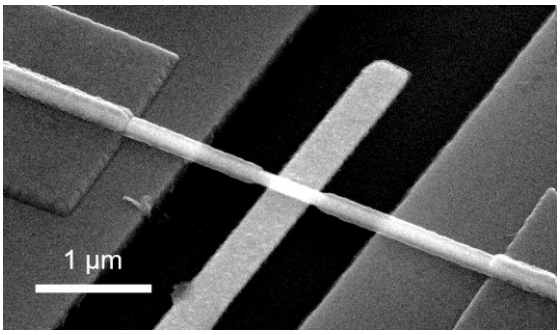
# Fermionic-bosonic qubits

One of the most promising architectures in large-scale quantum information processing is the one based on superconducting electrodynamic (bosonic) qubits. They rely on an elementary device: the Josephson tunnel junction, a tunnel barrier between two superconducting leads, which exhibit nonlinear and non-dissipative behavior. Josephson tunnel junctions are only an example of superconducting weak links, among which are also atomic contacts and semiconducting nanowire weak links. In these other examples, localized, fermionic states, known as Andreev levels, can be addressed. We recently performed their spectroscopy [1-4] and quantum manipulation [5,6].




Here we propose to design, fabricate and measure new hybrid qubits that combine bosonic and fermionic degrees of freedom in the quest to realize more robust quantum states.

We are looking for a strongly motivated student having a good understanding of quantum physics. She/he will be integrated in an active research group on quantum electronics and get acquainted with advanced concepts of quantum mechanics and superconductivity. He/she will also learn several experimental techniques: low temperatures, low-noise and microwave measurements, and nanofabrication.

[1] L. Bretheau, Ç. Ö. Girit , H. Pothier , D. Esteve , and C. Urbina, "Exciting Andreev pairs in a superconducting atomic contact" Nature 499, 312 (2013). arXiv:1305.4091

[2] L. Tosi, C. Metzger, M. F. Goffman, C. Urbina, H. Pothier, Sunghun Park, A. Levy Yeyati, J. Nygård, P. Krogstrup, "Spin-Orbit Splitting of Andreev States Revealed by Microwave Spectroscopy", Phys. Rev. X **9**, 011010 (2019).

[3] C. Metzger, Sunghun Park, L. Tosi, C. Janvier, A. A. Reynoso, M. F. Goffman, C. Urbina, A. Levy Yeyati, H. Pothier, "Circuit-QED with phase-biased Josephson weak links", Phys. Rev. Research **3**, 013036 (2021).

[4] F. J. Matute Cañadas, C. Metzger, Sunghun Park, L. Tosi, P. Krogstrup, J. Nygård, M. F. Goffman, C. Urbina, H. Pothier, A. Levy Yeyati, "Signatures of interactions in the Andreev spectrum of nanowire Josephson junctions", arXiv:2112.05625

[5] C. Janvier et al., "Coherent manipulation of Andreev states in superconducting atomic contacts" Science **349**, 1199 (2015), arXiv:1509.03961

[6] C. Meztger, "Spin & charge effects in Andreev Bound States", PhD thesis (2022)

## Quantronics group website