Dynamics of solid particles in turbulent flows

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The transport of solid particles in turbulent flows is of relevance in various fields, like air quality management (indoor pollution), particle laden industrial flows and in the physics of rain formation. One of the most interesting questions about solid particle transport is the influence of turbulence on the deposition rates.

In this talk, some aspects of the stochastic approach to modelling turbulent dispersion will be illustrated. In particular, two problems must be discussed.

The first one is the *trajectory crossing* effect, due to the inertia of particles and to gravity, related to the ratio of the Stokes relaxation time scale τ_s and the turbulent time scale (e.g., the Eulerian time scale τ_e). This effect produces a *selection* mechanism, with different statistics of the turbulent flow being *sampled* along particle trajectory. This happens in particular at sufficiently short time scales (less than τ_s), when the particle may see the turbulent flow as frozen.

The second one is related to the inertial range of turbulence. If we consider the turbulent time scales in the inertial range, the fluid velocity variations experienced by the particle can be characterized by an *anomalous scaling* ($\langle du^2 \rangle$ not linear in time), in which the scaling exponent depends on the dynamical evolution.

One of the main goals in recent research is just the modelling of these two effects (selecting mechanics and anomalous scaling).

In this work we shall focus on the first aspect, neglecting the second one. This is possible considering only time scales above the inertial range. This is often the most interesting situation. Furthermore, this constrain allows us not to consider the existence of an inertial range (fully developed turbulence), so that also low Reynolds number regimes can be treated.

We are currently working on the derivation of an operative stochastic model, with the ability to treat solid particle transport in complex geometry, keeping into account the possible presence of low Reynolds number regions near the flow boundaries. The model is based on the generation of a random field with given one-point statistics (known by DNS or by experiments) and modelled two-point statistics (but only for small separations). Then, the particle trajectories are simply *extracted* from the random field. In a channel flow geometry, the simplest implementation of the model

(Gaussian statistics, isotropic small scales i.e. no coherent structures) qualitatively reproduces the experimentally observed near-wall accumulation effect of low-inertia particles.

In the near future, our code will be coupled in cascade with a CFD model which will provide the flow field characteristics in input.

References

[1] P.Olla "Transport properties of heavy particles in high Reynolds number flows" Phys. Fluids **14**, 4266 (2002)

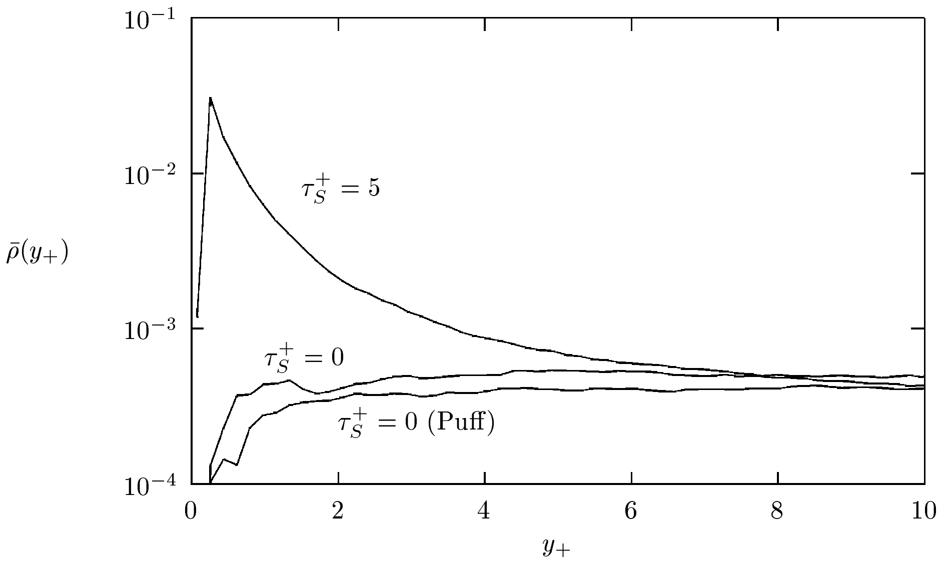

Figure 1: Concentration profiles after 20 eddy turnover times at mid-channel, for very small particles ($\tau^+ = 5$, i.e. Stokes time in the viscous range) and passive tracers ($\tau_S = 0$). With the exception of the *puff* case (instantaneous release at mid-channel), the initial condition was a uniform particle distribution. Notice the near wall concentration peak from solid particles trapped in the near wall region because of their inertia.