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Deriving hydrodynamic equations for the flocking dynamics of self-propelled agents THOMAS IHLE, ALEMAYEHU GEBREMARIAM, Department of Physics, North Dakota State University — Hydrodynamic equations for interacting many-body systems follow, in principle, from microscopic laws. However, it is often difficult to quantitatively establish this link. Therefore, the general form of the macroscopic equations is usually obtained by symmetry arguments. We first study a particle-based model for fluid flow with a stochastic and discrete time evolution and show how the macroscopic transport equations can be rigorously derived from microscopic collision rules. The approach starts with the Liouville equation and leads to a multi-particle Enskog-equation which is treated by a Chapman-Enskog expansion. The same procedure is then applied to a simple model of self-propelled agents which mimick swarming birds. This model was proposed by T. Vicsek et al. [Phys. Rev. Lett. **75** (1995) 1226]; it has "multi-particle collisions" where birds within some interaction range align their flying directions. Spontaneous symmetry breaking leads to a global particle drift; the system is neither Galilean-invariant nor momentum conserving. The transition to global alignment of the flying birds is found to be continuous. We analyze the transition for small and large bird density, derive the hydrodynamic equations and perform a stability analysis of the flocking state.

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