Superstructures and turbulent heat and momentum transport in inclined low-Prandtl-number convection

The project is devoted to the investigation of the origin and dynamics of the superstructures that develop in inclined turbulent thermal convection in low Prandtl-number fluids. These superstructures are clusters of the thermal plumes that follow the large-scale circulation of the fluid. Within the project, algorithms to identify, extract and analyze the geometrical and physical properties of the superstructures and their temporal evolution are to be developed or advanced. The superstructures will be extracted from the flow fields that will be generated in our direct numerical simulations. The focus here will be on low Prandtl-number fluids, like in liquid metals, and on slender convection cells, where a favourable combination of buoyancy and shear in a tilted thermal convection cell can significantly enhance the heat transfer, compared to the classical Rayleigh-Bénard convection without any cell tilt. In particular, we will investigate the contribution of the superstructures to the global heat and momentum transport in the system, which are expressed, respectively, by the Nusselt and Reynolds numbers. Furthermore, the influence on the superstructures dynamics of the control parameters, such as the Rayleigh number, Prandtl number, convection cell length ratios and the angle of inclination, will be studied. Finally, the relationship between the local heat transport (Nusselt number) and the instantaneous form of the superstructure will be investigated.

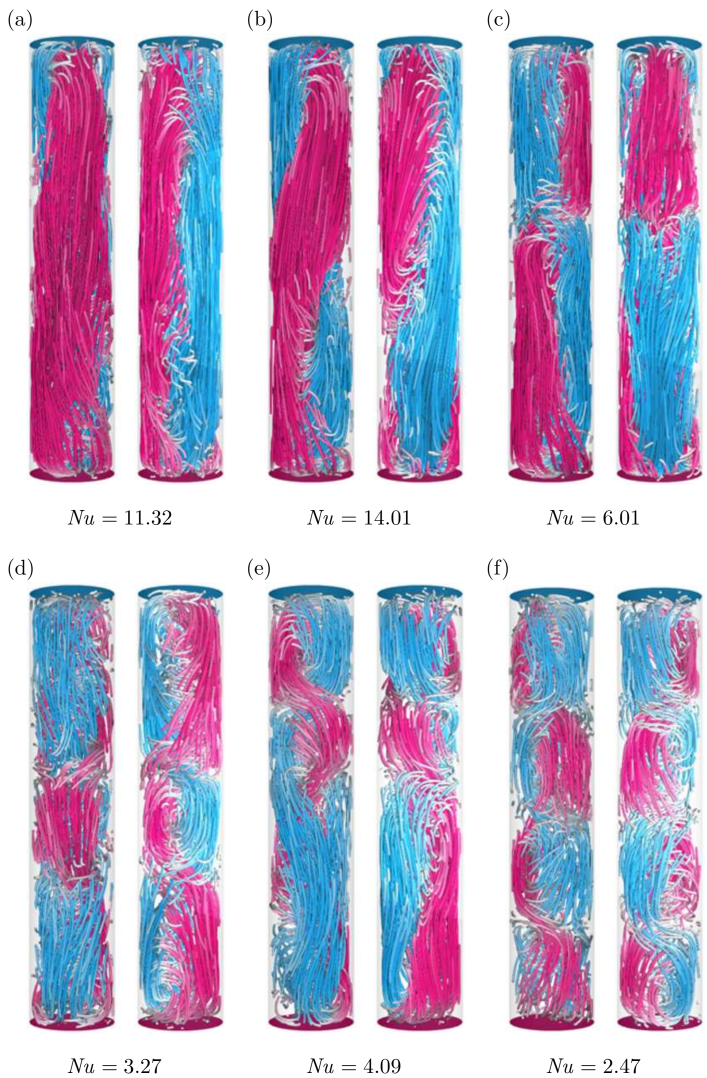

Figure 1: Visualizations of the instantaneous flow fields from two perpendicular perspectives of the flow for different number of rolls n: a) $n = 1$, b) twisted $n = 1$ c) $n = 2$, d) $n = 3$, e) $n = 3$ (two small + one large), f) $n = 4$; The snapshots show trajectories of passive tracer particles (obtained with the ParaView *"Particle Tracer"*-Filter) and their color reflects the vertical velocity component (upward flow in red and downward flow in blue). The instantaneous Nusselt numbers $Nu(t)$ are given. Parameters: $Ra = 5 \times 10^6$, $Pr = 0.1$, $H = 5D$.