Imaging Anyons with Scanning Tunneling Microscopy

Michael Zaletel

Assistant Professor of Physics
Princeton University

Email: mzaletel@princeton.edu

Anyons are exotic quasi-particles with fractional charge that can emerge as the fundamental excitations of interacting topological phases. Unlike ordinary fermions and bosons, they may obey non-abelian statistics–a property that would help realize fault tolerant quantum computation. Non-abelian anyons have long been predicted to occur in certain fractional quantum Hall (FQH) phases, most recently in bilayer graphene heterostructures. However, direct experimental tests which can distinguish between different non-Abelian and Abelian topological phases have remained elusive. Here we propose a new experimental approach to directly visualize the structure of interacting electronic states of FQH states using a scanning tunneling microscope (STM). Our theoretical calculations show how spectroscopy mapping with the STM near impurity defects can be used to image the "fractional exclusion statistics" of FQH states, providing a unique fingerprint which can distinguish different proposed ground states. The presence of locally trapped anyons should leave distinct signatures in STM spectroscopic maps, and enables a new approach to directly detect - and perhaps ultimately manipulate - these exotic quasi-particles.