Sharp-interface modeling of laser-induced rapid cavity formation

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Droplet breakup can be initiated by rapid deposition of thermal energy within a droplet through a laser. This causes locally higher pressure than in the remaining droplet. Shock and expansion waves form and propagate through the droplet. Due to reflection at the phase-interface and three-dimensional focusing effects, strong tension arises within the droplet. Subsequently, cavitation can occur in the liquid that disintegrates the droplet explosively. In recent experiments water microdrops were subjected to highenergy laser pulses that deposited energy equivalent to a pressure on the order of 100 GPa in a small region along the drop axis [1,2]. The initial stages of the subsequent violent droplet breakup were investigated by numerical simulation in a previous work, in which the model was restricted to a core vapor cavity along the drop axis [3]. Therefore, off-axis cavitation effects that dominate the explosive breakup stages were not captured.

In this work, we present our extended numerical model as well as results of cavity formation for the laserinduced droplet breakup using the high-resolution compressible finite-volume solver ALPACA [4]. Particular focus is on the modeling of vapor formation and its transformation into distinct cavities within the liquid. The underlying multi-phase system is modeled by the level-set approach and a conservative interface-interaction method. The sharp-interface representation is combined with a homogeneousmixture relaxation model to allow for phase-change within the bulk liquid. Larger clusters of vapor are then transformed into bulk vapor cavities enclosed by a newly created level-set interface.

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