Information Geometry in the analysis of Phase Transitions

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Abstract

The Uhlmann connection is a mixed state generalization of the Berry connection. The latter has a very important role in the study of topological phases at zero temperature. Closely related, the quantum fidelity is an information theoretical quantity which is a measure of distinguishability of quantum states. Moreover, it has been extensively used in the analysis of quantum phase transitions. In the first part of this lecture, we will show how one can use the fidelity and the Uhlmann connection to study phase transitions at finite temperature. Explicitly, we will apply the analysis to free fermion Hamiltonians exhibiting symmetry protected topological order at zero temperature (topological insulators and superconductors) and also for the BCS theory of superconductivity.
In the second part of this lecture, we study finite-temperature dynamical phase transitions by means of the fidelity and the interferometric Loschmidt echoes. These phase transitions occur in systems out of equilibrium upon performing a quench, i.e., when one suddenly changes the Hamiltonian to that of a different phase. We explain the physical and mathematical origin of the different behaviour seen in the two Loschmidt echoes by means of the associated dynamical susceptibilities.