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A novel model for the lift force acting on a prolate spheroidal particle in an arbitrary non-uniform flow

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The present work proposes a generic method to extend lift force models that were originally devised for single linear shear flow, to arbitrary flow conditions. The method computes the lift force due to the dominant streamwise flow shear in the Stokes flow regime by implementing a series of coordinate transformations, facilitating the computation of the lift force from dominant streamwise flow shear. The derived numerical algorithm is successfully applied to extend the lift model proposed by Harper & Chang [1] which is based on the lift tensor and single linear shear flow, and allow the computation of the lift force acting on prolate spheroidal particles (or fibres) in an arbitrary flow. The present work is valuable since no rigorously derived lift-force model exists for particles with shapes other than spherical and generalizations of the lift force from spherical to non-spherical particles are not at all straightforward.

The proposed shear lift model can be used for Lagrangian particle tracking [2] in fluid flows which are dominated by streamwise shear, and is verified by simulating the transport of a particle in Poiseuille pipe flow. By placing the particle at different circumferential positions in the pipe and by keeping the radial direction constant the computed particle trajectories for four different initial positions and two different aspect ratios are identical, confirming the correctness of the proposed shear lift force model.

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