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EDITORIAL

Colloidal dispersions in external fields

Guest Editor

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Colloidal dispersions have long been proven as pivotal model systems for equilibrium phase transition such as crystallization, melting and liquid–gas phase transition. The last decades have revealed that this is also true for nonequilibrium phenomena. In fact, the fascinating possibility to track the individual trajectories of colloidal particles has greatly advanced our understanding of collective behaviour in classical many-body systems and has helped to reveal the underlying physical principles of glass transition, crystal nucleation, and interfacial dynamics (to name just a few typical nonequilibrium effects). External fields can be used to bring colloids out of equilibrium in a controlled way. Different kinds of external fields can be applied to colloidal dispersions, namely shear flow, electric, magnetic and laser-optical fields, and confinement.

Typical research areas can be sketched with the by now traditional complexity diagram (figure 1). The complexity of the colloidal system itself as embodied in statistical degrees of freedom is shown on the x-axis while the complexity of the problem posed, namely bulk, an inhomogeneity in equilibrium, steady state nonequilibrium and full time-dependent nonequilibrium are shown on the y-axis. The different external fields which can be imposed are indicated by the different hatched areas.

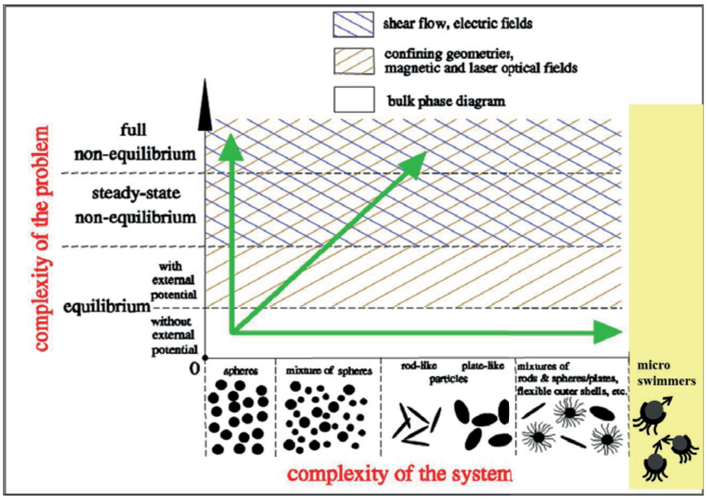

Figure 1. Diagram of complexity for colloidal dispersions in external fields: while the x-axis shows the complexity of the system, the y-axis shows the complexity of the problem. Regions which can be accessed by different kinds of external fields are indicated. The arrows indicate recent research directions. Active particles are also indicated with a special complexity of internal degrees of freedom [1].

This collection of papers reflects the scientific programme of the International Conference on *Colloidal Dispersions in External Fields III (CODEF III)* which took place in Bonn-Bad Godesberg from 20–23 March 2012. This was the third conference in a series that began in 2004 [2] and was continued in 2008 [3]. The CODEF meeting series is held in conjunction with the German Dutch Transregional Collaborative Research Centre SFB TR6 with the title *Physics of Colloidal Dispersions in External Fields*. Papers from scientists working within this network as well as those from further invited contributors are summarized in this issue. They are organized according to the type of field applied, namely:

- shear flow
- electric field
- laser-optical and magnetic field
- confinement
- other fields and active particles

To summarize the highlights of this special issue as regards *shear* fields, the response of depletion-induced colloidal clusters to shear is explored in [4]. Soft particles deform under shear and their structural and dynamical behaviour is studied both by experiment [5] and theory [6]. Transient dynamics after switching on shear is described by a joint venture of theory, simulation and experiment in [7]. Colloids provide the fascinating possibility to drag single particles through the suspension, which gives access to microrheology (as opposed to macrorheology, where macroscopic boundaries are moved). Several theoretical aspects of microrheology are discussed in this issue [8–10]. Moreover, a microscopic theory for shear viscosity is presented [11].

Various aspects of colloids in *electric* fields are also included in this issue. Electrokinetic phenomena for charged suspensions couple flow and electric phenomena in an intricate way and are intensely discussed both by experiment and simulation in contributions [12–14]. Dielectric phenomena are also influenced by electric fields [15]. Electric fields can induce effective dipolar forces between colloids leading to string formation [16]. Finally, binary mixtures in an electric driving field exhibit laning [17]. Simulation [18] and theoretical [19] studies of this nonequilibrium phenomenon are also discussed in this issue.

Laser-optical fields can be used to tailor a random substrate potential for colloids [20] or to bind colloids optically [21]. External *magnetic* fields are typically used to create dipolar repulsions of colloids pending at an air–water interface. This provides an avenue to two-dimensional systems, where the freezing transition [22] and various transport phenomena through channels are the focus of recent research [23, 24].

Confinement typically leads to interfaces. The classical problem of the Tolman length for a fluid–fluid interface is reviewed in detail in [25]. In fact, colloid–polymer mixtures constitute ideal model systems for liquid–gas interfaces in various geometries [26] and are also suitable for measuring the Tolman length experimentally. Crystalline phases in confinement [27] and crystal–fluid interfaces [28] are even more complex due to the inhomogeneity of the solid phase. Also in the confined fluid phase, there are still open issues in slit-pore geometry. These include how to scale the interparticle distance [29] and how to measure hydrodynamic interactions between colloidal particles [30].

Other external fields which can be applied to colloids are gravity [31] and temperature [32]. An important field of recently emerging research is active colloidal particles (so-called microswimmers) which possess fascinating nonequilibrium properties; for recent reviews see [33–35]. Two examples are also included in this issue: an active deformable particle [36] moving in gravity and the collective turbulent swarming behaviour of dense self-propelled colloidal rod suspensions [37].

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