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3D INCOMPRESSIBLE TWO-PHASE FLOW BENCHMARK COMPUTATIONS FOR RISING DROPLETS

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The modeling and simulation of three-dimensional two-phase flows is still an area of active research. Various approaches have been developed to improve conservation of mass, capturing of the fluid's interface or computation of interfacial surface tension. For the validation of these new methods, qualitative benchmark data is required.

We perform 3D incompressible two-phase flow simulations of rising droplets. Basing on a similar 2D benchmark proposed in [1], a 3D benchmark configuration with two test cases is formulated in which we compare the flow solvers DROPS [2, 3], NaSt3DGPF [4] and OpenFOAM [4]. All codes adopt different numerical techniques. We list the main features of each code in Table 1.

The droplet in both test cases rises due to buoyancy forces. However, the test cases differ in the chosen density and viscosity ratio and in the surface tension coefficient. The first test case with a moderate density and viscosity ratio of 1:10 and with strong surface tension forces leads to a mild deformation of the droplet. The second test case shows a stronger droplet deformation and is considered to be more challenging for the chosen codes due to higher ratios of 1:1000 and 1:100 for the density and viscosity, respectively,

Table 1: Comparison of the code features and schemes used for the 3D benchmark.

	DROPS	NaSt3D	OpenFOAM
developer	IGPM, RWTH Aachen	INS, University of Bonn	open source
discretization	XFEM	finite differences	finite volume
interface capturing	level set	level set	VOF
time discretization	implicit θ-scheme	Adams-Bash. 2nd	impl. Euler

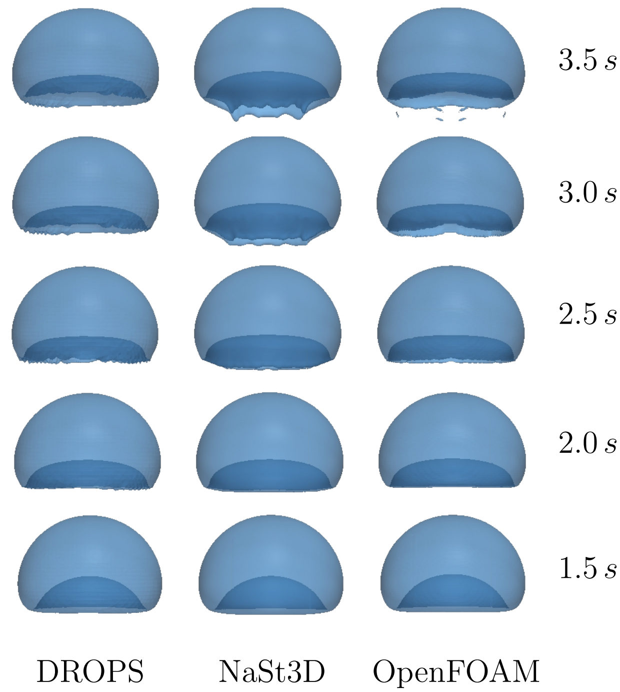

Figure 1: Rising droplet simulation results for the three 3D flow solvers.

and due to reduced surface tensions. We illustrate the second test case in Figure 1.

In this talk, we discuss the results of our benchmark computations. For a better comparison, we investigate not only the different droplet shapes in both test cases but also give qualitative results. For this purpose, we plot the evolution of the droplet's barycenter position, the rise velocity and its sphericity. We also discuss the significance of the chosen evaluation criteria as benchmark quantities.

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