PHENOMENOLOGY OF MAJORANA ZERO MODES IN FULL-SHELL HYBRID NANOWIRES

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Full-shell nanowires have been proposed as an alternative nanowire design in the search of topological superconductivity and Majorana zero modes (MZMs). They are hybrid nanostructures consisting of a semiconductor core fully covered by a thin superconductor shell and subject to a magnetic flux. They operate at smaller magnetic fields and low g-factor in comparison to their partial-shell counterparts, and the expected MZMs appear at well-controlled regions of parameter space. We find a very rich spectral phenomenology that combines the Little-Parks modulations of the parent-gap superconductor with flux, the presence of flux dispersing Caroli-de Gennes-Matricon (CdGM) analog subgap states and the emergence of MZMs across finite flux intervals. The phase diagrams for different models of the nanowires show that the MZMs typically coexist with CdGM analogs at zero energy, rendering them gapless, except for topologically protected parameter regions or *islands*. In consequence, the most promising candidate to obtain topologically protected MZMs is the nanowire with a tubular-shaped core.

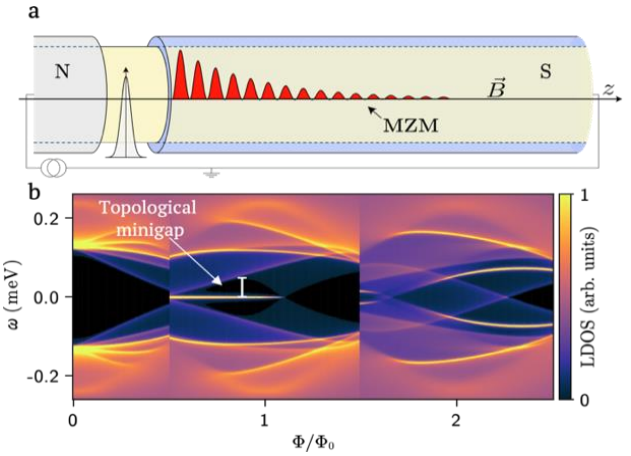

Figure 1. *(a) Schematics of a full-shell nanowire-based normal-superconductor junction threaded by a magnetic field. A semiconductor core (yellow) is surrounded by a thin superconductor shell (blue). In red, Majorana bound state wavefunction. (b) Local density of states at the edge of a nanowire with a tubular semiconductor. The MZM signal at zero energy is robust and gaped from CdGM analogs.*

On the other hand, radial mode mixing can act like a topological *p*-wave pairing between particle-hole Bogoliuvov partners, and is therefore able to create new topologically protected MZMs in regions of the phase diagram that were orginally trivial. As a result, the phase diagram is utterly transformed and exhibits protected MZMs in around half of the parameter space.

References

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