Topological Defects : Creating and Imaging Quantum Matter

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The tenfold classification of insulators and superconductors provides a useful and elegant framework to study topological features in condensed matter. It enables the classification of quantum materials based on certain symmetries, such as time reversal, particle-hole, and chiral, as well as spatial dimension. We demonstrate that building topological quantum materials on demand is feasible by introducing specific and properly tailored defects and textures (e.g., vortices, kinks, domain walls, vacancies) so as to navigate across the tenfold classification through modifications of symmetries and of effective spatial dimensions.

We introduce a new framework since spatial defects hinder utilizing the Bloch representation for Hamiltonians. Drawing from a deep analogy with the classification of topological defects in thermodynamic phase transitions, we develop a basis for a theory of topological phase transitions. Though predicting novel topological phases is valuable, observing them is crucial. We propose a direct measurement of topological numbers by examining dislocation patterns visible through STM imaging, stemming from a new mesoscopic interference effect. Finally, we will show how defect-induced and topologically protected states can be engineered to create and manipulate inter-particle quantum entanglement.