Seminar of SFB 910

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“How to extract long-range order from chaotic bacterial collective motion”

Dense bulk suspensions of swimming bacteria usually exhibit spatio-temporally chaotic collective motion. This resembles turbulent flow and is referred to as active turbulence. However, the boundary conditions of active turbulence have remained elusive and the presence of boundaries can modify the macroscopic behavior of active turbulence. In this talk, I will present two ways of realizing long-range order out of active turbulence and discuss the role of boundaries and how order and fluctuations compete in bacterial suspensions. (i) Long-range nematic order can be attained by confining elongated bacteria in a very thin fluid layer between two solid walls. This collective motion exhibits true long-range order and giant number fluctuations, the characteristic properties predicted by Toner, Tu, Ramaswamy et al. for globally ordered homogeneous active phases. The reason for this can be understood by reduced hydrodynamic interactions and adequate excluded volume interactions in our setup.

(ii) By imposing periodic constraints on bacterial turbulence by fabricating microscopic pillar arrays, we found that bacterial turbulence can self-organize into very stable antiferromagnetic vortex lattices spanning the whole system without any defects. Neighboring vortices stabilize each other and their persistence times are increased. These experimental observations can be explained by a coarse-grained spin model. The volume fraction of the microscopic pillars is 4% and thus our findings can contribute to the less invasive methodology for controlling active matter systems. If time permits, I would also like to briefly introduce our recent experiments on Janus particles fueled by an AC electric field and mammalian cells. By controling the frequency of the AC field and the ion concentration of the suspensions, we can tune the interactions between the Janus particles and accordingly we can observe a turbulent phase, chain formations, and even an ordered phase.

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