Graphene Quantum Devices

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Graphene is a semimetal, but can become a gapped semiconductor in case of bilayer graphene (BLG). High-quality quantum dots can be prepared in gate-defined bilayer graphene. Spin, charge and valley states have been experimentally characterized and the intrinsically weak spin–orbit coupling (SOC) in graphene has been measured in a number of experiments.
Integrating BLG with transition metal dichalcogenides (TMDs) enhances the spin–orbit coupling SOC via proximity effects. While this enhancement has been demonstrated in 2D-layered structures, we focus on 1D and 0D nanostructures in BLG/TMD using quantum point contacts and quantum dots in BLG/WSe2 heterostructures with different stacking orders. Across multiple devices, we reproducibly demonstrate spin–orbit splitting up to 1.5 meV which is more than one order of magnitude higher than in pristine graphene. This enhancement and in situ tunability establish SOC as a control mechanism for dynamic spin and valley manipulation.
We discuss quantum devices in superconducting twisted graphene layers, such as Josephson junctions and SQUIDs and explore the possibility to combine charge confinement with superconductivity in view of hybrid quantum systems.
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