Magnetic resonance imaging study of Rayleigh-Benard convection in near and supercritical hexafluoroethane

JOSHUA M. BRAY, SARAH L. CODD, Mechanical and Industrial Engineering, Montana State University, JOSEPH D. SEYMOUR, Chemical and Biological Engineering, Montana State University — Rayleigh-Benard convection (RBC) has been extensively studied; however, the regime of temperature and pressure above the critical point (Tc, Pc) remains largely unexplored experimentally. In this regime, convection modes are sensitive to divergence in various transport properties, providing a unique model system for many geophysical flows and allowing access to high Rayleigh numbers $Ra$, of order $10^{13}$. We present magnetic resonance imaging (MRI) analysis of RBC in a supercritical fluid. Spatially resolved velocity images and ensemble-averaged transport dynamics were acquired non-invasively for C$_2$F$_6$ ($Tc = 20$ C, $Pc = 31$ bar) in a low aspect ratio chamber at pressures 32 bar and 70 bar with and without a 2.5 C temperature gradient. With no applied gradient, within the temperature control resolution of +/-0.1 C, convection at 70 bar is minimal, but is rapid at 32 bar due to near-critical density divergence. The velocity profile is concentric, in contrast to a single convective cell in non-critical fluids. An applied temperature gradient produced turbulent flow, destabilizing the concentric velocity distribution at 70 bar and generating incoherent fluid motion at 32 bar. Near and supercritical fluids provide a model system for tuning fluid dynamics through thermodynamics.

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