# CPP 25: Focus: Active Fluids

Time: Wednesday 9:30–12:30 Location: H39

**Invited Talk** CPP 25.1 Wed 9:30 H39

**Designing small swimmers** — •Ramin Golestanian — Department of Physics and Astronomy, University of Sheffield, Sheffield, UK

The directed propulsion of small scale objects in water is problematic because of the combination of low Reynolds number and strong thermal fluctuations at these length scales. One possibility for designing propulsion is to devise non-reciprocal deformation strategies that are simple enough to be realizable. This opens up the discussion of what is the minimum number of degrees of freedom that we can use in our design strategies for objects that can swim at low Reynolds numbers. We introduce a simple prototype of a model based on a linear assembly of three spheres that are attached by two flexible linkers that can change their lengths. We analyze the motion of this model swimmer both in the deterministic and stochastic regimes. Another strategy to achieve propulsion at low Reynolds numbers could be to take advantage of various phoretic phenomena. We propose a simple model for the reaction-driven propulsion of a small device is proposed as a model for a molecular swimmer in aqueous media. Finally, a number of experimental realizations of such microswimmers are discussed including, in particular, one experiment in Sheffield and another one in Barcelona.

**Invited Talk** CPP 25.2 Wed 10:00 H39

**Magnetic actuation of paramagnetic colloids at interfaces** — •Thomas Fischer — University of Bayreuth

Spatio temporal variations of a magnetic field allow the dynamic control of paramagnetic colloids near interfaces. The flux of magnetic energy into the colloidal system renders the colloid into an active fluid. We report on the structure, dynamics, and transport of active two dimensional paramagnetic colloids in magnetic fields that vary on the colloidal scale. Several novel dynamical regimes are observed and reported, from localized trajectories to direct particle transport, depending on the geometry of the underlying magnetic pattern and on the parameters, which control the external driving field, such as frequency, strength and direction.

CPP 25.3 Wed 10:30 H39

**Brownian dynamics of a self-propelled particle on a substrate** — •Borge ten Hagen[1], Sven van Teeffelen[2], and Hartmut Löwen[1] — [1]Institut für Theoretische Physik II: Weiche Materie, Heinrich-Heine-Universität Düsseldorf, Universitätsstr. 1, 40225 Düsseldorf, Germany — [2]Department of Molecular Biology, Princeton University, LTL-343A Washington Road, Princeton, NJ 08544, USA

By solving the Langevin equation analytically, we study the overdamped Brownian motion of a self-propelled particle which is driven by a projected internal force. The "active" particle under study is restricted to move along a linear channel or in a two-dimensional plane. Its orientation, the direction of the internal force, is either freely diffusing on the unit sphere or confined to a plane perpendicular to the substrate. For a subset of the cases considered, the impact of a uniaxial torque and of external potentials is investigated as well. While the basic model applies to spherical particles, a generalized version which holds for ellipsoidal particles is also developed. The model is relevant for active particles like catalytically driven Janus particles and bacteria moving on a substrate. Analytical results for the first four time-dependent displacement moments are presented and analysed for several special situations. A significant dynamical non-Gaussian behaviour at finite times is signalled by a non-vanishing normalized kurtosis.

**15 min. break**

CPP 25.4 Wed 11:00 H39

**Efficiency of phoretic micromotors** — •Benedikt Sabass and Udo Seifert — II. Institut für Theoretische Physik, Universität Stuttgart

Small objects, propelled through phoretic surface processes, could be employed for active transport or even as micromotors. A common characteristic of these processes is the generation of a surface flow around the motor by different mechanisms. Here we investigate the thermodynamic properties of phoretic effects. We derive a general expression for the efficiency of motors and show that it is bounded by its hydrodynamic contribution. A general argument is proposed according to which the hydrodynamic efficiency of propulsion mechanisms relying on surface effects scales as $L/R$ where $L$ is the thickness of the interface layer and $R$ is the lengthscale of the object. This finding supports the notion that this class of processes is very often quite inefficient. We also illustrate our findings with concrete examples.

**Invited Talk** CPP 25.5 Wed 11:15 H39

**Active behavior of the cytoskeleton** — •Jean-Francois Joanny and Jacques Prost — Institut Curie Centre de Recherche Physico-Chimie Curie 26 rue d'Ulm, 75248 Paris Cedex 05 France

The mechanical properties of cells are dominated by the actin-myosin cytoskeleton. It is a gel-like structure formed by actin filaments which is active and intrinsically out of equilibrium since it contains molecular motors which permanently consume energy in the form of ATP.

We first present a hydrodynamic theory of active polar systems that allows for the description of the mechanical properties of the cytoskeleton. This theory is based on symmetry principles and is thus very similar to the hydrodynamic theories proposed for other active systems at very different length scales (animal behavior, bacterial suspensions...).

We then illustrate this theory by presenting some instablities of cells associated to the cortical actin layer: bleb formation, cell oscillations, contractile ring formation.

**Invited Talk** CPP 25.6 Wed 11:45 H39

**Active cytoskeletal polymer networks: from model systems to cells** — •Christoph F. Schmidt — Drittes Physikalisches Institut, Georg-August-Universität Göttingen, Germany

Mechanical processes, such as cell division and growth or cell locomotion, are essential in cell life and are driven and controlled by the cytoskeleton. The polymeric components of the cytoskeleton are semiflexible polymers. Force-generating motor proteins are tightly integrated into these polymer networks which makes the cytoskeleton a prototypical "active gel".

We study mechanical properties and collective dynamics of cells and of in vitro model systems for active cytoskeletal networks with microrheology techniques. We use micron-sized probe particles, embedded in the medium to be studied, and laser optical traps to confine the particles, combined with laser interferometry to detect either their Brownian motion or the particles' response to a driving force with sub-nm accuracy and bandwidths up to 100 kHz. We have applied this technology to non-equilibrium systems and have measured, at the same time, the elastic properties and the fluctuations and forces generated by myosin motor proteins interacting with a cross-linked actin network. We have also applied the same type of approach to several types of cells, and have monitored cellular forces transmitted to externally attached probe particles.

CPP 25.7 Wed 12:15 H39

**Active fluids and soft matter in biotechnology and medicine** — •Magnus Jaeger — Saarland University, Faculty of Clinical Medicine (2.28), 66421 Homburg / Saar, Germany

Biologically and medically relevant fluids are highly complex. They consist of suspensions containing non-negligible concentrations of deformable particles: cells. The cells have to be (a) identified in mixtures and (b) sorted into individual fractions. Both requirements are fulfilled by different methods commonly employed. However, these methods become inapplicable, if only small sample volumes are available, e. g. a drop of blood. Additional demands comprise disposables, robustness, low costs and quick results in minutes.

We aim at contributing to this crucial topic, based on our expertise in micro- and nanofluidics. We pursue several research approaches: (I) cells can conveniently be identified by their mechanical properties. To this end, we deform them in a harmless electric field. This technique is fast (seconds), simple (integrable into chip systems) and automatable. We clearly distinguished cancer cells from normal cells of the same tissue. (II) Microfluidics depends on the surface properties of materials, e. g. wettability. We investigate effects of coatings with switchable polymers that change their conformation in a sharp, reversible phase transition between a hydrated, elongated state and a dehydrated, collapsed state. The transition can arbitrarily be controlled externally through the temperature. (III) Further issues concern controllably releasing substances from the cells (RNA) and the separation of the macromolecule solutions.