CPP 83: Microfluidics (joint session DY/CPP)

Time: Wednesday 17:00–18:30 Location: ZEU 147

CPP 83.1 Wed 17:00 ZEU 147

Near-field acoustic manipulation in a confined evanescent Bessel beam — •Pierre-Yves Gires[1,2] and Cédric Poulain[1,3] — [1]University Grenoble Alpes, CEA LETI — [2]University of Bayreuth, Experimental Physics I — [3]University Grenoble Alpes, CNRS, Grenoble INP, Institut Néel

Microparticles such as cells can be manipulated in a suspension by the application of an ultrasonic acoustic field. Following the path taken in the development of optical tweezers, we demonstrate the potential of working in the evanescent regime, with both sub-wavelength confinements and resonators [1]. We generate an evanescent acoustic Bessel beam in liquid above a thin, circular, axisymmetrically excited plate. In the sub-MHz domain, the resulting radiation force causes the particles to assemble at the pressure antinodes along concentric circles corresponding to the Bessel profile. By imposing an axial confinement in the evanescent region, the sub-wavelength two-plate sandwich system becomes resonant, increasing the radiation force magnitude. Resonances occur for some well-defined gaps for which whole numbers of antinodal circles are observed. Through fine tuning, particles as small as bacteria can be patterned. Further amplification can be obtained by trapping a microbubble in the Bessel beam axis.

[1] Pierre-Yves Gires and Cédric Poulain. Near-field acoustic manipulation in a confined evanescent bessel beam. Communications Physics, 2(1):1-8, 2019.

CPP 83.2 Wed 17:15 ZEU 147

Theoretical and numerical investigation of an EWOD-driven micro pump — •Sebastian Bohm and Erich Runge — Technische Universität Ilmenau, Theoretische Physik 1, Weimarer Straße 25, 98693 Ilmenau

We show how the EWOD (electrowetting-on-dielectric) effect can be used to realize a micro pump that uses no moveable components at all, see patent [1]. The flow is generated due to the periodic movement of liquid-vapor interfaces in a large number ($\approx 10^6$) of microcavities ($\Delta V \approx 1$ pl per cavity). The total flow resulting from all microcavities adds up to a few hundred nanolitres per cycle. Tesla-Diodes are used as valves to completely forgo on moving parts. They must be optimized to generate a reasonable valve action even at the small Reynolds numbers that are typical for micro pumps.

The theoretical description of the pumping mechanism is a challenge due to the coupling of the fluid- and electrodynamics and the intrinsic multi-scale character of the system. In each microcavity, the flow can be modelled as multiphase flow with time-dependent wetting properties as boundary conditions. It is implemented via a boundary element method. Additionally, an approximation is presented that allows the fast calculation of the stationary shape of liquid/vapor interfaces in electrical fields. Topological optimization methods for the optimization of the Tesla-Diodes are presented, in which the complete micro pump system is considered as well.

[1] Hoffmann, M., Dittrich, L., Bertko, M.; German patent DE11 2011 104 467 (2012)

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Digital magnetofluidics with planar Hall effect sensors — •Julian Schütt[1], Rico Illing[1], Oleksii Volkov[1], Tobias Kosub[1], Pablo Granell[1,2], Hariharan Nhalil[3], Jürgen Fassbender[1], Lior Klein[3], Asaf Grosz[4], and Denys Makarov[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf e.V., 01328 Dresden, Germany — [2]Escuela de Ciencia y Tecnología, UNSAM, Buenos Aires, Argentina — [3]Department of Physics & Institute of Nanotechnology and Advanced Materials, Bar-Ilan University, Israel — [4]Department of Electrical and Computer Engineering, Ben-Gurion University of the Negev, Israel

