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Trajectory and flow properties for a rod spinning in a viscous fluid: An asymptotic solution with a no-slip plane LONGHUA ZHAO, Case Western Reserve University, ROBERTO CAMASSA, University of North Carolina at Chapel Hill, TERRY JO LEITERMAN, St. Norbert College, RICHARD MCLAUGHLIN, LEANDRA VICCI, University of North Carolina at Chapel Hill —
Utilizing singularity theory and the slender body theory, asymptotic solutions are constructed for a slender body sweeping out a double cone or single cone in free space in the low Reynolds number regime. The asymptotic solutions are compared quantitatively with the exact solutions for a prolate spheroid performing similar motion. With a set of singularities, Blakelet, an asymptotic solution is developed for a slender cylinder attached to a no-slip plane and sweeping out an upright cone. The no-slip boundary condition is satisfied exactly. Trajectory and flow properties are examined with special attention paid to the case study on slenderness between the exact and asymptotic free space solutions. For flow with no-slip plane, the theoretical prediction is compared with the experimental data, which shows good agreement. Far field asymptotic analysis is presented for the asymptotic velocity when the slender body precesses cones in free space and with no-slip plane. When the cone is tilted, the asymptotic solution is constructed in the lab frame, and the experimental data are reported compared with the theoretical prediction. This study is of direct use to nano-scale actuated fluidics where similar epicyclical behavior has been observed.

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