Flocking through disorder
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How do flocks, herds and swarms proceed through disordered environments? This question is not only crucial to the displacement of animal groups in the wild, but also to virtually all applications of collective robotics, and active materials composed of motile units. In stark contrast, apart from very rare exceptions, our physical understanding of flocking motion has been hitherto restrained to homogeneous media. Here, we elucidate how collective motion survives to geometrical disorder. Combining experiments on colloidal bots flocking through random repelling obstacles, and analytical theory, we establish two generic results: Firstly, we show how the bending elasticity of flocking phases restrains their flows to sparse channel networks akin those found beyond plastic depinning in driven condensed matter. Secondly, we demonstrate how further increasing disorder, collective motion is suppressed in the form of a first-order phase transition generic to all polar active materials.

**Question:** How much disorder is needed to melt a flock?

**Flocking through heterogeneous media**

**Disorder induces melting**

**Nature of the transition: 1st order**

\[ \partial \theta_i(t) = -\beta_i \sum_j h(r_i-r_j) + \sqrt{D \Pi} \]

Quenched disorder

\[ \Pi \sim -\nabla \Phi \]

Time dependent angular noise

\[ \Phi \sqrt{2} \]

Theory prediction \( L_F \sim \Gamma \langle \hat{\theta}_i \rangle \) agrees with experiments.

**A Vicsek 1st order transition**

**Question:** Spatio-temporal fluctuations?

**Emergence of sparse flowing networks as \( v_0 \to 0 \)**

**Network area**

**Active fluid in a random potential**

\[ \partial_\Pi + \nu_3 \Pi \nabla = P \left[ -\beta_i \nabla \rho + \nu_3 \nabla^2 (\rho \Pi) + \gamma_i (\partial_\Pi, \Pi) + F_\Pi \right] \]

Pressure force

\[ F_\Pi \sim \sqrt{v_0} \]

**Bending by a random potential**

\[ \partial_\Pi + \nu_3 \Pi \nabla = P \left[ -\beta_i \nabla \rho + \nu_3 \nabla^2 (\rho \Pi) + \gamma_i (\partial_\Pi, \Pi) + F_\Pi \right] \]

Disorder force

\[ F_\Pi \sim \sqrt{\nu_0} \]

**Elasticity vs disorder \( \Rightarrow \) Sparse network**

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