TT 29: Topological Superconductors

Time: Friday 13:30–15:00 Location: H7

TT 29.1 Fri 13:30 H7

Doping a topological insulator: a promising strategy to find topological superconductors? — Sebastian Wolf, Tylor Gardener, and •Stephan Rachel — School of Physics, University of Melbourne, Parkville, VIC 3010, Australia

The search for topological superconductors is one of the most pressing and challenging questions in condensed matter and material research. Despite some early suggestions that doping a topological insulator might be a successful recipe to find topological superconductors, until today there is no general understanding of the relationship of the topology of the superconductor and the topology of its underlying normal state system. One of the major obstacles is the strong effect of the Fermi surface and its subsequent pairing tendencies, usually preventing a detailed comparison between different topological superconducting systems. Here we present an analysis of various doped insulators-topological and trivial–for which the differences of the Fermi surfaces have been removed. Our approach allows us to analyze and compare superconducting instabilities of different insulating normal state systems with identical Fermi surfaces and to present rigorous results on how beneficial it might be to dope a topological insulator.

TT 29.2 Fri 13:45 H7

Accidental Two-Component Order Parameter in UTe_2 — •Florian Theuss[1], Gael Grissonnanche[1], Nicholas Butch[2,3], Johnpierre Paglione[3], Sheng Ran[4], Kelly Nygren[5], Peter Ko[5], and Brad Ramshaw[1] — [1]Cornell University, Ithaca, NY, USA — [2]NIST, College Park, MD, USA — [3]University of Maryland, College Park, MD, USA — [4]Washington University, St. Louis, MO, USA — [5]CHESS, Ithaca, NY, USA

The recently discovered unconventional superconductor UTe_2 is a promising candidate to host time-reversal symmetry breaking (TRSB) in the ordered state, below about 1.6 K. TRSB, indicated by a field trainable Kerr effect, would require a two-component order parameter. Due to the orthorhombic crystal symmetry of UTe_2, a two-component order parameter is expected to be accidental, resulting in two successive superconducting phase transitions. We address this question with Resonant Ultrasound Spectroscopy, where we measure mechanical resonance frequencies of the sample and can resolve two jumps in their temperature dependence with close to part per million resolution. This gives us information about the possibility of a two-component order parameter and constrains its symmetry. Additionally, we perform near-field/far-field high-energy X-ray diffraction experiments to investigate sample homogeneity.

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TT 29.3 Fri 14:00 H7

Sub-gap and supra-gap transport characteristics of the finite Kitaev chain — •Nico Leumer[1], Milena Grifoni[1], Bhaskaran Muralidharan[2], and Magdalena Marganska[1] — [1]Institute for Theoretical Physics, University of Regensburg, Germany — [2]Department of Electrical Engineering, Indian Institute of Technology Bombay, India

We investigate the nonlinear transport in a normal - Kitaev chain- normal (N-K-N) junction. Using exact analytical results for the spectrum and Green's function of the Kitaev chain in the whole regime of parameters, an exact expression for the linear conductance is provided, and insight into the complex interplay of crossings and anticrossings in the supra-gap region is obtained. In particular, we discuss how the ratio of the direct charge transfer and the local Andreev reflection relates to the spatial profile of the lowest lying state. Also, we demonstrate that the supra-gap transport shows stable and strong contributions from the local Andreev reflection which yields the same contribution as the direct processes at the anti-crossing [1].

[1] N. Leumer, M. Grifoni, B. Muralidharan, M. Marganska, Phys. Rev. B, **103**, 165432 (2021)

TT 29.4 Fri 14:15 H7

2π Domain Walls for Tunable Majorana Devices — •Daniel Hauck[1], Stefan Rex[2,3], and Markus Garst[1] — [1]Karlsruhe Institute of Technology, Institute for Theoretical Solid State Physics, Wolfgang-Gaede-Str. 1, 76131 Karlsruhe — [2]Institute for Quantum Materials and Technologies, Karlsruhe Institute of Technology, 76021 Karlsruhe, Germany — [3]Institute for Theoretical Condensed Matter Physics, Karlsruhe Institute of Technology, 76131 Karlsruhe

Superconductor-magnet hybrid structures provide a platform for investigating topological phases with localized Majorana states. Such states have previously been predicted for elongated Skyrmions in the magnetic layer. Here we consider 2π domain walls that can be easily controlled experimentally. Depending on the boundary conditions, we demonstrate that localized Majorana states can be found at both ends of such walls. This establishes 2π domain walls as tunable elements for the realization of Majorana devices.

TT 29.5 Fri 14:30 H7

Majorana Bound States Induced by Antiferromagnetic Skyrmion Textures — •Sebastián A. Díaz[1,2], Jelena Klinovaja[2], Daniel Loss[2], and Silas Hoffman[3,2] — [1]Faculty of Physics, University of Duisburg-Essen, Duisburg, Germany — [2]Department of Physics, University of Basel, Basel, Switzerland — [3]Department of Physics, University of Florida, Gainesville, USA

Majorana bound states are zero-energy states predicted to emerge in topological superconductors and intense efforts seeking a definitive proof of their observation are still ongoing. A standard route to realize them involves antagonistic orders: a superconductor in proximity to a ferromagnet. Here, we show that this issue can be resolved using antiferromagnetic rather than ferromagnetic order. We propose to use a chain of antiferromagnetic skyrmions, in an otherwise collinear antiferromagnet, coupled to a bulk conventional superconductor as a novel platform capable of supporting Majorana bound states that are robust against disorder. Crucially, the collinear antiferromagnetic region neither suppresses superconductivity nor induces topological superconductivity, thus allowing for Majorana bound states localized at the ends of the chain. Our model introduces a new class of systems where topological superconductivity can be induced by editing antiferromagnetic textures rather than locally tuning material parameters, opening avenues for the conclusive observation of Majorana bound states.

[1] S. A. Díaz, J. Klinovaja, D. Loss, S. Hoffman, arXiv:2102.03423

TT 29.6 Fri 14:45 H7

Interaction-Stabilized Topological Magnon Insulator in Ferromagnets — •Alexander Mook, Kirill Plekhanov, Jelena Klinovaja, and Daniel Loss — University of Basel, Basel, Switzerland

Condensed matter systems admit topological collective excitations above a trivial ground state, an example being Chern insulators formed by Dirac bosons with a gap at finite energies. However, in contrast to electrons, there is no particle-number conservation law for collective excitations, which gives rise to particle-number-nonconserving many-body interactions whose influence on single-particle topology is an open issue of fundamental interest in the field of topological quantum materials.

Taking magnons in ferromagnets as an example, we uncover topological magnon insulators that are stabilized by interactions through opening Chern-insulating gaps in the magnon spectrum. This finding can be traced back to the fact that the particle-number nonconserving interactions break the effective time-reversal symmetry of the harmonic theory. Hence, magnon-magnon interactions are a source of topology that can introduce chiral edge states. Importantly, interactions do not necessarily cause detrimental damping but can give rise to topological magnons with exceptionally long lifetimes. Our results demonstrate that particle-number-nonconserving many-body interactions play an important role in generating nontrivial single-particle topology.

[1] A. Mook, K. Plekhanov, J. Klinovaja, D. Loss, Phys. Rev. X 11, 021061 (2021)