Lift-induced drag increase in turbulent wall transport of small inertial particles

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Recent particle-resolved simulations of small inertial particles in turbulent channel flow have shown that lift forces play a key role in near-wall turbulence modulation (Costa *et al.* *J. Fluid Mech.* 922 A9 (2021)). This type of simulations allows us to unveil the dynamics of small inertial particles in these flows with little modeling assumptions, but they are too expensive to be used in upscaled models. Accordingly, point-particle simulations have been the method of choice to simulate the dynamics of these flows during the last decades. While this approach is simpler, cheaper, and physically sound for small inertial particles in turbulence, a few outstanding issues remain. In the present work, we address the effect of lift force models in near-wall turbulence modulation observed in two-way-coupled point-particle simulations, their fidelity, and the implications of not considering lift forces. We performed two-way-coupled direct numerical simulations (DNS) of small inertial point-particles in turbulent channel flow at fixed Stokes number for varying particle sizes and mass loading. The results confirm the importance of lift forces and that the choice of lift force model significantly impacts basic turbulent statistics. Figure 1 illustrates this for the Reynolds stresses profile of a DNS at friction Reynolds number $\mathrm{Re}_\tau \approx 180$: the standard Saffman lift model dampens fluid Reynolds shear stresses, while other, more accurate variants do not show modulation of this quantity.

At the conference, we will present the results from the current simulation campaign and discuss in detail the mechanisms for turbulence modulation due to the different lift force models and comment on their fidelity in light of observations from particle-resolved simulations.

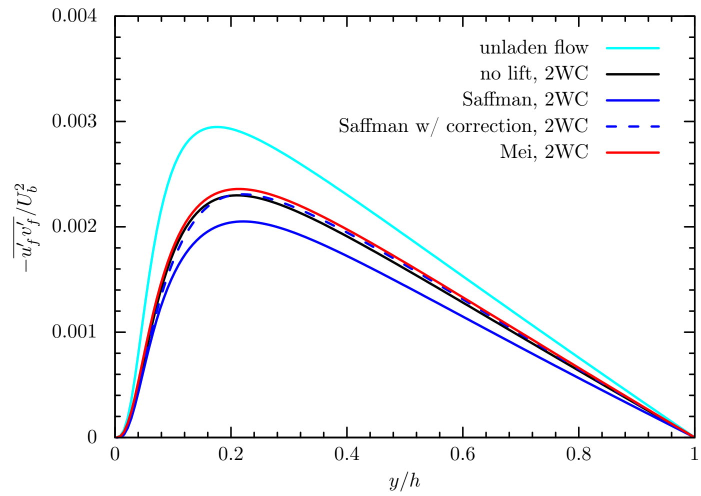

Figure 1: Fluid Reynolds shear stresses normalized by the squared bulk velocity in a two-way coupled DNS of turbulent channel flow laden with small inertial particles, simulated using a point-particle model including the Saffman and Mei lift force models, a modified formulation of Saffman lift based on particle-resolved channel flow data, and the reference lift-free and unladen cases.

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