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Physical Colloquium

„Nonreciprocal active matter - Irreversibility, heat flows, and persistent currents“

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Colloquium on

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Room No. W02 1-148

While the action-reaction principle rules all fundamental physical interactions and constraints equilibrium physics, the dynamics we effectively observe in complex systems far from equilibrium ubiquitously breaks reciprocity on various scales. Even in a simple system of two nonreciprocally coupled Brownian particles, nonreciprocity can have surprising thermodynamic implications, such as generating heat flows against a temperature gradient [1]. I will discuss the impact of nonreciprocal interactions in many-body systems using two example systems. First, we show that nonreciprocal vision-cone interactions implemented in a two-dimensional XY model can lead to long-range order and directional propagation of defects [2]. Then we consider binary fluids where nonreciprocal interactions can induce travelling wave solutions. Using fluctuating field theories, we show for a wide class of models that close to transitions to travelling states, fluctuations not only inflate, as in equilibrium criticality, but also develop an asymptotically increasing time-reversal asymmetry and associated surging entropy production [3,4]. The formation of dissipative patterns and the emergence of irreversible fluctuations can both be attributed to a mechanism of mode coupling in the vicinity of critical exception points.

[1] Loos and Klapp, NJP 22, 123051 (2020).
[2] Martynec, Klapp, Loos, PRL 130, 198301 (2023); Bandini, Venturelli, Loos, Jelic, Gambassi, J. Stat. Mech. 053205 (2025).
[3] Suchanek, Kroy, and Loos, PRL 131, 258302 (2023).
[4] Suchanek, Kroy, and Loos, PRE 108, 064610 (2023); PRE 108, 064123 (2023)

Host: Prof. Dr. Alexander Hartmann