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. It allows to characterise quantum materials according to specific symmetries (e.g. time reversal, particle-hole and chiral) and spatial dimension. We show that it is possible to build on demand topological quantum materials by introducing specific and properly tailored defects and textures (e.g vortices, kinks, domain walls, vacancies) so as to navigate on the tenfold classification through modifications of symmetries and of effective spatial dimensions.

To that purpose, we propose a new theoretical framework since spatial defects prevent using the powerful Bloch representation for Hamiltonians. We build upon a deep analogy with the classification of topological defects in thermodynamic phase transitions. This analogy paves the way to a theory for topological phase transitions. While important to predict new topological phases, it is essential to observe them. We show how to directly measure topological numbers by analysing dislocation patterns easily accessible from imaging methods such as STM and resulting from a novel 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.