Dynamics of semi- and neutrally-buoyant particles in thermally stratified turbulent channel flows

M.X. Zhang[1], F. Zonta[2], Z.F. Tian[1], G.J. Nathan[1], R.C. Chin[1] and A. Soldati[2,3]
[1] Centre for Energy Technology, School of Mechanical Engineering
The University of Adelaide, Adelaide, Australia
[2] Institute of Fluid Mechanics and Heat Transfer, TU Wien, Vienna, Austria
[3] DPIA, University of Udine, Udine, Italy

Many environmental flows laden with particles, from the air circulation and contaminant dispersion in the urban area to floaters moving in water bodies, are influenced by the presence of stratification. The ability to predict the mixing and dispersion of particles in these situations is therefore of great importance. Stably-stratified flows are characterised by the presence of internal gravity waves (IGWs), which constitute a barrier for mass, heat, momentum and species vertical transport (Zonta & Soldati, 2018).

In this study, the dynamics of semi- and neutrally-buoyant particles in three-dimensional, stably-stratified turbulent channel flow is investigated, using direct numerical simulations (DNS), one-way coupled with a Lagrangian particle tracking (LPT) routine. The fluid is characterised by a shear Reynolds number $Re_\tau = 1000$ and a shear Richardson number $Ri_\tau = 200$, such that the turbulence is sustained only in the near-wall region, whereas IGWs are observed at the core of the channel. Different sets of particles, with each set containing one million of particles and a particle-to-fluid density ratio $\rho_r = 1.0$ or 0.8, are released into the system at different distance from the wall. Results indicate that particles released in the near-wall region are significantly influenced by the near-wall vortices and show chaotic pathlines. In contrast, particles released at the channel core exhibit smooth oscillating movements which are determined by IGWs (see Fig. 1). An in-depth analysis, including particles acceleration and dispersion, is also performed to further characterize the dynamics of particles.

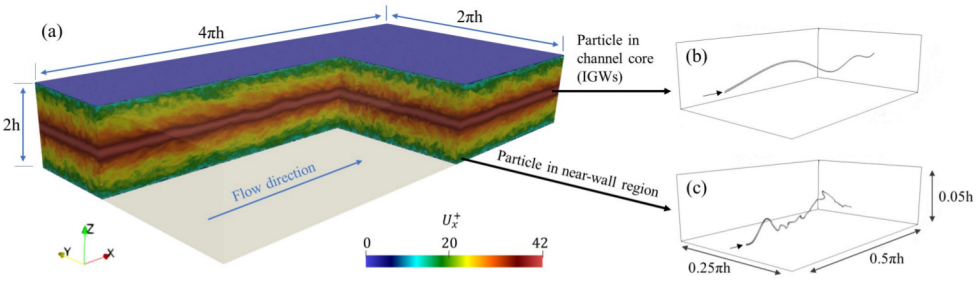

Figure 1: Flow structure (left) and particle trajectories near the boundary and at the channel core.

References

Zonta, F., Soldati, A., 2018. Stably stratified wall-bounded turbulence. Applied Mechanics Reviews 70, 040801.