Abstract

A high resolution spectrally accurate three-dimensional flow solver is developed in order to simulate convection dominated fluid flows. The governing incompressible Navier Stokes equations along with the energy equation for temperature are discretized using a second-order accurate projection method which utilizes Adams Bashforth and Backward Differentiation formula for temporal discretization of the non-linear convective and linear viscous terms, respectively. Spatial discretization is performed using a Fourier/Chebyshev spectral method. Extensive tests on three-dimensional Taylor Couette flow are performed and it is shown that the method successfully captures the different states ranging from formation of Taylor vortices to wavy vortex regime. Next, the code is validated for convection dominated flows through a comprehensive comparison of the results for two dimensional Rayleigh Benard convection with the theoretical and experimental results from the literature. Finally, fully parallel simulations, with efficient utilization of computational resources and memory, are performed on a model three-dimensional axially homogeneous Rayleigh Benard convection problem in order to explore the high Rayleigh number flows and to test the scaling of global properties.