Thermo electro hydrodynamic convection at moderate Rayleigh numbers in rectangular cavity

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Thermo-electro-hydrodynamic (TEHD) describes convective flows with a buoyancy force generated by an electric potential. This is investigated in numerical and experimental setups by filling a gap between two plates or cylindrical annulus or spherical shells with a non-conducting dielectric fluid. Then, a temperature gradient, and a high frequency AC Voltage is applied at the boundaries. This induced a dielectrophoretic force $\vec{f}_{DEP} = \frac{1}{2}\vec{E}^2\nabla\epsilon$, with $\vec{E}$ as electric field and ϵ as temperature dependent permittivity. From this force, an electrical gravity equivalent can be derived and an electric Rayleigh number defined. Thus, an analogy to classical Rayleigh-Bénard convection is established. A good overview is given by Mutabazi et al.[1]. However, the direction and strength of forcing is controlled by the geometrical constraints and the applied Voltage. Furthermore, this dielectrophoretic force is utilized to establish a central force field in microgravity experiments of geophysical[2] and atmospherical[3] purpose. In this study, 2D DNS simulations in a rectangular cavity, from the onset of convection up to a Rayleigh number of $Ra_{el} = 10^7$where made and boundary layer thickness, velocity, heat flux and flow structure are investigated. The results are compared to terrestrial gravity driven Rayleigh-Bénard convection. For low Rayleigh number, similar structures are observed. But at moderate Rayleigh number, where classical Rayleigh Bénard convection is expected to become chaotic and time dependent, in TEHD a strict ordered flow structure is observed, as presented in Fig. 1.

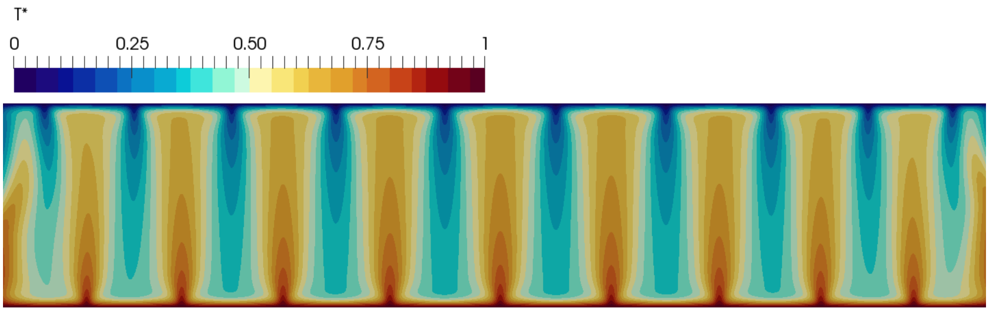

Figure 1: Temperature field in TEHD convection in rectangular cavity at electrical Rayleigh number of 2×10^6, 2D simulation, adiabatic boundaries left and right, w/h aspect ratio of 5.

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[1]Mutabazi et al. *Fluid Dyn. Res.* **061413**, 46 (2016).

[2]Zaussinger et al. *Phys. Rev. Fluids* **063502**, 5 (2020).

[3]Zaussinger et al., *Microgravity Sci. Technol.* **569–587**, 31 (2019).