Quantum Imaging of Berry's Phase and Topological Order in Dirac Materials

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Deforming a material and restoring it precisely back to its starting point intuitively implies that the material before and afterwards is identical. This is true classically, and was believed to be true in general until recently in the history of quantum mechanics. Even if all the atoms, electrons, and other ingredients are returned exactly to where they started, we now know that the restored material can differ from the undeformed material by nontrivial quantum mechanical phase factors. The importance of these so-called geometric or Berry phases has garnered increasing appreciation and attention in recent years. The quantum Berry phase can fundamentally alter the ground state of a system, lead to new states of quantum matter, and be exploited in quantum devices and topological quantum computing strategies. This talk will overview new experiments from our lab, employing scanning tunneling microscopy and atomic manipulation, that directly visualize and control Berry's phase in nanostructures, graphene, and topological insulators.