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Numerical simulations of thermal convection at high Prandtl numbers

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Direct numerical simulations of thermal convection are conducted for a cylindrical cell of aspect ratio $1/2$. The Prandtl number (Pr) varies from 10^0 to 10^4 and the Rayleigh numbers (Ra) are moderate ($10^5 < \mathrm{Ra} < 10^9$). This study is motivated by the fact that the role of the Prandtl number in convective heat transport is not yet fully understood. The three-dimensional behaviors of the temperature and velocity fields, of the viscous and thermal dissipation fields, and of the diffusive and convective heat fluxes are explored. In the ranges of Pr and Ra considered, we find steady, periodic and chaotic regimes, and large-scale structures which are more complex than the single recirculation cell filling the whole volume. Multiple flow structures are found to be associated with a given set of conditions. The multiple solutions seem to be more probable at higher Pr numbers and could explain the scatter in some data trends. In collaboration with Katepalli Raju Sreenivasan, The Abdus Salam International Centre for Theoretical Physics - Trieste, and Roberto Verzicco, DIM, Università degli Studi di Roma Tor Vergata - Roma.