# Effect of fluid-inertial torque on the orientation of tiny spheroidal particles in turbulent channel flow

Zhiwen Cui*, Jingran Qiu*, Xinyu Jiang* and Lihao Zhao*

The orientation of non-spherical particles in a fluid flow depends on the hydrodynamic torque they experience. However, little is known about the effect of fluid-inertial torque on the dynamics of tiny inertial spheroids in wall turbulence, as only Jeffery torque has been considered in previous studies. In this study, we investigate the orientation of tiny spheroidal particles by direct numerical simulations considering both fluid-inertial torque and Jeffery torque. Our findings reveal that the orientation of tiny spheroidal particles is significantly affected by the fluid-inertial torque when the Stokes number (normalized by viscous time scale) is greater than a critical value $St_c \approx 2.3$, suggesting that the inertial torque is non-trivial for most particle cases considered in earlier studies. Furthermore, in contrast to the earlier findings considering only Jeffery torque, we find that the preferential orientation of inertial particles is confined in a thinner region in the vicinity of the wall, as the presence of the fluid-inertial torque weakens the influence of Jeffery torques on the particle preferential alignment. In the channel central region, where the flow shear is negligible, the fluid-inertial torque becomes dominant and drives the particles to align their broad side with the direction of slip velocity rather than a random orientation observed in earlier studies (see Fig. 1). Our findings imply the importance of fluid-inertial torque in modelling the behavior of inertial non-spherical particles in wall turbulence.

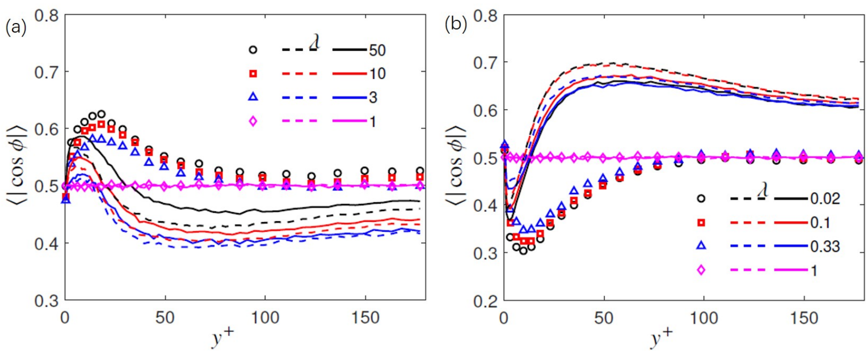


Figure 1: The cosine values of the relative angles $\phi$ between symmetry axes of (a) prolate and (b) oblate spheroids and the direction of fluid-particle slip velocity at $St = 30$. Here, $\lambda$ is the aspect ratio of the spheroids. The symbols represent the cases with Stokes drag and Jeffery torque, the dashed lines represent the cases with Stokes drag, Jeffery and inertial torques, and the solid lines represent the cases with Oseen drag, Jeffery and inertial torques.

*AML, Department of Engineering Mechanics, Tsinghua University, Beijing, 100084, China