Two-way coupled simulations of ellipsoidal particles suspended in a turbulent channel flow

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This paper aims to present a mixed Eulerian-Lagrangian approach to simulations of dilute suspensions of solid ellipsoidal particles in turbulent fluid flows. The focus is mainly on the turbulence modulations induced by the presence of ellipsoidal particles. To achieve this goal, based on the Newton's third law, a two-way force-coupling scheme is implemented in a Navier-Stokes solver in order to study the detailed force interactions between the ellipsoidal particles and the carrier fluid. The turbulence field is fully resolved by means of Direct Numerical Simulations (DNS) at a frictional Reynolds number 360 (based on the wall distance h). The translational and rotational motions of the particles are handled by a Lagrangian point-particle approach. The size of the particles is assumed to be smaller than the smallest eddies and the particle Reynolds number is below unity.

A case with translational response time 30 and particle aspect ratio 10 was selected and simulated with 5 million particles. The results with force-coupling indicate an expected increase of mean bulk velocity as compared with the unladen flow. Furthermore, the streamwise turbulent intensity is augmented whereas the spanwise turbulent intensity and, in particular, the Reynolds shear stress are attenuated compared with the unladen flow. By looking at the instantaneous velocity contours, we observed that the overall turbulence is suppressed, i.e. the small-scale eddies are damped, and the flow comprises larger eddies than a flow without particles.