Spin-valley coupling in single-electron bilayer graphene double quantum dots

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Graphene quantum dots (QDs) are attractive candidates for hosting spin qubits since the low nuclear spin densities and weak spin-orbit interaction promise long spin coherence times. Physically etched graphene QDs have been studied for about a decade. However, the influence of edge disorder prevented a precise control of the number of charge carriers. Recent results in the preparation of electrostatically confined quantum dots in gapped bilayer graphene (BLG) allow for the formation of clean and well-controllable QDs. We present an electrostatically confined bilayer graphene double QD based on a van-der-Waals heterostructure. Finger gates are used to modulate the band edge profile along a one-dimensional channel confined between split gates [1]. The dense finger gate pattern allows to independently tune the number of charge carriers on each of the QDs from the few-electron regime down to the last, as well as the interdot tunnel coupling and capacitive interdot coupling, leading eventually to the formation of a large single QD [3]. Furthermore, the small band gap in BLG together with the good electrostatic control along the channel allows to form ambipolar electron/hole double QDs. Understanding how the electron spin couples to orbital degrees of freedom, such as a valley degree of freedom in solid-state systems is central to applications in spin- and valley-based electronics and quantum computation. By making use of the high energy resolution of interdot transitions in the low-coupling regime we resolve the lifting of the fourfold spin and valley degeneracy of the single electron spectrum by a Kane-Mele type spin-orbit coupling gap of Δ_{SO} = 60 μeV [2].

References

[1] L. Banszerus et al., Nano Lett. 20, 7709 (2020);
[2] L. Banszerus et al., Appl. Phys. Lett. 118, 103101 (2021)
[3] L. Banszerus et al., arXiv: 2103.04825 (2021)

Figures

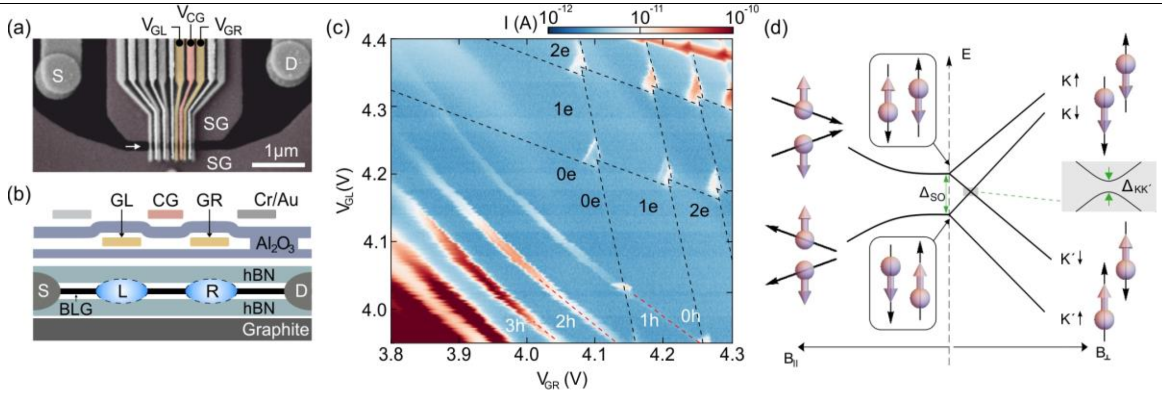

Figure 1: (a) SEM image of the sample and gate design. (b) Schematic cross section through the device. (c) Charge stability diagram in the few electron/hole regime. (d) Single-particle spectrum of a BLG QD as function of a parallel and perpendicular magnetic field.