Non-axisymmetric fictitious forces in inertial drop collision

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Résumé

Understanding how liquid drops merge when suspended in another liquid is essential for controlling emulsions in many natural and industrial processes. When two drops approach each other, a thin film of the surrounding liquid forms between them and must drain before coalescence can occur. The theoretical framework for film drainage in the inviscid limit was established for bubbles, predicting dimple formation and universal thinning rates. For drops, fluid inertia has been shown to significantly impede coalescence under certain circumstances by inducing pressure build-up in the film, causing them to rebound before eventually coalescing on subsequent approaches. However, real drop collisions in turbulent flows are inherently three-dimensional, and the non-axisymmetric nature of such collisions introduces additional complexity that existing models do not capture. Here we show that centrifugal effects arising from the tangential velocity component during off-axis collisions can be incorporated into axisymmetric simulations through a fictitious force term in the axial momentum equation. In the thin film model, this effect translates into a modified boundary condition for the film height evolution. Our preliminary results indicate that this centrifugal contribution accelerates rebound and modifies the dimple structure compared to purely axisymmetric predictions. By comparing predictions of our direct numerical simulations performed with Basilisk against those of both the original model of Chesters and Hofman for bubbles and of an extended formulation accounting for the drop's viscosity, we quantify the relative importance of inertia, surface tension and centrifugal forces for drops with similar densities and viscosities as the surrounding liquid. We anticipate these results can help improve predictions of coalescence rates in turbulent liquid-liquid dispersions.

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