Colloquium

MAX PLANCK INSTITUTE
FOR DYNAMICS AND
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Phase behaviour and higher-order structure in active matter in two and three dimensions

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We present results from three active matter model systems: Quincke Rollers (2d colloids) metal-dielectric Janus particles (3d colloids) and zebrafish.

Quincke Rollers exhibit intriguing bulk phase behaviour with two regimes of mesophase separation, similar to passive systems such as diblock copolymers and short range attraction-long range repulsion systems. At low driving, activity suppresses phase separation, while at high driving, activity-induced banding leads to mesophase separation [1]. Clusters of Quincke Rollers exhibit a hierarchy of novel bound states, reminiscent of excited state in molecules, but with coupling through both steric and hydrodynamic interactions [2,3].

In passive matter, dimensionality has a profound effect upon phase behaviour. To explore this in 3d active colloids, we use specially modified metal-dielectric Janus particles. This is somewhat akin to a passive system of dipolar colloids, which forms arrays of polymorphic colloidal crystal structures. Beyond this already rich and complex behaviour, the active system forms novel long-lived structures such as sheets and a labyrinthine phase [4].

Zebrafish are a well-characterised model system whose bulk behaviour maps onto a modified Vicsek model with surprising accuracy. For genetically modified zebrafish, we find that changes in Vicsek parameters directly correspond to genetically induced physiological changes. Finally, three zebrafish exhibit a tristable state and already capture the essential collective behaviour, applicable to much larger systems with only weak changes [5].

[1] A. Mauleon-Amieva et al., Phys. Rev. E 102 (2020), [2] A. Mauleon-Amieva et al. ArXiV 2107.07934 (2021), [3] F.J. Schwarzendahl et al., ArXiV 2212.11597 (2022), [4] N. Sakaï & C. P. Royall, ArXiV 2010.03925 (2020), [5] Y. Yang et al., PLOS Comp. Biol. 18 (2022)

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