Direct Numerical Simulations of In-Air Droplet Interactions

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In technical processes such as the production of fibers and capsules or application of sprays in coatings or medical inhalators, droplet-jet and droplet-droplet interactions are elementary processes. Such interactions are investigated with the ITLR's in-house multiphase flow code Free Surface 3D (FS3D) using Direct Numerical Simulations (DNS) [1]. FS3D employs the Volume of Fluid (VOF) method [2] with a Piecewise Linear Interface Calculation (PLIC) [3]. Recent developments enabled the simulation of immiscible droplet-jet interactions and grouping processes, i.e., the tendency of initially separated droplets to convene and coalesce in droplet streams.

The feasibility of simulating such droplet-jet interactions was recently demonstrated [4]. This poster will show a first parametric study on the influences of wettability, i.e., the surface and interfacial tensions, on the droplet-jet interaction, see Fig. 1.

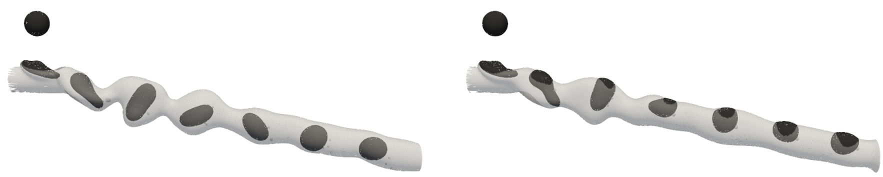

Figure 1: Exemplary droplet-jet interaction of a fully (left) and partially wetting (right) liquid combination.

Besides the interaction of immiscible liquids, grouping phenomena in monodisperse streams were numerically investigated. Detailed information about the development of inter-droplet distance and velocity, drag forces due to pressure and shear on each single droplet, and detailed flow characteristics (see Fig. 2) in such streams were already gathered [5]. This poster will present first results on the appropriate scaling of relevant characteristics, e.g., the time until droplet pairs come into contact with each other at a particular relative velocity, obtained by a comprehensive parametric study varying the initial inter-droplet separation and velocity.

Performance optimizations in the major parts of the solver allowed this extent of simulations within a reasonable compute time [4]. By implementing a connected-component labeling (CCL) algorithm to extract relevant droplet information

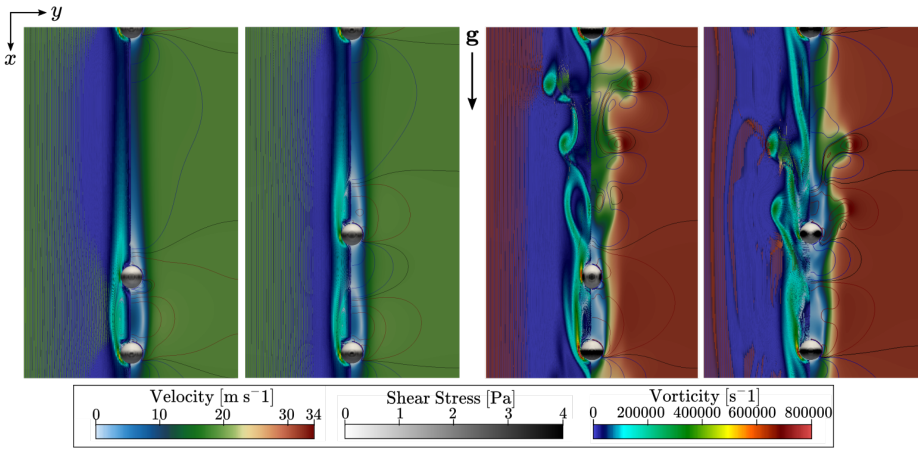

Figure 2: Visualization of droplet grouping at different initial droplet separation distances and injection velocities.

efficiently from the simulation during runtime, the workflow for post-processing was drastically improved [6]. This poster will demonstrate further progress in performance enhancements in FS3D towards a hybrid parallelization with OpenMP and MPI, which enables the simulation of increasingly larger systems with DNS.

References

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