

Benchmark Comparison of Numerical Simulations in 2-D Buoyancy Driven Convection

Introduction

A comparison of the commercial code COMSOL is performed with the benchmark solution provided by P. Le Quere and J. Pecheux for a tall, differentially heated annulus. The stability of the flow in an annulus is governed by the Prandtl number (Pr), the Rayleigh number (Ra) and the geometry of the annulus. At small Rayleigh numbers the flow is dominated by conduction. As the Rayleigh number is increased the flow becomes unstable, first resulting in multicellular secondary flow patterns, and then as the Rayleigh number is further increased the flow becomes turbulent. The benchmark solution is based on a pseudospectral Chebyshev spatial expansion with a second-order time stepping scheme. Comparison of the predicted wavenumber, period, and characteristic streamfunctions are shown. The effect of COMSOL's numerical diffusion options are evaluated. Results are also compared to the commercial code FIDAP.

Use of COMSOL Multiphysics

COMSOL has been used to model this problem and explore the instability of the natural convection in this geometry. This paper is part of a broader effort to model the critical Rayleigh number of a similar system with a parabolic wall condition using COMSOL. The benchmark solution explores the numerical diffusion options in COMSOL with applications to a buoyancy driven flow which may provide useful insights to other researchers.