The detection of magnetic nanoparticles is of major importance in biomedical and biological applications. Here, the trend goes towards improvements of state-of-the-art methods in the spirit of high-throughput analysis at ultra-low volumes. Microfluidics addresses these requirements as it deals with the control and manipulation of liquids in confined microchannels. Sensor elements utilizing the planar Hall Effect (PHE) are exceptionally suited for this conjunction and were already applied in continuous flow microfluidics. We present a sensing strategy relying on PHE sensors in digital microfluidics for the detection of a multiphase liquid flow. We show the detection of nanoliter-sized superparamagnetic droplets with a concentration of 0.58mg/cm3, biased in a geomagnetic field, down to 0.04mg/cm3 in a magnetic field of 5mT. We are convinced that the tracking of microfluidic droplets can greatly contribute to state-of-the-art magnetoresistive sensing with dramatic downscaling of the analyzed volume.

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Positioning of Gold Nanoparticles by Thermo-Osmotic Flows in Electrolytes — •Martin Fränzl and Frank Cichos — Molecular Nanophotonics Group, Peter Debye Institute for Soft Matter Physics, Universität Leipzig, Germany

The application of gold nanoparticles as plasmonic sensors in fluidic applications requires exact positioning which is often only achieved by rigid templating using physical or chemical lithography. Here we investigate the control of single and multiple gold nanoparticles with the help of optically induced thermo-osmotic flows in electrolyte solution. Our control is using a thin gold film on substrates to allow for a local heating of an electrolyte solution in a liquid film. The local temperature rise at the gold induces thermo-osmotic flows at the gold electrolyte solution. By tuning the electrolyte concentration, we to confine the mobility of the gold-nanoparticles to a two-dimensional layer at a distance of a few 10 nanometers from the gold film in which a positioning with the help of thermo-osmotic flows is easily possible. The experimental results of the gold nanoparticle dynamics are compared the theoretical predictions.

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Flow in Responsive Porous Media — •Thomas Darwent[1], Enrico Segre[2], Ran Holtzman[3], and Lucas Goehring[1] — [1]Nottingham Trent University — [2]Weizmann Institute of Science — [3]Coventry University

Fluid flows in porous media, such as sand, rocks and biological tissues, are controlled by the geometry of that media and the properties of the fluids. Here, we explore the situation where the properties of the fluid and solid are coupled, such that an invading fluid modifies the structure of a porous medium around it. Specifically, we look at the case where the porous matrix is deformable, and we show that a new invasion pattern is seen: capillary fracturing. This results from the fluid pushing and pulling on individual grains making up the solid body, which changes the pressures required to flow past, or invade, those grains. This effect occurs in hydrocarbon recovery and CO2 sequestration where fluids are injected underground and deform the local structure. To study this problem, we use soft lithography and microfluidic techniques to produce PDMS micromodels, allowing us to tune the elasticity and disorder of a model porous medium. Along with numerical simulations, we show that deformation caused by the fluid leads to localised fingering patterns in more compliant materials, and that this effect is restricted by increasing the disorder in the system.

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Actuation of soft particles in oscillating Poiseuille flow — •Winfried Schmidt[1], Sebastian W. Krauss[2], Andre Förtsch[1], Matthias Laumann[1], and Walter Zimmermann[1] — [1]Theoretische Physik 1, Universität Bayreuth, 95447 Bayreuth, Germany — [2]Experimentalphysik 1, Universität Bayreuth, 95447 Bayreuth, Germany

What is the dynamical behavior of soft particles in oscillatory (pulsating) Poiseuille flow at low Reynolds number? By investigating the overdamped motion of 2D bead-spring models, as well as 3D capsules and red blood cells, we predict particle actuation in the case of vanishing mean flow. This effect is generic as it does not depend on the model. We show that symmetric particles propagate for asymmetric flow oscillations with non-equal flow sections. The mean actuation (swim) velocity of a particle is caused by its varying shape in both parts of the flow period. Since the actuation steps depend also on the size and the rigidity of soft particles, this novel actuation (passive swimming) mechanism is also appropriate for particle sorting.