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Layered convection in double diffusive fluids

F. Zaussinger (1), F. Kupka (2), H. J. Muthsam (2), N. Happenhofer (2), and H. Grimm-Strele (2)
(1) BTU-Cottbus, Aerodynamics and Fluid Mechanics, Cottbus, Germany, (2) University of Vienna, Faculty of Mathematics, Vienna, Austria

Double diffusive convection plays an important role in astrophysics and oceanography where under certain conditions a thermally unstable temperature gradient is counteracted by a stable solute gradient. This configuration is well known from salt lakes, where the salt concentration stabilizes convective motions and a layered structure emerges. Similar conditions are found in stellar interiors, where helium as the stabilizing component inhibits the development of convection and the occurrence of double-diffusive staircases is assumed.

We investigate mixing timescales and stability conditions using theoretical estimates and numerical simulations covering a broad range of parameter sets by varying Prandtl-, Lewis- and Rayleigh numbers. To shed light on the numerically inaccessible astrophysical case we extrapolate to the relevant parameter range. We investigate the initial layer formation process as well as the stability of evolved layers by performing direct numerical simulations in 2D and 3D using the Boussinesq approximation. A fitting formula for the Nusselt numbers and the effective mixing rates is given. Finally, we present a semi-implicit method to solve the compressible counterpart of the governing equations which has the advantage to cover the entire relevant Mach number range.