Computational Analysis of Crown Formation During Drop Impact onto A Liquid Film with Experimental Validation

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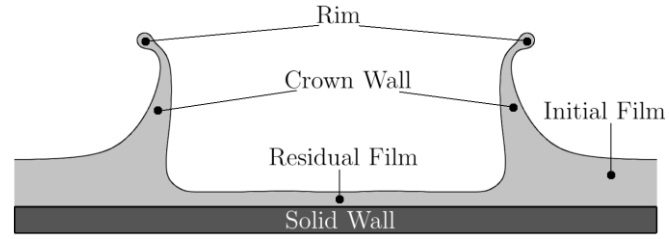
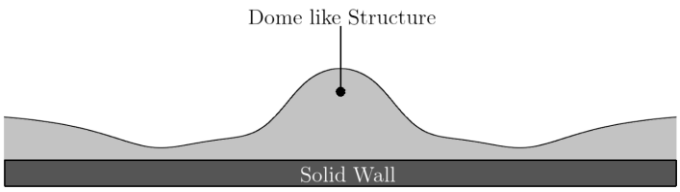
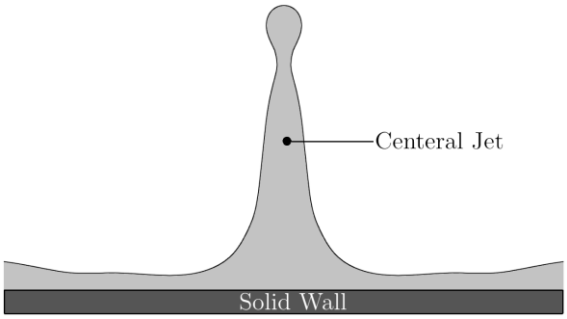
In this study the silicone oil drop impact onto liquid film of the same liquid without generation of secondary droplets is investigated both experimentally and numerically. Experiments have been conducted for three different Weber numbers and a fixed film thickness. Impact outcomes with characteristic morphologies of deposition, crown formation including the formation of a dome-like structure or a central jet have been observed (see Fig. 1).



(a) crown formation (without splashing)



(c) dome-like structure



(c) central jet

Fig. 1: Different outcomes of drop imapct on a liquid film

The evolution of the crown top diameter, base diameter and height have been measured and compared with the numerical results. Numerical simulations were performed using the diffuse interface phase-filed method where the two-phase flow is described by the coupled Cahn-Hilliard-Navier-Stokes equations implemented in the open source C++ library OpenFOAM (code phaseFieldFoam). Due to rotational symmetry of the impact process, axisymmetric computations have been made. In addition, adaptive mesh refinement for resolving the diffuse interface has been used (Fig. 2).

Choice of models for the characteristic parameters of the phase-field method, e.g. the scaling law for the mobility parameter or the matching condition for the interfacial energy, have been found crucial. It has been noticed that for high Weber numbers for a formation of a consistent dome-like structure and a central jet a non-standard formulation for the interfacial energy matching condition is imperative. Here, the interfacial energy parameter is calculated locally based on interfacial dynamics and topological changes of the interface. Moreover, the use of a scaling law based on a diffusion length scale is described in this work.

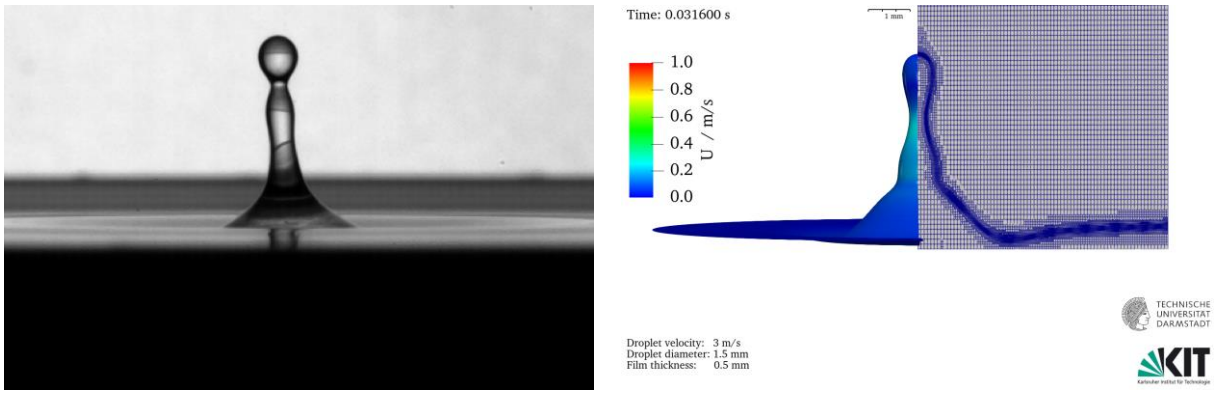


Fig. 2: Comparison between experimental and numerical simulation