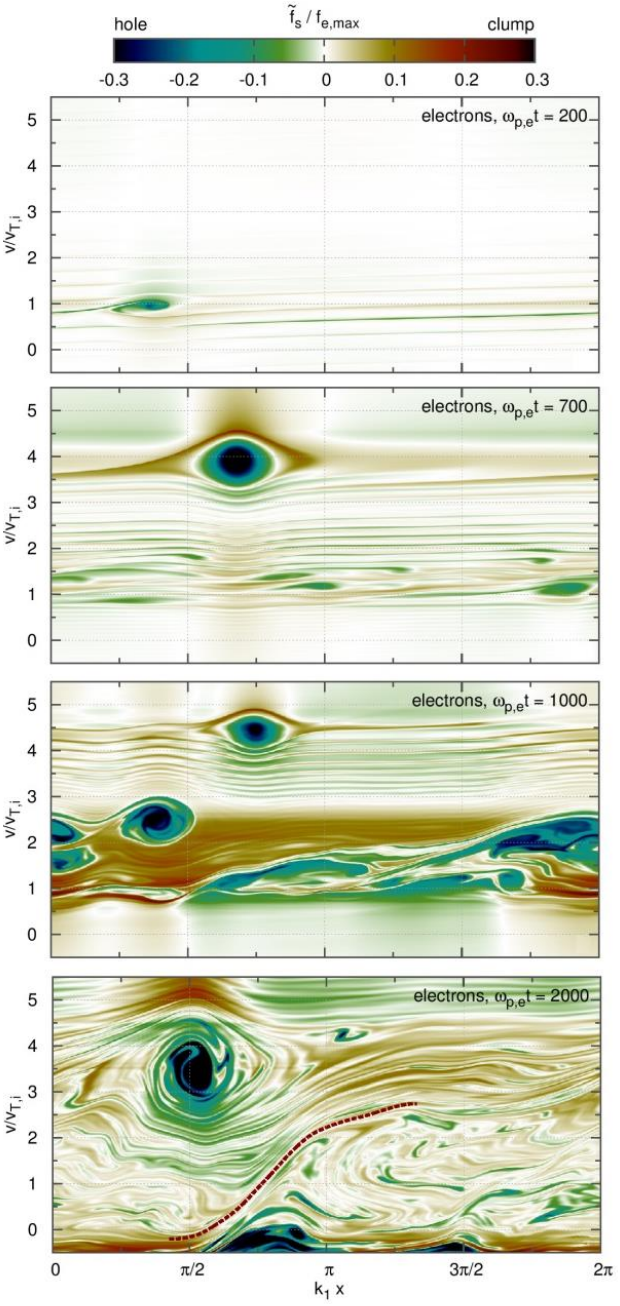

Fig.1. Snapshots of the electron phase-space in a subcritical ion-acoustic simulation.