第 34 回トポロジカル物質科学セミナー
Topological Materials Science Seminar (34)

Nonequilibrium quantum dynamics -- from real to imaginary

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Place: **Room 413, School of Science Bldg. #5, Kyoto University**
Date: **Friday, 24 Februay 2017**
Time: **13:00-14:30**

Abstract: In this talk, we will discuss two relatively independent issues on nonequilibrium quantum dynamics – the Zeno Hall effect [1] and the dynamical quantum phase transition [2], which, however, are both related to well-known phenomena by exchanging a real physical quantity to its imaginary counterpart.

Part I: Zeno Hall effect – anomalous Hall effect with imaginary band gap The quantum Zeno effect [3] and the Hall effect [4] are two seemingly unrelated physical phenomena, yet we find that the former can give rise to the latter by dissipatively tailoring the Hilbert space of a two-dimensional lattice system into a single Bloch band with a nontrivial Berry curvature. Consequently, a wave packet undergoes transverse motion in response to a potential gradient – a phenomenon we call the Zeno Hall effect to emphasize its quantum Zeno origin and to distinguish it from other Hall effects. In particular, we find that the Zeno Hall effect leads to a retroreflection at the edge of the system due to an interplay between the band flatness and the nontrivial Berry curvature. We argue that the retroreflection is a universal phenomenon protected by the trivial band topology. We propose an experimental implementation of this effect with cold atoms in an optical lattice.

Part II: Dynamical quantum phase transition – phase transition at imaginary temperature Inspired by the Lee-Yang phase transition theory [5], M. E. Fisher proposed a systematical approach to study thermal phase transitions by looking at the zeros of the partition function over the entire complex temperature plane [6], now known as Fisher zeros. In the thermodynamic limit, Fisher zeros can approach the real temperature axis, leading to the singular behavior of the partition function at a critical temperature. Recently, the imaginary temperature analogue has been established for the nonequilibrium unitary evolution of a quantum system after a quench [2]. Nonanalyticity can emerge at a critical time, corresponding to a dynamical quantum phase transition. We briefly review the previous works on one-dimensional and two-dimensional systems, highlighting the topological aspects, and present some preliminary results for three-dimensional systems, especially on the universal scaling near a critical time.

References: [1] Z. Gong, S. Higashikawa, and M. Ueda, arXiv: 1611.08164. [2] M. Heyl, A. Polkovnikov, and S. Kehrein, Phys. Rev. Lett. 110, 135704 (2013). [3] B. Misra and E. C. G. Sudarshan, J. Math. Phys. 18, 756 (1977). [4] N. Nagaosa, J. Sinova, S. Onoda, A. H. MacDonald, and N. P. Ong, Rev. Mod. Phys. 82, 1539 (2010). [5] C. N. Yang and T. D. Lee, Phys. Rev. 87, 404 (1952). [6] M. E. Fisher, in Boulder Lectures in Theoretical Physics (University of Colorado, Boulder, 1965), Vol. 7.

Host: Norio Kawakami [Kyoto U.]