

Tuning the superconducting gap in monolayer NbSe₂ on graphene via in-situ twist spectroscopy

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Twist angle engineering in van der Waals heterostructures provides a route to controlling electronic states and emergent quantum phases. The relative rotation between atomic layers modifies interlayer hybridization and electronic band structures, yet how superconductivity evolves continuously with twist angle remains poorly understood because conventional fabrication fixes the orientation of each sample.

Monolayer NbSe₂ on graphene offers a platform for addressing this question. While previous Bogoliubov quasiparticle interference studies at selected twist angles have shown that Fermi-surface alignment strongly influences the electronic properties [1], the evolution of the superconducting gap across the full angular range has remained unexplored.

Here, we use an STM tip to continuously rotate monolayer NbSe₂ islands in situ while performing tunneling spectroscopy below 100 mK. This enables twist-dependent measurements on the same microscopic system. We find that the superconducting gap exhibits a pronounced sixfold periodicity, varying by nearly a factor of two. The gap modulation correlates with the momentum-space alignment of the NbSe₂ and graphene Fermi surfaces, revealing a direct connection between interfacial geometry and superconducting pairing. Our results demonstrate continuous twist control as a means of tuning collective quantum states in two-dimensional superconductors.

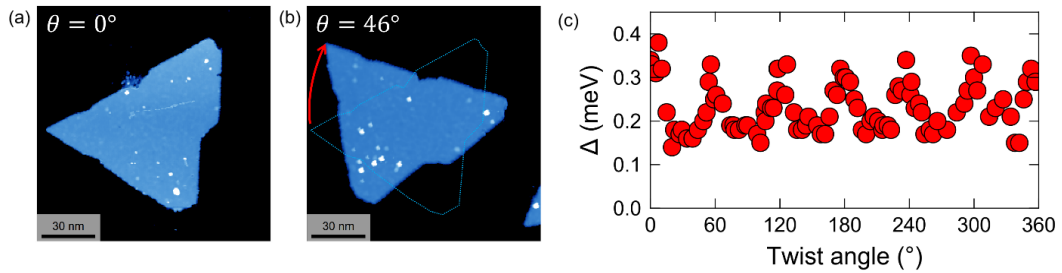


Figure 1: (a), (b) STM images of an NbSe₂ island on graphene before and after mechanical manipulation using an STM tip. The twist angle θ is defined as the angle between the primitive lattice vectors of NbSe₂ and graphene. (c) Twist-angle dependence of the superconducting gap size showing six-fold symmetry.

[1] M. Naritsuka *et al.*, "Superconductivity controlled by twist angle in monolayer NbSe₂ on graphene", *Nature Physics* **21**, 746 (2025).