Particle-turbulence interaction

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We study the interaction between a turbulent flow and a spherical particle. Our approach is based on the *Physalis* method [1, 2], the analytical and numerical implementation of which being described in [2, 3, 4].

This method, designed for the simulation of Navier-Stokes flows with rigid spheres, exploits the no-slip condition to linearize the flow around a rigid body motion in the vicinity of each particle. In this way, an analytical solution, valid inside the boundary layer, is available. The flow at a greater distance is calculated by using a standard finite-difference projection method. One of the major advantages of this method is the fact that the hydrodynamic force and torque acting on the particles are calculated from first principles, without any parameterization. Also, thanks to the two-fold representation of the flow (analytical/numerical), one demands that the finite-difference solution matches the local solution at the points of a suitable cage of nodes surrounding the particle. In this way, the geometric complexity arising from the mismatch between a regular (Cartesian) grid and the particle boundaries is avoided: a finite-difference grid covers the entire domain, irrespective of the presence of the spheres.

In order to study the interaction between particles and stationary turbulence, we impose to the flow a linear forcing: $\vec{F} = A\vec{u}$, proportional to the velocity [5]. Prescribing the parameter A and keeping it constant during a simulation is equivalent to imposing a prescribed turnover time scale. Our choice for this forcing has been motivated by two criteria: (i) it acts in the physical space; (ii) it tends towards zero as one approaches the particle surface (in the particle rest frame).

We investigate the two-way coupling between turbulence and a particle, as a function of the ratio between the particle diameter and the Kolmogorov scale.

References

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