Eugene Wigner Colloquium

joint event of GRK 1558 and SFB 910

Thomas Ihle

Ernst-Moritz-Arndt Universität Greifswald

"Kinetic theory of active particles: von Mises distribution, Chapman-Enskog expansion and ring-kinetic theory"

We consider Vicsek-type models for self-propelled particles. In these models, particles try to align their travel directions with the average direction of their neighbors plus some noise. At low noise, a globally ordered state of collective motion forms. Starting from the exact evolution equation for the N-particle probability distribution, using Boltzmann's approximation of Molecular Chaos an Enskog-like kinetic equation is derived. Recently, the von Mises distribution, a geometric series and a Gaussian ansatz were proposed to treat this nonlinear integral equation. We critically assess and improve them. We also present a non-standard Chapman-Enskog expansion to derive macroscopic transport equations. The Enskog-like kinetic equation is also solved numerically. Steep soliton-like waves are observed that lead to an abrupt jump of the global order parameter if the noise level is changed. The shape of the waves is shown to quantitatively agree with agent-based simulations at large particle speeds. At small densities and realistic particle speeds, the mean-field assumption of Molecular Chaos is invalid near the onset of collective motion, and correlation effects become relevant. It is shown how to self-consistently include correlations at the level of ring-kinetic theory. Instead of just one kinetic equation, an additional equation for the time evolution of the two-particle correlations is solved numerically.

M. Bär

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