量子物理学・ナノサイエンス第 38 回特別セミナー

Long-range nematic order and anomalous fluctuations in collective motion of swimming filamentous bacteria

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場所　：　本館 1 階　H155B　理学院セミナー室

概　要

Collective motion of self-propelled elements, as seen in bird flocks, fish schools, bacterial swarms, etc., is so ubiquitous that it has driven physicists to search for its possibly universal properties. Evidence for such universality has been provided by many theoretical and numerical studies using simple flocking models such as Vicsek-style models and hydrodynamic theories [1-2]. However, no experiments so far have been fully convincing in demonstrating the existence of this universality.

In this seminar, after introducing standard models of collective motion and giving state-of-the-art interpretations on previous experimental studies, I show our experiments on elongated bacteria swimming in a quasi-two-dimensional fluid layer [3]. Strong confinement and the high aspect ratio of bacteria induce weak nematic alignment upon collision, which gives rise to spontaneous breaking of rotational symmetry and global nematic order at sufficiently high density of bacteria.
This homogeneous but fluctuating ordered phase has turned out to exhibit true long-range orientational order, non-trivial giant number fluctuations, and algebraic correlations associated with Nambu-Goldstone modes, which verifies the existence of an active phase predicted to emerge in standard flocking models. Such properties contrast our system with usual bacterial experiments that end up with turbulent states without any global orientational order.

Through our experiments, I will also discuss (i) what might be crucial for the emergence of such universality in reality and (ii) possible discrepancy between our experiments and theoretical predictions with approximations.

[1] F. Ginelli, “The Physics of the Vicsek model”, Eur. Phys. J.: Special Topics, **225**, 2099 (2016).
[2] J. Toner, Y. Tu, and S. Ramaswamy. “Hydrodynamics and phases of flocks”, Ann. Phys. (N.Y.), **318**, 170 (2005).
[3] D. Nishiguchi, K. H. Nagai, H. Chaté, and M. Sano, “Long-range nematic order and anomalous fluctuations in suspensions of swimming filamentous bacteria”, Phys. Rev. E, **95**, 020601(R) (2017).

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