In search of equal-spin triplet superconductivity: doping MoS2 into the superconducting state
(M1 or M2 Internship Proposal, AY 2023-24)

In conventional Bardeen-Cooper-Schrieffer (BCS) superconductors, Cooper pairs of electrons of opposite spin (i.e. singlet structure) form the ground state. Equal spin triplet pairs (ESTPs), as in superfluid 3He, are of great interest for superconducting spintronics and topological superconductivity. In (few-)monolayer superconducting $NbSe_2$, odd-parity ESTPs have been predicted to arise from the non-colinearity between the out-of-plane Ising spin-orbit field (due to the lack of inversion symmetry in monolayer NbSe2) and an applied in-plane magnetic field. These ESTPs couple to the singlet order parameter at finite field.

We have recently seen preliminary evidence for these ESTPs in tunnel devices at high magnetic fields, in the magnetic field dependence of the superconducting energy gap. More striking spectral features ('mirage gaps') have been predicted in $NbSe_2$ and TMDs of the same band structure (e.g. MoS_2) when the material is doped close to the band edge. In addition to ESTP, recent experimental data on TMDs (including doped MoS_2), have been interpreted as evidence for other unconventional superconducting phases, e.g. the finite-momentum 'orbital FFLO' state.

This project is part of a larger ANR collaboration between the LPS (Charis Quay et al.), C2N (Hervé Aubin et al.) and PHELIQS (Julia Meyer et al.) which has the goal of probing ESTPs directly, through spin resonance.

The intern will work on the fabrication and measurement of MoS_2 devices with solid state gates. A former intern (Jericho Narvasa) began this work last year with the characterisation of the oxide barrier. The intern will fabricate contacts with electron-beam lithography and testing TMD contact to them, before proceeding to fabricate gates. The intern is welcome to participate in other work on TMDs going on in the NS2 group at the Laboratoire de Physique des Solides.

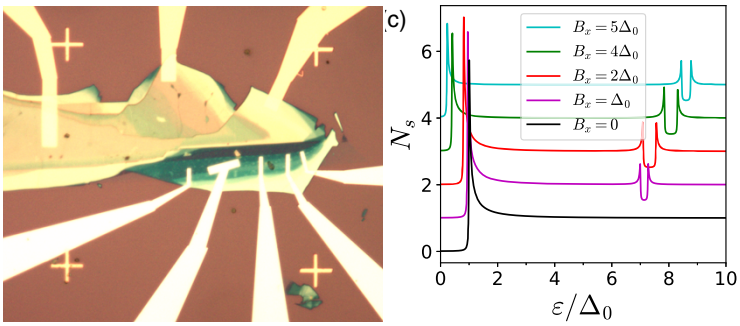

Figure (left) Optical image of a typical tunnel junction TMD device made in the NS2 group, made by Sara Loucif (PhD student) and Charis Quay. The crosses are about 10μm across. **(right)** Expected spectral signatures of triplet superconductivity. (From reference below.)

References

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