Titles and abstracts

Y. Kawaguchi

Generalized Berry phase for a bosonic Bogoliubov system with exceptional points

We discuss the topology of the excitation bands from a Bose-Einstein condensate in an optical lattice. Since the Bogoliubov equation for a bosonic system is non-Hermitian, complex eigenvalues often appear and induce dynamical instability. As a function of momentum, the onset of appearance and disappearance of complex eigenvalues is an exceptional point (EP), which is a point where the Hamiltonian is not diagonalizable and hence the Berry connection and curvature are ill-defined, preventing defining topological invariants. In this paper, we propose a systematic procedure to avoid EPs from the Brillouin zone by introducing an imaginary part of the momentum. We then define the Berry phase for a one-dimensional bosonic Bogoliubov system. Extending the argument for Hermitian systems, the Berry phase for an inversion-symmetric system is shown to be Z2. As concrete examples, we numerically investigate two toy models and confirm the bulk-edge correspondence even in the presence of complex eigenvalues. The Z2 invariant associated with particle-hole symmetry and the winding number for a time-reversal-symmetric system are also discussed.

A. Suzuki

Winding numbers in one-dimensional quantum walks

Quantum walks have used for explaining various types of topological phenomena, where winding numbers have often played crucial roles. In this talk, we provide two types of relations between the winding numbers and one-dimensional quantum walks. First, we give a criterion for the self-adjointness of time operators of the quantum walk in terms of the winding number. Secondly, we introduce an index for a general class of quantum walks, classify the index for a one-dimensional split-step quantum walk in terms of the asymptotic conditions, and review a result by Matsuzawa on the relation between the index and the winding number.

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H. Fukaya

Domain-wall fermion and index theorem

The Atiyah-Patodi-Singer index theorem describes the bulk-edge correspondence of symmetry protected topological insulators. The mathematical set-up for this theorem is, however, not directly related to the physical fermion system, as it imposes on the fermion fields a non-local boundary condition known as the "APS boundary condition" by hand, which is unlikely to be realized in the materials. In 2017, we showed that the same integer as the APS index can be obtained from the eta-invariant of the domain-wall Dirac operator. Recently we invite three mathematicians to our group and prove that this correspondence is not a coincidence but generally true. This talk is based on the work in collaboration with M.Furuta, S.Matsuo, T.Onogi, S.Yamaguchi and M.Yamashita.

T. Natsume

Ginsparg-Wilson operators from mathematical perspective

This is a part of joint work with H. Moriyoshi. The notion of Ginsburg-Wilson operators was introduced in finite lattice gauge theory. We study those operators in infinite-dimensional setting. In particular, we show an index formula for the Ginsburg-Wilson index, which is an analogue discovered in finite lattice gauge theory. We investigate this analogue from K-theoretic viewpoint.

S. Tamura

Spectral bulk-boundary correspondence for chiral symmetric systems

Odd in frequency Cooper pairs with chiral symmetry emerging at the edges of topological superconductors are a useful physical quantity for characterizing the topological properties of these materials. In this work, we show that the odd in frequency Cooper pair amplitudes can be expressed by a winding number extended to a nonzero frequency, which is called a "spectral bulk-boundary correspondence," and can be evaluated from the spectral features of the bulk. The odd in frequency Cooper pair amplitudes are classified into two categories: the amplitudes in the first category have the singular functional form $\sim 1/z$ (where z is a complex frequency) that reflects the presence of a topological surface Andreev bound state, whereas the amplitudes in the second category have the regular form $\sim z$ and are regarded as non-topological.

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