LadHyX Seminar — March 26, 10:45

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Instabilities and transition in stratified and compressible flows

Flow instability and laminar-to-turbulence transition in stratified and compressible flows have significant importance in geophysical and high-speed flows. They have been one of the most popular subjects of fluid dynamics research for decades, but there still exist lots of unresolved issues. For instance, the instability mechanism and route-to-turbulence of geophysical vortices are crucial for momentum transfers in the atmosphere and oceans but are not fully understood. The transition to turbulence in hypersonic flows also requires further investigation to establish robust flow control strategies for better high-speed vehicle performances.

In the first part of the presentation, I review fundamentals of geophysical fluid dynamics and stability of vortices in stratified and rotating fluids. I examine the inertia-gravity wave emission on stratified vortices in the presence of the Coriolis force and analyze the stability both numerically and theoretically by means of the WKBJ approximation. Moreover, I present some recent numerical and experimental work on the Taylor-Couette flow in stratified fluids to discuss instabilities, the onset of transition, and fully-developed turbulence.

Secondly, I describe instability and transition to turbulence in compressible high-speed boundary layers. Then I formulate the sensitivity of instability to base-flow distortion by means of theoretical adjoint analysis and numerical techniques using parabolized stability equations. The sensitivity analysis provides a more robust prediction of flow stability in the presence of uncertainties in the mean velocity and temperature profiles of the boundary layer flows. I also discuss the uncertainty due to wall heating.