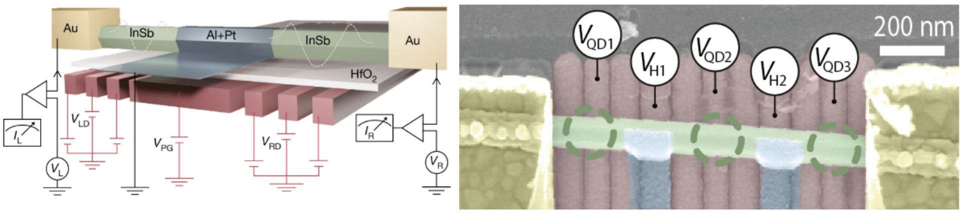
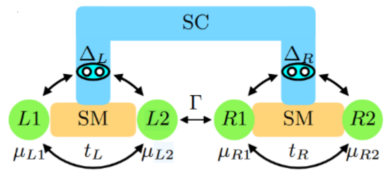
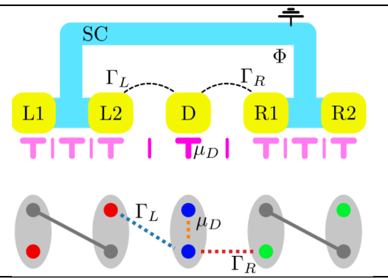
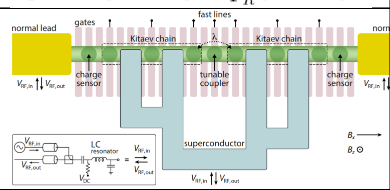
Kouwenhoven lab MEP Projects 2025 – *Contact person:* *Vincent Sietses V.P.M.Sietses@tudelft.nl*

Majorana bound states are predicted to appear in arrays of quantum dots coupled by superconductors when the coupling parameters have been finetuned. These Majorana states could offer a pathway towards protected quantum computing. Recent advances in materials and understanding of the physics of superconductor-semiconductor systems has allowed the detection of Majorana signatures in arrays (called Kitaev chains) of two and three quantum dots [1,2]. This has opened the door to quantum information experiments with Majorana bound states.



Left: a schematic of a 2-site Kitaev Chain [1] **Right:** an image of a 3-site Chain [2]

MEP projects typically include nanofabrication, conducting cryogenic measurements with a dilution refrigerator, and carrying out measurement analysis or simulations. Ongoing research directions where a project could be involved with are:

Majorana parity qubit based on two-site Kitaev chains Coupling two chains with four Majorana states allows encoding a qubit into the parity of the two chains. Control over the couplings within and between the chains allows for universal qubit control.		[3]
Braiding with two-site Kitaev chains Majorana modes are predicted to have non-abelian statistics which can be demonstrated through "braiding", i.e. coherently exchanging the Majoranas in space.		[4]
Qubit based on three-site Kitaev chains As three-site Kitaev chains are more robust to charge noise than two-site chains, a three-site qubit will likely have better coherence properties.		[5]

[1] Dvir, Tom, et al. "Realization of a Minimal Kitaev Chain in Coupled Quantum Dots." *Nature*, vol. 614, no. 7948, 2023, pp. 445–450

[2] Bordin, Alberto, et al. "Signatures of Majorana Protection in a Three-Site Kitaev Chain." *arXiv*, 29 Feb. 2024, arxiv.org/abs/2402.19382

[3] Pan, Haining, et al. "Rabi and Ramsey Oscillations of a Majorana Qubit in a Quantum Dot-Superconductor Array." *arXiv*, 23 July 2024, arxiv.org/abs/2407.16750

[4] Miles, Sebastian, et al. "Braiding Majoranas in a Linear Quantum Dot-Superconductor Array: Mitigating the Errors from Coulomb Repulsion and Residual Tunneling." *arXiv*, 27 Jan. 2025, arxiv.org/abs/2501.16056.

[5] Bordin, Alberto. *Engineering the Kitaev Chain*. Delft University of Technology, 2025