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The modeling of the effect of the streamline curvature for the fluid force on a sphere

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To improve a point-particle model for fluid-particle two-phase flows, we obtain the angular velocity and lift force on a sphere in a free vortex and a rigidly-rotating flow by means of the finite-difference method. We propose a new boundary condition for background curved flows. The spherical particle in a curved flow without vorticity is found to rotate and it is not represented by traditional models which use the vorticity as a prime parameter for determining the particle rotation. The lift force is proportional to the curvature in both background flows, and it is remarkably influenced by the particle rotation even in the free vortex. Based on these findings, we propose a new model of the steady angular velocity and the lift force, which includes the term representing the effect of the curvature of the streamlines of the undisturbed flow.

Keywords: Solid particle, Streamline curvature, Particle rotation, Lift force