Abstract

Self-propelled particles (SPPs) are non-equilibrium systems and as such they are not forced to obey the fluctuation-dissipation theorem. Moreover, SPPs can exhibit fluctuations in the direction of motion uncorrelated from those in the speed. In this Thesis it is shown that uncorrelated fluctuations lead to a non-Brownian motion characterized by expressions for the mean square displacement and diffusion coefficient that differ from the classical results by additive corrections. It is also indicated that such effects have been observed in cell motility experiments.

Interacting SPPs represent another fascinating kind of systems with remarkable differences with equilibrium system. For instance, while in equilibrium two-dimensional systems with continuum symmetry long-range order is forbidden, SPPs can develop such long-range order. Though it is well known that two-dimensional SPPs with local polar interactions can exhibit such transition to orientational order, a recurring question refers to alternative physical mechanisms that lead to collective motion in SPPs. In this Thesis it is shown that a self-propelling force together with volume exclusion are sufficient to cause collective migration. This is clearly illustrated through a model for self-propelled rod-shaped particles. In particular, it is indicated that the emerging collective patterns depend on the particle elongation. For instance, it is shown that for a given density there is critical particle aspect ratio that triggers non-equilibrium clustering. It is also suggested that those effects might play a major role in the collective motion of gliding bacteria such as myxobacteria.

Volume exclusion represents an apolar interaction. This rises the question how the results known for SPPs with polar interactions change when the interactions become apolar. This issue is addressed in this work and it is shown that though SPPs with apolar interactions can also achieve long-range order, the character of the transition highly depends upon particle density.

Finally, it is shown that the ordering dynamics in SPPs with either polar or apolar interactions can be described with the same continuum theory.