LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN | ARNOLD SOMMERFELD CENTER FOR THEORETICAL PHYSICS

Sommerfeld Theory Colloquium

Wednesday, 19th May 2021
at 16.15 h

Prof. Erwin Frey
(LMU Munich)

Topological Phase Transitions in Population Dynamics

Topological phases were discovered in condensed matter physics and recently extended to classical physics such as topological mechanical metamaterials. Their study and realization in soft-matter and biological systems has only started to develop. In this talk we discuss how topological phases may determine the behavior of nonlinear dynamical systems that arise, for example, in population dynamics. We have shown that topological phases can be realized with the anti-symmetric Lotka-Volterra equation (ALVE). The ALVE is a paradigmatic model system in population dynamics and governs, for example, the evolutionary dynamics of zero-sum games, such as the rock-paper-scissors game [1], but also describes the condensation of non-interacting bosons in driven-dissipative set-ups [2]. We have shown that for the ALVE, defined on a one-dimensional chain of rock-paper-scissors cycles, robust polarization emerges at the chain's edge [3]. The system undergoes a transition from left to right polarization as the control parameter passes through a critical value. At the critical point, solitary waves are observed. We found that the polarization states are topological phases and that this transition is indeed a topological phase transition. Remarkably, this phase transition falls into symmetry class D within the "ten-fold way" classification scheme of gapped free-fermion systems, which also applies, for example, to one-dimensional topological superconductors. Beyond the observation of topological phases in the ALVE, it might be possible to generalize the approach of our work to other dynamical systems in biological physics whose attractors are nonlinear oscillators or limit cycles.

[1] J. Knebel, T. Krüger, M. F. Weber, and E. Frey, Phys. Rev. Lett. 110, 168106 (2013).
[2] J. Knebel, M. F. Weber, T. Krüger, and E. Frey, Nature Communications 6, 6977 (2015).
[3] J. Knebel, P. M. Geiger, and E. Frey, Phys. Rev. Lett. (in press) [arXiv:2009.01780].

via ZOOM