Particle mixing and collision processes in turbulent suspensions

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Abstract

This seminar is about the role turbulent structures play in the transport, mixing and collisions of small particles suspended in a turbulent flowing gas: how under certain circumstances such structures can cause suspended particles to cluster and agglomerate. It is also about the methods and approaches that have been used to simulate and model these processes. The particles are not passive scalars, they do not follow precisely the motion of the carrier flow, either the mean flow, or the large or small scale structures of the underlying turbulence. Such particles are referred to as inertial particles. So my seminar in particular is about the way these inertial particles respond individually to both the large and small scale structures of the turbulence and in turn through their response how the turbulence disperses and demixes them, how it deposits them to surfaces exposed to the flow, and how it brings the individual particles closer together and enhances their collision rates. I will show how these processes can be described and analyzed by a PDF approach analogous to that used in Classical Kinetic Theory. For large scale dispersion the focus will be on transport in simple generic flows like statistically stationary homogeneous isotropic turbulence and simple shear flows. Special consideration will be given to the transport and deposition of particles in turbulent boundary layers. For small scale transport the focus will be on how the small scales of the turbulence together with the particle inertial response enhances collision processes like particle agglomeration. In this case the importance of segregation and the formation of caustics, singularities and random uncorrelated motion will be highlighted and discussed.

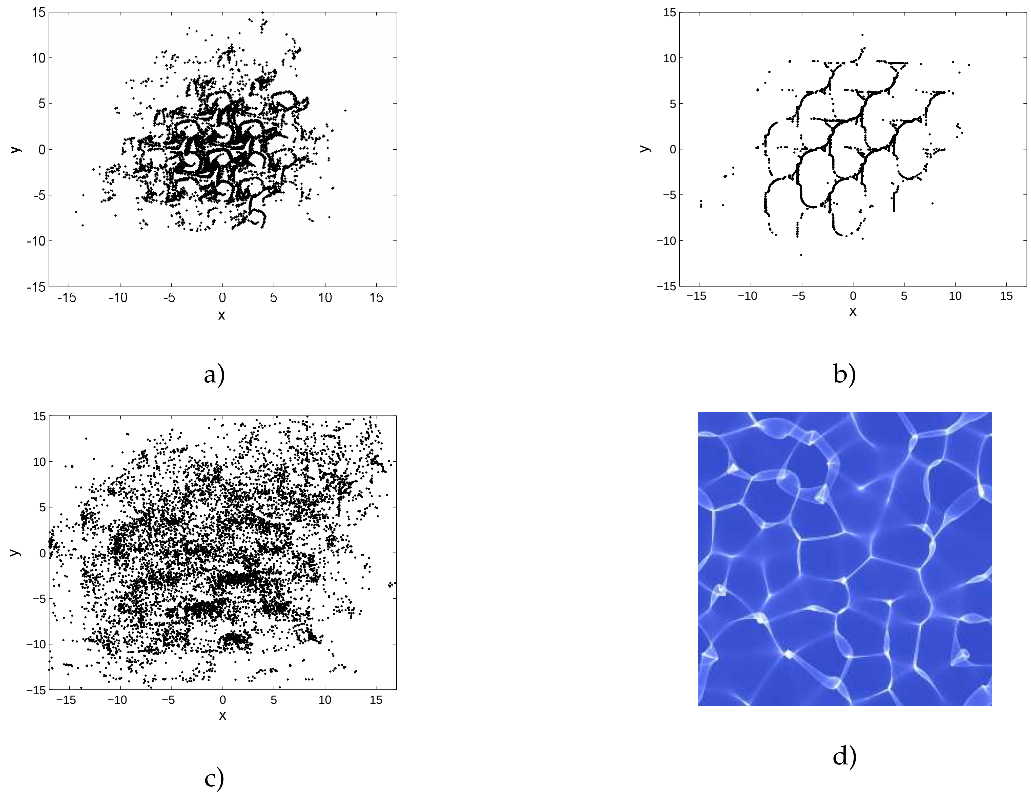

Figure 1: a)-c) Positions of 10^4 particles after time $t = 20$ in a non-isotropic random straining flow, for (a) $St = 0.05$, (b) $St = 0.5$, (c) a $St = 5$ and (d) Caustics at the bottom of a swimming pool.

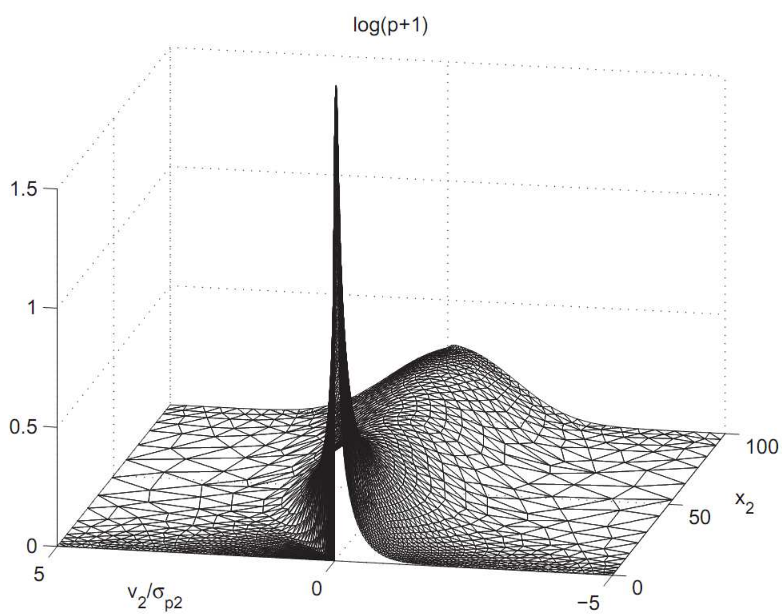

Figure 2: Inertial particle deposition in a fully developed turbulent boundary layer: the particle near wall phase space density $p(v_2, x_2)$ as a function of distance from the wall x_2; the particle response time $\tau^+ = 10$ (both τ^+ and x_2 are in wall units), v_2 is the particle velocity in the wall normal direction and σ_{p2} is the corresponding local particle equilibrium rms velocity.