PHYSICAL MATHEMATICS SEMINAR

STABILITY PROBLEMS IN THE CONTINUUM LIMIT

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ABSTRACT:

We study the hydrodynamic stability of rarefied gas flows. While the problems under consideration are already well known in the context of incompressible fluids there is evident interest in clarifying the effects of rarefaction on instability phenomena, especially in the limit of small Knudsen numbers ('continuum limit'). Stability analyses of rarefied gas flows have appeared in the literature during the last decade and are essentially based on numerical simulations. However, the statistical `noise' and time demands of these simulations at low Knudsen numbers makes it difficult to clearly identify and characterize the final states obtained, especially in the vicinity of transition to instability. Consequently, only two-dimensional investigations are available in limited number of parameter combinations .

We focus on linear temporal stability analysis of rarefied gas flows. Making use of the 'slip-flow' model, we consider the classical Rayleigh-Bénard and Taylor-Couette problem. The results obtained enable exact delineation of instability domains and characterization of the transition states in each problem. Good agreement is found with simulation results appearing in the literature and carried out during the research. In all cases considered we find that instability phenomena are limited to small Knudsen numbers. We show that this results from the combined effects of viscous and compressible mechanisms in the fluid. The effect of slip and jump boundary conditions is comparatively negligible. In the Rayleigh-Bénard problem the convection domain is confined to small Knudsen numbers due to the combined effects of a minimal Rayleigh number criterion and a mechanism of adiabatic expansion. In the Taylor-Couette problem the instability domain is bounded by a minimal value of the Reynolds number at low Mach numbers and a mechanism related to large dissipation rates at high Mach. Additionally, we show that the traditional Boussinesq approximation used in the Rayleigh-Bénard problem becomes singular when compressibility effects are dominant and analyse this case asymptotically.

TUESDAY, NOVEMBER 14, 2006
2:30 PM
Building 4, Room 270

Refreshments at 3:30 PM in Building 2, Room 349
(Applied Math Common Room)

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