Institute of SCIENCE TOKYO

Advanced Research Center for ***Quantum Physics and Nanoscience***

量子物理学・ナノサイエンス第 121 回特別セミナー

Interactions in nonequilibrium systems: from active self-organization to nonreciprocal fluctuations

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日程　：　6 月 8 日（月）10:30 -

場所　：　南 5 号館 5 階 503CD 大会議室 および Zoom*

概　要

In systems far from thermal equilibrium, structure and dynamics are intertwined, leading to emergent phenomena such as collective motion in active matter or anomalous wave propagation in nonreciprocal systems. This talk explores the role of microscopic interactions in shaping these behaviors: What forms do they take? What are their consequences at macroscopic scales? And how can we infer them from experiments?

In the first part, I will present a study of self-propelled Janus particles (developed in the Nishiguchi lab), which exhibit coherent flocking at the collective level. Using a recent framework known as Stochastic Force Inference, we learned the microscopic interactions between particles [1]. These interactions not only reproduce experimental observables in simulations but also reveal a mechanism for flocking: pairwise torques that cause particles to turn away from their neighbors.

The second part focuses on flowing droplets with nonreciprocal hydrodynamic interactions, where left/right asymmetry gives rise to unexpected dynamics. Despite being overdamped, a 1D stream of such droplets supports nonlinear waves due to nonreciprocal coupling. Theoretically, we predict solitary waves described by the Korteweg–de Vries (KdV) equation (or KdV-Burgers with damping) [2]. A physics-informed neural network further uncovers this dynamics directly from experimental data.

If time permits, I will briefly discuss two ongoing theoretical projects on active and nonreciprocal systems: (1) how memory effects in viscoelastic media alter Motility-Induced Phase Separation of active particles, and (2) how Kardar-Parisi-Zhang fluctuations are evidenced in a 1D lattice model with nonreciprocal interactions.

[1] Hem, Poncet, Ronceray, Nishiguchi & Démery, Soft Matter **21** (37), 7257-7269 (2025)
[2] Colen, Poncet, Bartolo & Vitelli, Physical Review Letters **133** (10), 107301 (2024)

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＊Zoom 登録リンク：https://zoom.us/meeting/register/qw3pWA-kTjW7F01RXWqJSg

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