

ADVANCES IN NUMERICAL ANALYSIS AND APPLICATIONS OF CAPSULE AND PARTICLE DYNAMICS IN COMPLEX FLOWS

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ABSTRACT

Flows containing dispersed entities such as capsules, particles, and droplets occur in many natural, biological, and industrial systems, including suspensions, emulsions, and microfluidic flows. Their motion and deformation are governed by strong two-way coupling with the surrounding flow through fluid-structure interactions, linking microscopic dynamics to macroscopic behavior [1]. Flow complexity increases when large deformations, inertial or hydrodynamic interactions [2], or external fields such as magnetic fields are involved. In biological systems, including microcirculation and confined cellular transport, these effects are essential yet difficult to understand due to their multiscale and multiphysics nature.

From a computational perspective, accurate, robust, and efficient simulations for dispersed systems in complex flows remain highly challenging. Numerical methods must resolve large motions and deformations, strong nonlinear coupling, and complex interactions of different materials while maintaining stability and computational efficiency, often under severe multi-scale and -physics conditions. Although significant progress has been made in numerical analysis such as interface-capturing and tracking methods, immersed boundary methods, and morphology-adaptive method [3], further advances are still required to address these challenges.

This minisymposium focuses on recent advances in numerical analysis and computational approaches for investigating the dynamics of capsules, particles, and droplets in complex flows. Contributions addressing fundamental algorithmic developments as well as applications to biological flows, microcirculation, ferrofluids, and related industrial processes are welcome.

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