DY 30: Complex Fluids and Soft Matter 1 - organized by Uwe Thiele (Münster) (joint session DY/CPP)

Time: Tuesday 14:30–16:30 Location: DYc

DY 30.1 Tue 14:30 DYc

How Frost Forms and Grows on Lubricant Impregnated Surfaces — •Lukas Hauer[1], William S.Y. Wong[1], Lou Kondic[2], and Doris Vollmer[1] — [1]Max Planck Institute for Polymer Research, Mainz, Germany — [2]Department of Mathematical Sciences, NJIT, Newark, USA

In many technical applications the formation of frost and ice displays a hazard to the steady functionality of devices. This motivates the development of new materials to tackle the reduction of frosting and icing on surfaces. While icing on surfaces is commonly studied by localized nucleation mechanisms, the formation of frost is comparable more complicated: Formation of condensate droplets, freezing, and frost front propagation are multi-physical processes on multiple time and length scales. Lubricant impregnated surfaces are known for improved anti-icing properties. They experience lower ice drop adhesion and allegedly delayed surface frost formation. We show that frost formation can induce immensely strong capillary forces that could result in surface damage, lubricant depletion and the loss of anti-icing properties. Laser scanning confocal microscopy enables us to monitor the dynamic lubricant migration during condensation frosting on microstructured surfaces. We present a quantitative model of the lubricant migration, utilizing lubrication theory. This work serves to improve understanding of lubricant dynamics during condensation frosting, providing roadmaps towards the future design of anti-icing surfaces.

DY 30.2 Tue 14:50 DYc

Hydraulic and electric control of cell spheroids — •Charlie Duclut[1], Jacques Prost[2], and Frank Jülicher[1,3] — [1]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — [2]Laboratoire Physico Chimie Curie, Institut Curie, Paris, France — [3]Center for Systems Biology Dresden, Germany

In addition to generating forces and reacting to mechanical cues, tissues are capable to actively pump fluid and create electric current. In this talk, we will discuss how a hydraulic or electrical perturbation, imposed for instance by a drain of micrometric diameter, can be used to perturb tissue growth dynamics. We address this issue in a continuum description of a spherical cell assembly that includes the mechanical, electrical and hydraulic properties of the tissue. This approach allows us to discuss and quantify the effect of electrohydraulic perturbations on the long-time states of the tissue. We highlight that a sufficiently strong external flow or electric current can drive a proliferating spheroid to decay. We propose that this could have applications in medicine.

DY 30.3 Tue 15:10 DYc

Controlling Elastic Turbulence — •Reinier van Buel and Holger Stark — Institut für Theoretische Physik, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin, Germany

Controlling the flow patterns of viscoelastic fluids is extremely challenging due to their inherent non-linear and time-dependent properties. These complex fluids exhibit transitions from laminar to turbulent flows, which is useful for heat and mass transport in liquids at the micron scale [1], whereas in Newtonian fluids transport is dominated by diffusion. Turbulent viscoelastic flows show similar properties as their counterparts in Newtonian fluids [1,2] and consequently the observed flow pattern is called *elastic turbulence* [1]. It occurs in shear flow for increasing Weissenberg number Wi, the product of polymer relaxation time and shear rate.

Numerically solving the Oldroyd-B model in a two-dimensional Taylor-Couette geometry, we have identified and described the supercritical transition to turbulent flow at a critical Weissenberg number [2]. Here, we demonstrate that elastic turbulence can be controlled by a time-modulated shear rate. The order parameter measuring the strength of turbulence continuously goes to zero with increasing modulation frequency or Deborah number De. It ultimately vanishes via a supercritical transition, where flow then becomes laminar. Moving closer to the critical Weissenberg number, smaller modulation frequencies are sufficient to induce laminar flow.

[1] A. Groisman and V. Steinberg, Nature **405**, 53 (2000).
[2] R. Buel, C. Schaaf, H. Stark, Europhys. Lett. **124**, 14001 (2018).

