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Lattice Boltzmann Simulation of Dynamic Behavior of Liquid Droplets on Solid Surfaces

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Summary

Dynamics of droplet impact on solid surfaces is of great importance in many engineering applications such as ink-jet printing and rapid spray cooling of hot surfaces. In this study, the lattice kinetic scheme based on the lattice Boltzmann method for immiscible two-phase fluids [Inamuro (2006)] is applied to such micro-fluid problems. The present method enables us to perform stable calculations of two-phase flows with large density ratios of up to 1000. The boundary condition based on the wetting potential that is calculated according to a prescribed static contact angle is used on solid surfaces [Briant, Papatzacos, and Yeomans (2002)]. First, the dynamic behavior of a single droplet impinging on a horizontal wall is investigated for various Weber numbers. The dynamic contact angle, the contact line velocity, and the wet length are calculated, and found to be in good agreement with available experimental data. Next, the collision of a falling droplet with a stationary droplet on a solid surface is investigated. The behavior of the droplets and the mixing process during their collision are simulated for various impact velocities and several static contact angles on the solid surface. It is seen that mixing occurs around the rim of the coalescent droplet owing to the circular flows. Also, the relation between the mixing rate of the primary coalescent droplet and Weber number is obtained. Finally, adherence and bouncing of liquid droplets impacting on dry surfaces are examined for several Reynolds numbers based on the droplet diameter. These calculated results indicate that the present method can be a promising numerical approach to investigation of microscale droplet dynamics on solid surfaces.