Πανεπιστήμιο Κύπρου

ΤΜΗΜΑ ΦΥΣΙΚΗΣ

Το Τμήμα Φυσικής του Πανεπιστημίου Κύπρου
σας προσκαλεί την

Παρασκευή, 10 Μαΐου 2019, ώρα 10:00
στην αίθουσα Β228, στο κτίριο 13 στην Πανεπιστημιούπολη

στην παρουσίαση της Διδακτορικής Διατριβής του Κυριάκου Κυριάκου

"Topological Band Theory: Non-Hermitian contributions and topological stabilization"

Motivated by the increased importance of boundary effects in topological states of condensed matter, combined with the involvement of geometric and topological concepts within a quantum mechanical framework, this dissertation is dedicated to the reformulation and extension of some fundamental concepts, which in turn cause important measurable consequences.

We have reconsidered the so called Modern Theory of Orbital Magnetization by defining additional quantities that incorporate a non-Hermitian effect due to anomalous operators that break the domain of definition of the Hermitian Hamiltonian. As a result, overlooked boundary contributions to the observable are rigorously and analytically taken into account. These are expected to give giant contributions to orbital magnetization whenever band crossings occur along with Hall voltage due to imbalance of electron accumulation at opposite boundaries of the material.

Similar arguments with non-Hermitian contributions have been applied to spin physics. We show how one can set up a global quantum equation of motion for the spin transport processes without any local conservation law being necessary, in contrast to the established practice. In this framework, we have defined the intrinsic spin current operator as the time derivative of the correlation between electron's position and electron's spin. This intrinsic spin current is free from any complications, it explicitly takes into account boundary contributions, and for systems that lack local spin-torques turns zero value.

In addition, we have made a dynamical extension of the standard Hellmann-Feynman theorem to one that can be applied to time-dependent states with time-dependent parameters. The resulting formula for the dynamics of the observables is found to have profound connections to generalized Berry curvatures as well as to boundary contributions due to an emerging non-Hermitian effect. By way of application we have derived the quantum equations of motion of the electron which extends the semiclassical counterpart. Application of the theorem to the study of particle transport in the non-adiabatic limit, shows that the quantization breaks down due to a non-trivial Aharonov-Anandan phase. Similarly, application of the theorem to the study of the electric polarization indicates that there is a boundary non-Hermitian contribution that has been so far overlooked.

By using an orthonormal basis we have analyzed further the dynamical extension of the Hellmann-Feynman theorem. We have found a formula for the observables that depends on the dynamics through the expansion coefficients together with the topology of the instantaneous occupied Hilbert space. Interestingly, the observables acquire dependence on non-Abelian Berry curvatures when the quantum state occupies more than one dimensions. The form of these non-Abelian Berry curvatures resembles the Yang-Mills field strength tensors. In the fully dynamical limit, when all expansion coefficients evolve in time coupled one to each other, these non-Abelian Berry curvatures turn to zero. By way of application of this extension we can justify the theoretical results that have come out in the last few years in non-equilibrium transport studies where they find that, the conductivity as well as the particle transport, are given as integrals of Berry curvatures weighted by the occupation numbers.

Για περισσότερες πληροφορίες παρακαλώ επικοινωνείτε: Τμήμα Φυσικής, τηλέφωνο: 22892820