PHYSICAL MATH SEMINAR

Following marginal stability manifolds in quasilinear dynamical reductions of multiscale flows in two space dimensions

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ABSTRACT:

We extend a recently developed formalism for slow–fast quasilinear (QL) systems with fast instabilities to two dimensions (2D). These systems exhibit slow evolution of mean fields coupled to marginally stable, fast fluctuations. Exploiting this scale separation enables an efficient hybrid algorithm: fast fluctuation amplitudes are slaved to the slowly evolving mean fields to maintain marginal stability and temporal scale separation. In 2D, fluctuation eigenfunctions are indexed by Fourier wavenumbers, and the marginal mode must correspond to the fastest-growing mode among all admissible wavenumbers.

We derive an ordinary differential equation governing the slow evolution of this wavenumber, constrained to maintain zero growth rate. The approach is demonstrated using a 2D model PDE resembling equations for strongly stratified shear flows and other geophysical turbulence in extreme parameter regimes. The slaved evolution tracks marginal stability manifolds—state-space structures that, while not fully invariant, capture quasi-coherent structures akin to invariant solutions in transitionally-turbulent shear flows. We propose these manifolds as key organizing structures in a dynamical systems framework for multiscale flows where QL approximation is justified by scale separation.

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2:30 PM – 3:30 PM

Building 2, Room 449

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