Dynamic capillary phenomena using weakly compressible SPH

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Abstract

At the mesoscopic scale, due to the increase of the specific surface area of a medium, the capillary force becomes the dominant factor, causing anomalous phenomena such as adhesion and capillary-induced elastic deformation. These phenomena involve the coupling between the interface, fluid and solid, and show complex nonlinear behaviors (such as liquid bridge rupture). In this study, a meshless Lagrangian method, the smoothed particle dynamics (SPH) method, is adopted to establish a numerical model to simulate the dynamic capillary phenomena. The fluid-solid interaction SPH algorithm framework considering the capillary force is proposed. The model is used to simulate several typical capillary phenomena, including self-cleaning process of a super-hydrophobic surface and elasto-capillarity deforming an elastic surface with a liquid droplet. Results show that the model is able to reproduce the dynamic process of the liquid motion or a solid deformation, which is induced by the capillary force. This study will enrich the numerical modeling of fluid-solid interaction theory, and may be beneficial to engineering new materials and new devices in such areas as fabrics, agriculture, petroleum, and micro/nano technology.

Keywords: smoothed particle hydrodynamics (SPH); fluid-structure interaction; surface tension; adhesion; typical capillary phenomena.