Three dimensional simulation of liquid droplets impact on elastic structures
based on the SPH method

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Abstract: The impact of liquid droplets on elastic surfaces is a common phenomenon, such as plant leave repelling raindrop, piezoelectric sensor harvesting droplet energy. It involves the coupling of free surface flow, elasticity and surface/interface with large deformations, which is difficult to simulate using traditional numerical methods. In this study, a novel fluid-solid coupling model is established based on smoothed particle hydrodynamics (SPH) method. The droplet is described by weakly compressible (WC) SPH formulation, and the elastic substrate is described by total Lagrangian (TL) SPH formulation and Mindlin–Ressiner shell theory using one-layer of particles. Surface tension and wetting effects are simulated by an additional negative pressure term which creates attractive forces among fluid particles, and kernel functions are properly selected to eliminate stress instability due to droplet spreading and retraction. The model is applied to simulate the dynamic process of droplets impact on hydrophilic and super-hydrophobic cantilever beams. The interaction of droplet and beam is investigated under various conditions including stiffness, *We*, wettability. Predicted phenomena such as springboard effect, droplet morphology, beam deformation and vibration are well consistent with experimental observations. The modeling strategy of using TL-SPH shell formulation and free-surface WC-SPH formulation shows better computational efficiency for 3D simulations. Nonlinear behaviors such as droplet spreading, splashing, and large deflection of substrate can be effectively reproduced, which demonstrates the great advantage of SPH in simulating this type of problem

Keywords: TL-SPH shell model, free surface droplet, fluid-solid coupling, surface tension, 3D simulation.