Boulder Fluid Dynamics Seminar Series

Tuesday, December 2, 2014
3:30pm-4:30pm (refreshments at 3:15pm)
Bechtel Collaboratory in the Discovery Learning Center (DLC)
University of Colorado at Boulder

Attacking low Rossby number convective flows via asymptotics, simulations and experiments

Keith Julien, *University of Colorado, Boulder*

Convection in a rotating layer of fluid has been the subject of a great deal of theoretical and experimental research. This problem is relevant to convectively driven fluid flows in the Earth's atmosphere, ocean and interior and also in the Sun and other stars, where the influence of rotation is generally important. In general numerical simulations of rotationally constrained flows are unable to reach realistic parameter values, e.g., Reynolds (Re) and Richardson (Ri) numbers. In particular, low values of Rossby number (Ro), defining the extent of rotational constraint, compound the already prohibitive temporal and spatial restrictions present for high-Re simulations by engendering high frequency inertial waves and the development of thin (Ekman) boundary layers. Extensive explorations of low Rossby number - high Rayleigh number convection present a fundamental challenge for both laboratory experiments and DNS. While simulations of asymptotically reduced system of equations valid in the limit of strong rotation has provided some progress in characterizing the possible fluid states some important discrepancies still remain. In this talk Rapidly rotating Rayleigh-Bénard convection is studied by combining results from direct numerical simulations (DNS), laboratory experiments and asymptotic modeling.

Characteristic-based Volume Penalization Method for Arbitrary Mach Flows Around Solid Obstacles

Nurlybek Kasimov, *University of Colorado, Boulder*

A new volume penalization method to enforce immersed boundary conditions in Navier-Stokes and Euler equations is presented. Previously, Brinkman penalization has been used to introduce solid obstacles modeled as porous media. This approach is limited to Dirichlet-type conditions on velocity and temperature, and in inviscid supersonic flows led to wrong shock reflection. It builds upon Brinkman penalization by allowing Neumann conditions to be applied in a general fashion. Correct boundary conditions are achieved through characteristic propagation into the thin layer inside of the obstacle. Inward pointing characteristics ensure nonphysical solution inside the obstacle does not propagate out to the fluid. Dirichlet boundary conditions are enforced similarly to Brinkman method. Penalization parameters are chosen so they act on a much smaller timescale than the characteristic timescale of the flow. Main advantage of this method is systematic means of controlling the error. This approach is general and applicable to a wide variety of flow regimes. This talk is focused on the progress that was made towards moving obstacles and method extension to the 3D flows around irregular shapes.