Editorial

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In this special issue we collect some of the studies, and following extensions, presented at the 596 Euromech Colloquium, held in Venice, May 18–20, 2018. The aim of the colloquium was to present the latest advancement in numerical simulations of flows with particles, bubbles and droplets.

Fluids with a dispersed phase are multiscale by nature, as the physics at the microscale affects the macroscopic behavior of the flow and vice versa giving rise to surprising and fascinating phenomena as well as making this one of the most important practical problems still to solve. Investigating the mechanisms by which the system microstructure determines the macroscopic flow properties and the macroscopic dynamics affect the interactions and mixing at the microscale will give valuable insights into the nature of often turbulent flows and the associated transport phenomena, and also lead to new ways to model and control the flow. Similarly, interface phenomena, involving heat and mass transfer, are of fundamental

importance in energy converting systems, especially if complex mixtures as low-temperature evaporation refrigerants and biofuels want to be used at best efficiency. In addition, the details of these processes are particularly difficult to examine in laboratory experiments and numerical simulations become therefore a fundamental tool to gain fundamental understanding.

In this context, the development of high-fidelity numerical algorithms and computational power has recently enabled interface resolved simulations of suspensions of rigid and deformable particles, two-fluid systems where one of the fluids could be viscoplastic or viscoelastic in nature, and elastic/porous media. Current efforts include heat and mass transfer, phase change and fluxes at the interface, different short-range interactions, as well as the viscoplastic and viscoelastic behavior of one of the phases as shown by the papers presented in this volume.

These studies are becoming more frequent and have received a significant attention. As an example, we mention the fact that several journal highlights and review papers appeared in the last few years, focusing on important advancements in interface resolved simulations of multiphase flows such as sediment transport, wall-bounded turbulence of neutrally-buoyant particle suspensions, rheology of capsules and droplets in homogeneous and isotropic turbulence, as well as numerical methods. It is now recognized that

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the biggest new development in multiphase flow research has been the use of interface-resolved simulations and that these simulations are already starting to have a major impact. However, we are still exploring their potential and there are therefore plenty of opportunities to improve our understanding of the different physical processes involved as applied to a huge number of industrial applications as well as natural phenomena as debris flow and ocean–atmosphere interactions. The challenge the community is going to face is to exploit at best the new capabilities, collect results for more and more complex systems in a systematic and repeatable way, and to advance the modelling of these systems. In this respect, the increase of the possibilities offered by numerical simulations is shaping the way laboratory experiments are performed and their objectives, in the same way the improved experimental data provide fundamental insights on microscale processes and thus input to numerical modelling. Indeed, simulations of multiphase flows in the presence of a suspended phase of microscale size inevitably contain some model coefficients, e.g. the restitution coefficient for rigid particle collisions, or are bound to depend on some numerical detail as in the case of coalescence-merging.

To break new ground in a field of obvious broad engineering interests we need to solve some fundamental scientific problems in non-equilibrium physics and understand, among others, the role of the fluctuations induced by the suspended phase and their coupling to the mean flow; the effect of inertia and the modifications of the interactions when increasing the shear rates. Fundamental is also an understanding of the local concentration, migration and segregation of the suspended phase on the flow properties. In addition to physics-based modelling, which we expect to require innovative experiments, high-fidelity simulations of multiphase systems would reply upon the development of new computational algorithms, able to exploit and adapt to the present and future computational hardware. As current results clearly show, large scale fluid and particle/bubble/droplet motions significantly affect the macroscopic system behavior, e.g. drag and heat transfer, future simulations would require larger and larger computational resources.

The objective of the discussions held at the colloquium was to identify the main challenges ahead of us. In particular, in terms of unresolved scientific questions, physics-based closures such as repulsive

and attractive forces within the dispersed phase, lubrication and collision models to be included in the numerical algorithms. In addition, the participants commented on the creation and best use of the large datasets now available, e.g. for upscaling procedures, as well as possible validations and efficient use of the increasingly available computational resources. The three invited speakers were chosen to cover three emerging areas. Prof. Frölich from TU-Dresden presented examples of the rich parameter space defining particle and bubble-laden flows and discussed how the numerical data could be used to advance CFD models. Prof. Tanguy from IMFT Toulouse, documented advances and challenges of the simulations of boiling flows, where heat and mass transfer across a thin interface need to be accurately captured to be able to reproduce experimental observations. Finally, prof. Poelma from TU Delft critically reviewed current experimental technique and discussed the way experiments and simulations could complement each other.

The works presented in this selection well represent current advances and challenges ahead of us. As mentioned above, Jain et al. [1] document the role of particle shapes. Investigations of the behavior of a suspended phase in a complex non-Newtonian fluids, viscoelastic or viscoplastic, are also initiating. The two examples here deal with microfluidics applications, a train of particles in a viscoelastic fluids [2] and the flow of yield-stress fluids in porous media [3]. Dotto et al. [4] and Rosti et al. [5] are example of the possible interactions between turbulence and elastic deformable fibers and filaments, the diversity of behaviors and the role of the ratio between time scales despite the large disparity in spatial scales. Soligo et al. [6] present a diffuse-interface approach to model the surfactant dynamics close to an interface and studies its effect on droplet deformation. Numerical methods for the simulations of high-speed droplet impact and the motion of a solid particle in a viscous flow are presented in [7] and [8]. Finally, Vaitukatis et al. [9] present an application of transport and absorption for a specific application such as pharmaceutical tablets. The selection here is certainly far from complete but we believe provides a broad overview of the different problems involving particles, droplets and bubbles that resolved numerical simulations can tackle and can stimulate further developments and interactions.

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