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SPECTRAL ELEMENT SIMULATION OF FLOW PAST AN ELLIPSOID AT DIFFERENT REYNOLDS NUMBERS

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Many industrial, mechanical and biomedical phenomena involve two phase flows. The mutual interactions between particles and a carrier fluid have been extensively studied experimentally and numerically. Most of the research, however, is for spherical particles. Non-spherical particle two phase flows are becoming the interests of some researchers. This paper presents a spectral/hp element simulation of an ellipsoidal particle in confined domains. A novel method to describe the two-way coupled motion between the fluid phase and the particle phase is addressed. The novelty of this method is that it fully utilizes the high order accuracy of a spectral element method and also reduces a two-phase flow problem into essentially a single phase flow problem. First, a mathematical description of this method is presented this paper, including how the two-way coupled motion is handled, and how an ellipsoid is represented in the computational method and domain. The key idea of this method is based on the Force-coupling method which was developed by Maxey et al. Therefore this method is essentially a low order multipole expansion method. The presence of an ellipsoidal particle is implicitly included in the mathematical formulation by a set of terms called force monopole and dipole terms. The forces and torques involved in the mutually coupled motion are distributed finitely via tailored Gaussian functions according to the orientation and the length of the semi-axes of an ellipsoid. A spectral/hp element method is used to find the numerical solutions to this two phase flow problem involving an ellipsoid. The benchmark simulation examples are provided in this paper for both Stokes flows and finite Reynolds number flows. The induced drag, lift and torque are verified and compared with analytical results (Happel and Brenner) as well as direct numerical simulation (DNS) results. Computational error is reported thereafter. The limitation of this method is also discussed at the end. Keywords: Two Phase Flows, Simulation, Fluid Mechanics, Flow Visualization, Computational Fluid Dynamics.

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