Settling of moderately dense inertial particles in turbulence

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We present experimental observations of the dynamics of inertial particles settling in a turbulent flow of water at high Reynolds number. The flow is generated by 16 pumps firing upwards in a spatio-temporally random way and located at the bottom of a water column with a square section 30×30 cm^2 and height 200 cm (figure 1, left). This unsteady forcing, inspired from the work of Variano and Cowen[1], creates a turbulent flow that decays downstream the jets but shows a good isotropy and a weak mean flow far enough from the jets with a Reynolds number $Re_\lambda \simeq 300$ with a dissipative scale $\eta \simeq 180$ μm, and a turbulent velocity $u' \simeq 5$ cm.s^{-1}.

We focus on nearly spherical glass particles with density ratio $\rho_p/\rho_f = 2.4$ with a diameter $d_p = [350, 550, 750]$ μm which are tracked in a thick laser sheet of $6 \times 6 \times 0.6$ cm^3 together with fluorescent tracers using a two colors Particle Tracking setup. As the laser sheet is thick, it is possible to compute the mean settling velocity of the particles, $\langle v_z \rangle$, while conditioning flow properties around them. Depending on the particles Rouse number $Ro = v_s/u'$, where v_s is the particles settling velocity in quiescent water, we observe that settling velocity is 35% larger at small Rouse number, the enhancement decreasing when increasing the Rouse number as observed in numerical simulations [2] and experiments [3] in the case of large density ratios $\rho_p/\rho_f \gg 1$. Conditioning the flow statistics around particles indicate that the slippage velocity between phases remains close to that of quiescent fluid, the enhancement being attributed to preferential sampling of downward velocity regions.

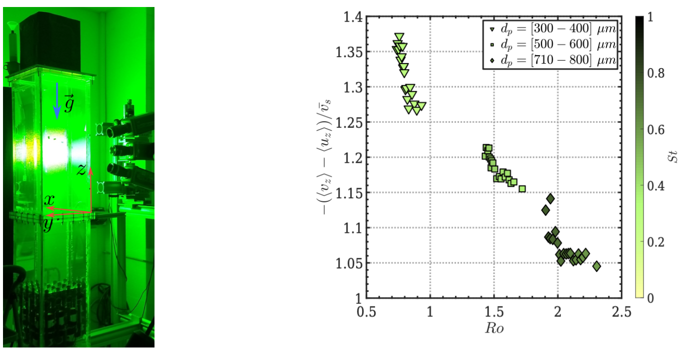

Figure 1: Left: photograph of the water tower with the pumps at the bottom and the 3 high speed cameras and laser sheet. Right: Normalized settling speed of the particles with respect to the fluid. $\langle v_z \rangle$ is the particle mean vertical velocity, $\langle u_z \rangle$ is the fluid mean vertical velocity in the field of view, and v_s the particle settling velocity measured in quiescent water. Ro is the Rouse number v_s/u', where $u' = \sqrt{\langle u_z^2 \rangle - \langle u_z \rangle^2}$ is the turbulent velocity.

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[1]Variano and Cowen, *J. Fluid Mech.* **604**,1-32 (2008).

[2]Good, Ireland, Bewley, Bodenschatz, Collins, and Warhaft. *J. Fluid Mech.* **759**,R3 (2014)

[3]Berk and Coletti. *J. Fluid Mech.* **917**,A47 (2021)