Mean Field Theory for a Vicseklike Model on a Lattice

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Active matter research seeks to understand how collective motion emerges without a leader from individual particle interactions. The Vicsek model[1] explains this emergence as a phase transition dependent on density and noise, with an order parameter related to collective particle velocity. By studying active matter, we can understand how complex behaviors arise from simple interactions. In this work, we study a model of active matter where particles on a triangular lattice can have only three velocity directions. Using a mean-field analysis, we derived motion equations for particle density in each direction, considering an alignment rule and a noise term. Aligned particles move through the lattice via a density transfer process constrained by excluded volume. The evolution of the system depends on its initial configuration, density, and noise intensity. Our focus is on understanding the conditions necessary to maintain and/or form ordered states. The results show that the model exhibits spatial patterns characteristic of active matter in discrete spaces[2], such as bands and traffic jams, which disappear in the presence of high noise, leading to a disordered state. The order-disorder phase transition can be either continuous or discontinuous for the same initial configuration, depending on the density.

References

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