DY 27: Microfluidics

Time: Tuesday 11:15–12:45 Location: BH-N 128

DY 27.1 Tue 11:15 BH-N 128

Antimargination of microparticles and platelets in branching vessels — •Christian Bächer[1], Lukas Schrack[1,2], and Stephan Gekle[1] — [1]Biofluid Simulation and Modeling, Bayreuth, Germany — [2]Bio and Nano Physics, Innsbruck, Austria

A mixed suspension of red blood cells and microparticles flows through complex geometries typical for in vivo vessel networks: a vessel confluence and a bifurcation. Our three-dimensional Lattice-Boltzmann simulations show strong effects on cell and particle distribution: behind a confluence we observe an additional, surprisingly stable cell-free layer in the center containing microparticles undergoing anti-margination. In contrast to the perturbed margination in vessel confluence, we obtain full microparticle margination in branching vessels. Margination in branching vessels and antimargination behind confluences may explain in vivo findings of strongly different platelet distribution in arterioles (mainly bifurcations) and venules (mainly confluences).

DY 27.2 Tue 11:30 BH-N 128

Molecular dynamics simulations in hybrid particle-continuum schemes: Pitfalls and caveats — •Stefanie Stalter[1], Leonid Yelash[2], Nehzat Emamy[3], Maria Lukáčová-Medvid'ová[2], and Peter Virnau[1] — [1]Institute of Physics, Johannes Gutenberg University, Staudingerweg 9, 55128 Mainz, Germany — [2]Institute of Mathematics, Johannes Gutenberg University, Staudingerweg 9, 55128 Mainz, Germany — [3]Institute for Parallel and Distributed Systems, University of Stuttgart, Universitätsstraße 38, Stuttgart, Germany

Heterogeneous multiscale methods (HMM) combine molecular accuracy of particle-based simulations with the computational efficiency of continuum descriptions to model flow in soft matter liquids. In these schemes, molecular simulations typically pose a computational bottleneck. We found that it is preferable to simulate many small systems as opposed to a few large systems, and that a choice of a simple isokinetic thermostat is typically sufficient while thermostats such as Lowe-Andersen allow for simulations at elevated viscosity. We present suitable choices for time steps and finite-size effects which arise in the limit of very small simulation boxes. [1]

[1] S.Stalter et al., doi:10.1016/j.cpc.2017.10.016, CPC (2017)

DY 27.3 Tue 11:45 BH-N 128

Particle interactions in inertial microfluidics — •Christian Schaaf, Felix Rühle, and Holger Stark — Institut für Theoretische Physik, Technische Universität Berlin, Berlin, Germany

Solid particles immersed in a microfluidic Poiseuille flow at intermediate Reynolds numbers migrate laterally to discrete equilibrium positions [1]. This Segré-Silberberg effect can be explained by the inhomogeneous shear rate of the Poiseuille flow and can be rationalized by the lift force profile. In addition to this lateral inertial focusing, particles at low densities also form regular particle trains in the direction of the flow [2].

We conduct lattice-Boltzmann simulations to obtain some understanding for the formation of such structures. As a first step we focus on the dynamics of a flowing particle pair. We determine their lift force profiles as function of the lateral particle positions and axial distance as well as the Reynolds number. At small distances the profiles are dominated by viscous forces, while at large distances inertial forces take over. Additionally, we categorize the different types of trajectories and show how particles in the bound state spiral towards their equilibrium positions performing damped oscillations. In the end these results are used to explain the behavior of particle trains and to analyze their dynamics and stability.

[1] G. Segré and A. Silberberg, *Nature* **189**, 209 (1961).
[2] W. Lee, et al., *PNAS* **107**, 22413 (2010).
[3] C. Schaaf and H. Stark, submitted.

DY 27.4 Tue 12:00 BH-N 128

Mesoscopic simulations of dense suspensions of capsules in confined shear flow — •Othmane Aouane[1], Maarten Wouters[2], Andrea Scagliarini[3], and Jens Harting[1,2] — [1]Forschungszentrum Jülich GmbH, Helmholtz Institute Erlangen-Nürnberg for Renewable Energy (IEK-11), Nürnberg, Germany — [2]Department of Applied Physics, Eindhoven University of Technology, Eindhoven, The Netherlands — [3]Istituto per le Applicazioni del Calcolo, Rome, Italy

Complex fluids are ubiquitous in soft matter systems, such as colloidal suspensions and biofluids (tissues and blood). Understanding the dynamics of such systems is important for example for industrial production or disease detection. However, such systems are hard to solve analytically since they follow non-linear dynamics and might involve many-body interactions and multiscale problems. These circumstances call for numerical methods and computer simulations which can also provide access to observables not traceable in experiments such as the local fluid properties. In this work, we focus on computational simulations of dense suspensions of soft polymeric coated core-shells, i.e. capsules up to to 75% volume fraction under a confined shear flow using the lattice Boltzmann method with an emphasis on their local rheology. This study includes the effect of the mechanical properties of the individual capsules (stiffness/softness) on the flow behavior.

DY 27.5 Tue 12:15 BH-N 128

Inertial elevation of deformable particles in a shaken fluid — •Matthias Laumann[1], Andre Förtsch[1], Eva Kanso[2], and Walter Zimmermann[1] — [1]Theoretische Physik I, Physikalisches Institut, Universität Bayreuth, 95440 Bayreuth, Germany — [2]Aerospace and Mechanical Eng., University of Southern California, Los Angeles, California 90089, USA

Biological and bioinspired swimmers can move by shape actuation. Great progress has been made in understanding the direct control of shape variables for locomotory purposes. However, actuation via a time-dependent fluid motion is less well explored. Here, we examine the nonlinear coupling between shape variables and locomotion in a model system in oscillating flow including body inertia. As model we use a bead-spring tetrahedron. We determine effective conditions that lead to a non vanishing velocity in the oscillating external flow. Furthermore we give a simple explanation of the effect. These results suggest that one can tune the background flow properties to control the swimmer motion, and thus, they may have profound implications on design and employment of man-made swimmers in oscillatory flows.

DY 27.6 Tue 12:30 BH-N 128

Passive swimming of soft particles in oscillatory Poiseuille flow — •Winfried Schmidt[1], Matthias Laumann[1], Eva Kanso[2], and Walter Zimmermann[1] — [1]Theoretische Physik 1, Universität Bayreuth, 95440 Bayreuth, Germany — [2]Aerospace and Mechanical Engineering, University of Southern California, Los Angeles, California, USA

What is the dynamical behavior of soft particles in oscillatory (pulsating) Poiseuille flow at low Reynolds number? By investigating the overdamped motion of bead-spring models for a triangle, 2D ring polymers or 3D capsules, we predict particle actuation in the case of vanishing mean flow. This effect is generic as it does not depend on the model. Asymmetric, Janus like particles propagate in a symmetric flow. Symmetric particles swim for non-symmetric flow oscillations (non equal half periods). The mean actuation (swim) velocity of a particle is caused by its varying shape in both half periods. Since the actuation steps depend also on the size and the elasticity of soft particles, this novel actuation (passive swimming) mechanism is also appropriate for particle sorting.