Seminar/Talk

Towards robust Majorana modes: from Lutchyn-Oreg model to Poor Man's Majorana using Yu-Shiba-Rusinov states

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Majorana bound states are zero-energy modes that are created and annihilated by the same operator. They are highly sought after mainly due to their non-abelian statistics, a property desirable both for fundamental research and possible applications in the field of quantum computing. Majorana zero-modes are necessarily spin-less, which directs the attention of their pursuit on the boundary of topological superconductors. In the so-called Lutchyn-Oreg model, a semiconductor nanowire coupled to a superconductor is predicted to hold two Majorana zero-modes localized at the wire ends. My work had spanned two eras of utilizing InSb nanowires with epitaxial Al and InSb-Al selective area growth (SAG) platform [1][2]. Later, the realization of a two-site Kitaev chain featuring "poor man's Majorana (PPM)" states became a recent path forward in the field of topological superconductivity [3][4]. PPM is realized by two spin-polarized quantum dots in an InSb nanowire strongly coupled by both elastic co-tunneling and crossed Andreev reflection. This system can be fine-tuned to a sweet spot where a pair of PPM states is predicted to appear. At this sweet spot, the transport characteristics satisfy the theoretical predictions for such a system, including pairwise correlation, zero charge and stability against local perturbations. Furthermore, to increase their robustness to external perturbations, we form a two-site Kitaev chain using proximitized quantum dots hosting Yu-Shiba-Rusinov states [5]. The strong hybridization between such states and the superconductor enables the creation of PMM states with a gap larger than 70 eV. It also greatly reduces the charge dispersion compared to Kitaev chains made with non-proximitized quantum dots. The large gap and reduced sensitivity to charge fluctuations will benefit qubit manipulation and demonstration of non-abelian physics using poor man's Majorana states.1. De Moor*, Bommer*, Xu* et al. Electric eld tunable superconductor-semiconductor coupling in Majorana nanowires, New J. Phys. 20, 103049 (2018)2. Op het Veld*, Xu* et al. In-plane selective area InSbAl nanowire quantum networks, Commun. Phys. 3, 59 (2020)3. Wang et al. Singlet and triplet Cooper pair splitting in superconducting-semiconducting hybrid nanowires, Nature 612, 448453 (2022)4. Dvir et al. Realization of a minimal Kitaev chain in coupled quantum dots, Nature 614, 445450 (2023)5. Zatelli*, Van Driel*, Xu* et al. Robust poor man's Majorana zero modes using Yu-Shiba-Rusinov states. arXiv:2311.03193

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