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Raphael Wittkowski

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The proper description of the static equilibrium properties and the dynamic behavior of many-particle systems is one of the oldest problems in theoretical physics. This very general problem is highly relevant for most fields of physics. In the present work, several aspects in the context of this problem are investigated. These aspects concern the Brownian dynamics of interacting anisotropic colloidal particles, that can be passive (colloidal liquid crystals) or active (self-propelled microswimmers).

The main part of this work is subdivided into three chapters. In the first chapter, the Brownian dynamics of an individual active colloidal particle with arbitrary shape is investigated. After the formulation of the corresponding Langevin equation, analytical solutions for some special cases are derived and numerical solutions for more general situations are presented. Taking the example of a spherical colloidal particle, the effect of an imposed shear flow is discussed also. The second chapter considers the collective dynamics of a large set of interacting active colloidal particles with arbitrary shape. Starting from the appropriate many-particle Smoluchowski equation, classical dynamical density functional theory is generalized to arbitrarily shaped active or passive colloidal particles. It is proved, that this new and generalized dynamical density functional theory can be reformulated in terms of the variational optimization of a dissipation functional. This alternative representation of dynamical density functional theory allows an easier and much faster derivation of the dynamic equations of phase field crystal models with various order-parameter fields than the traditional formulation of dynamical density functional theory. The reformulation with a dissipation functional additionally establishes a basis for the interpretation of dynamical density functional theory out of linear irreversible thermodynamics. The third chapter finally treats the statics and dynamics of colloidal liquid crystals by means of microscopic, mesoscopic, and macroscopic classical mean-field theories. Using static and dynamical density functional theory (microscopic), phase field crystal models (mesoscopic) for apolar and polar colloidal liquid crystals in two and three spatial dimensions are derived and compared with static and dynamic symmetry-based approaches (macroscopic) on the basis of classical Ginzburg-Landau theory and generalized hydrodynamics.

The results obtained in this work can, for example, be applied to colloidal liquid crystals in order to explore their equilibrium phase diagram and phase transition dynamics as well as to the dissipative dynamics of topological defects in liquid crystalline phases and to artificial microswimmers or living microorganisms in order to describe their non-equilibrium swarming behavior. The results are also of more fundamental interest, since they help to clarify the relationship between classical density functional theory, phase field crystal models, and symmetry-based macroscopic approaches.