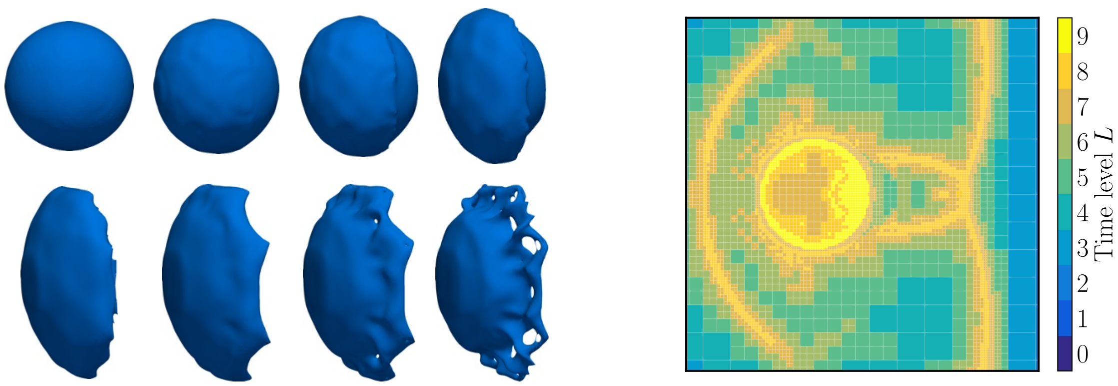
Numerical investigations of shock-droplet interactions using a novel space-time adaptive volume-of-fluid solver

Yijun Wang* and Patrick Jenny*

Shock-bubble/droplet interactions are of great importance both for unraveling a wide range of phenomena in natural science, such as astrophysical flows of interstellar clouds, and for advancing practical technologies, such as lithotripsy, material coating and fuel dispersion in supersonic combustion systems. This work performs a systematic numerical investigation on the dynamics of droplets exposed to shock waves. The numerical tool devised and employed here is a space-time adaptive volume of fluid (VOF) solver[1], which was developed based on a previous version for single-phase compressible flows[2]. The solver combines quad-/octree adaptive mesh refinement (AMR) and the adaptive conservative time integration[3] (ACTI) scheme, enabling dynamic allocation of computational resources where most needed. This is particularly advantageous for applications such as shock-droplet interactions, where the drastically evolving interfaces and intricate wave propagations generate a broad spectrum of spatiotemporal scales. Furthermore, the solver also integrates a novel artificial interface compression scheme that ensures sharp interfaces (up to few grid points) between immiscible fluids. Figure 1 depicts preliminary results of a 3D shock-droplet simulation with the solver. Primary influencing mechanisms for the droplet dynamics and breakup considered here are surface tension and viscous effects, which can be characterized by the Weber number *We* and Reynolds number *Re*. It is demonstrated that the trajectory of the droplet before complete breakup can be manipulated at given incidence Mach numbers.



(a) deformation of the droplet

(b) dynamic space-time adaptation (higher levels means locally smaller time step size)

Figure 1: Results from a 3D shock-droplet interaction simulation

*Institute of Fluid Dynamics, ETH Zurich, Sonneggstrasse 3, 8092 Zurich, Switzerland

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[2] Wang*, Luther*, Jenny* et al. (*equally contributed), *Submitted to Journal of Computational Physics*, 2025

[3] Jenny., *Journal of Computational Physics* **403**, 2020