Influence of disorder on vortex Majorana states in 3D topological insulators

Jukka Vayrynen
Rafal Rechcinski, Dmitry Pikulin, Roman Lutchyn

Department of Physics and Astronomy, Purdue University, West Lafayette, Indiana 47907 USA

vayrynen@purdue.edu

Abstract

Majorana states hosted in vortex cores of topological insulator/superconductor heterostructures present a promising alternative to nanowire-based approaches. Vortices can be pinned to anti-dots pre-fabricated in the superconductor; large anti-dots are relatively simple to fabricate and ensure that weak magnetic fields are sufficient to induce a required quantum of flux. However, it has thus far been unclear whether current topological insulator materials are clean enough to sustain Majorana vortex modes with a sizable gap to excitations. Also, if the anti-dot is too large, the level spacing of subgap vortex states may become too small even in a clean case. In this talk, I will present our numerical studies of the vortex subgap spectrum as a function of disorder, chemical potential, and the anti-dot size. We employ a two-dimensional low-energy description of the topological insulator surface, which allows as to simulate large system sizes with vortices up to 1 μm in diameter. We connect our results to existing mobility measurement data to translate the level of disorder in existing materials to our simulated disorder model.

References

[1] Deng, Bonesteel, Schlottmann, J. Phys.: Condens. Matter 33 035604 (2020)

[2] Ziesen, Hassler, J. Phys.: Condens. Matter 33, 294001 (2021)

Figures

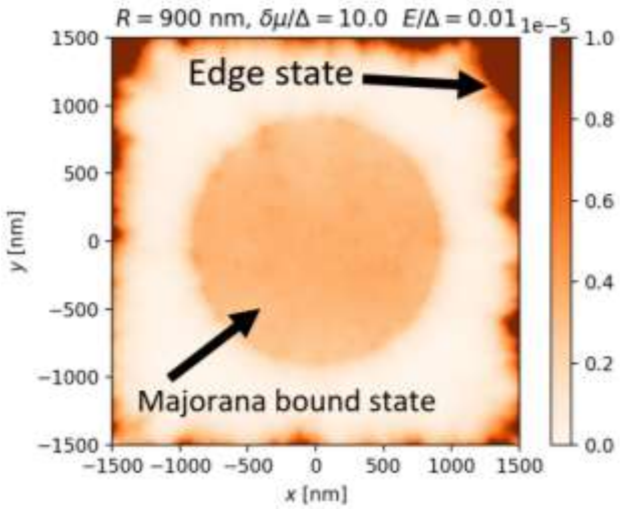

Figure 1: Majorana bound state wave function in disordered vortex of radius 900 nm.

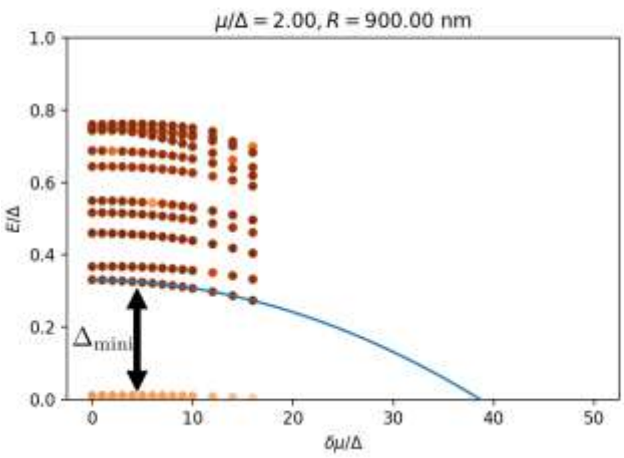

Figure 2: Energy spectrum of Andreev bound states inside of anti-dot (with trapped vortex) as a function of disorder strength on TI surface. For an antidot with micron radius critical disorder RMS is about 40 meV.