Topological superconductivity in van der Waals heterostructures

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There has been a surge of interest in designer materials that would realize electronic responses not found in naturally occurring materials. For example, it is not clear if topological superconductivity[1], which is a key ingredient in topological quantum computing, exist in any single material. These limitations can be overcome in designer van der Waals (vdW) heterostructures, where the desired physics emerges from the engineered interactions between the different components.

Here, we use molecular beam epitaxy (MBE) to grow a monolayer of ferromagnetic $CrBr_3$[2] on a superconducting $NbSe_2$ substrate. This combines out of plane ferromagnetism with Rashba spin-orbit interactions and s-wave superconductivity and allows us to realizate topological superconductivity in a van der Waals heterostructure[3]. We characterize the resulting one-dimensional edge modes using low-temperature scanning tunneling microscopy (STM) and spectroscopy (STS). The use of vdW heterostructures with uniform and high-quality interfaces is promising for future device structures and further control of topological superconductivity through external stimuli (e.g. electrostatic gating).

If time allows, in the second part of the talk, I am going to talk about how the moiré related physics will apply to topological superconductor systems. In particular, I am going to show, using moiré patterns to create a new topological region in the phase diagram at parameter values (e.g. chemical potential) where topological superconductor does not occur in the absence of the moiré[4]. Our results put forward moiré patterns as a powerful tool to overcome conventional constraints for topological superconductivity in vdW heterostructures. In a broader picture, periodic potential modulation provides a general way of controlling topological superconductivity towards the realisation of topological qubits in the future.

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