Subcritical instabilities destabilized by kinetic nonlinearities in hot plasmas

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Subcritical instabilities (nonlinear instabilities, which grow despite being linearly damped), or sub-marginal turbulence, are ubiquitous in fluids and plasmas [1]. These include small-scale turbulence (e.g. pipe flow) and large-scale perturbations (e.g. Kelvin-Helmholtz instability). In collisionless plasmas in particular, it is known that in theory, linearly stable large-scale modes can be destabilized nonlinearly by the dynamics of structures in the phase-space (position/velocity) of particle distributions [2]. In this presentation, we will review the theories of subcritical instabilities, with an emphasis on those driven by kinetic nonlinearities such as particle-trapping in phase-space (as opposed to those driven by fluid nonlinearities, such as parametric or modulational coupling).

Going further, we will introduce our latest addition to the theory, which is applicable to large-scale electromagnetic modes driven by energetic (suprathermal) particles. A new mechanism of subcritical instability was found, where growth requires a sustained collaboration between kinetic and fluid non-linearities [3]. This theory provides a viable interpretation for a surprising observation [4] of abrupt destabilization of large-amplitude, macroscale electromagnetic mode. The theory suggests that this is the first observation of a subcritical instability driven by kinetic nonlinearities. We will discuss how this involves synchronization phenomena, and how our theory contributes to the understanding of the long-lasting "trigger problem", concerning the onset of abruptly growing modes in general.

Références

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