171g Gravity-Driven Motion of a Drop or Bubble near an Inclined Wall at Low Reynolds Number

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Dynamical simulations for the creeping motion of a three-dimensional deformable drop or bubble in the vicinity of an inclined wall are performed. The main purpose is to study the steady-state drop/bubble velocity as a function of the Bond number, drop-to-medium viscosity ratio, and the wall inclination angle. The major difficulty is that for moderate-to-small deformations (the range where most experimental results are available), the drop/bubble is able to approach the wall very closely (to less than 1% of drop radius) in steady motion, and there is an extended lubrication region which has a strong effect on the solution that requires high resolution, even for moderate Bond numbers. Also, most experimental data are for very low viscosity ratios (bubbles), making such a numerical solution very demanding. We have developed a novel algorithm that is a combination of the boundary-integral and economical multipole techniques. In the boundary-integral formulation, the Green function for the half-space above an infinite plane wall is used, which circumvents discretization of the wall. A multipole acceleration allows calculations with as many as 20000-40000 boundary elements and many thousand time steps to reach a steady state. The steady drop-to-wall separation and drop velocity depend heavily on the Bond number and viscosity ratio for intermediate-to-large inclination angles (i.e. 30-75 degrees above horizontal). With decreasing Bond number, homoviscous drops travel increasingly closer to the wall. Viscous drops maintain smaller separations and deform more than bubbles at fixed Bond number over a large range of inclination angles. For small inclination angles, the steady drop velocity decreases due to increased proximity to the wall. Simulations for drop motion near a vertical plane wall have also been conducted and compare well with previous experimental and theoretical results.