DY 30.4 Tue 15:30 DYc

Hydrodynamics of a Pair of Soft Capsules in Inertial Microfluidics — •Kuntal Patel and Holger Stark — Institut für Theoretische Physik, Technische Universität Berlin, Berlin, Germany

In recent years, inertial microfluidics has emerged as a robust technique to precisely manipulate solid particles and biological cells. Also, the fact that inertial microfluidics operates at finite Reynolds numbers enables to achieve high throughput. In the present work, we perform 3D numerical simulations to study the hydrodynamic interaction and inertial migration of two soft capsules in a microchannel with quadratic cross section. We employ the lattice Boltzmann method to determine fluid flow and the finite element method to model capsule dynamics. The coupling between bulk fluid and capsules is realized using the immersed boundary method.

We investigate the effect of different starting positions for mono- and bi-dispersed pairs of varying softness and capsule shape. Based on the temporal evolution of interparticle distance, we characterize the dynamics of various mono- and bi-dispersed pairs into four types: stable pair, stable pair with damped oscillations, stable pair with bounded oscillations, and unstable pair. We observe that stable pairs become unstable when increasing the particle stiffness. Furthermore, a pair with both capsules in the same channel half is more prone to become unstable than a pair with capsules in the opposite channel halves.

DY 30.5 Tue 15:50 DYc

Hydrodynamics of immiscible binary fluids with viscosity contrast: A Multiparticle Collision Dynamics approach — •Zihan Tan[1], Vania Calandrini[2], Jan Dhont[1], Gerhard Nägele[1], and Roland Winkler[3] — [1]Biomacromolecular Systems and Processes, Institute of Biological Information Processing, Forschungszentrum Jülich, 52428 Jülich, Germany — [2]Computational Biomedicine, Institute for Advanced Simulation, Forschungszentrum Jülich, 52428 Jülich, Germany — [3]Theoretical Physics of Living Matter, Institute for Advanced Simulation, Forschungszentrum Jülich, 52428 Jülich, Germany

By coupling distinct collision steps in each fluid domain, immiscible binary fluids with different viscosities connected by coarse-grained planer interfaces are realized by multiparticle collision dynamics (MPC). The flow and the stress-viscosity relation of the system are investigated under shear flow, excellently agree with continuum hydrodynamics solution and the analytical theory of MPC. Later, the hydrodynamic mobility coefficients of an embedded colloid close to the fluid-fluid interface are measured, which coincide with hydrodynamic multipole expansion calculations. To validate the length and time scales of hydrodynamics in this model, we explore the corresponding transverse velocity correlations. It is found that the correlations for the fluid regions occupied by one phase are identical to single-phase MPC fluid. In contrast, the transverse modes at the interfacial region can be interpreted by the superposition of both viscous components.

DY 30.6 Tue 16:10 DYc

Optimal hematocrit for ATP release by red blood cell in microcirculation — •Zhe Gou and Chaouqi Misbah — Laboratoire Interdisciplinaire de Physique, Grenoble, France

ATP release by red blood cells (RBCs) acts as an important signaling molecule for various physiological functions, such as vasodilation. When flowing in microcirculation, RBCs experience a cascade of branching vessels, from arterioles to capillaries, and finally to venules, which affects not just flow behavior of blood but also ATP release. In a previous study, we have proposed a model of ATP release by RBCs through two pathways of cell membrane: pannexin 1 channel (Px1), sensitive to shear stress, and cystic fibrosis transmembrane conductance regulator (CFTR) which responds to cell deformation. As a continuation, present work further investigates the effect of flow strength, hematocrit, and vascular diameter by numerical simulations. We found a nontrivial spatial RBC organization and ATP patterns due to application of shear stress on the RBC suspension. Conditions for optimal ATP release per cell are identified, which depend on vessel size and hematocrit Ht. Increasing further Ht beyond optimum enhances the total ATP release but should degrade oxygen transport capacity, a compromise between an efficient ATP release and minimal

blood dissipation. Moreover, ATP is boosted in capillaries suggesting a vasomotor activity coordination throughout the resistance network. Further studies of vascular network may help to explore the whole signaling cascade of ATP.