Graphene quantum dots: Spin and valley degree of freedom

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Graphene is a promising candidate for future nano-electronic devices including building blocks for quantum information processing. Reasons are the expected long spin lifetimes and high carrier mobility. Recent improvements in fabrication technologies for graphene nanostructures, have leveraged the quality of quantum dots to such an extent, that few-electron or -hole quantum dots have been realized that are comparable to the best devices in gallium arsenide [1,2].
Here we confine charge carriers laterally by applying strong displacement fields forcing charge carriers to flow through a narrow channel (see inset in Fig. 1). In transport direction, charge carriers are confined by pn-junctions forming natural tunnel barriers, thus creating a p-type quantum dot coupled to n-type leads, or vice versa. These tunnel barriers can be tuned by additional gate, enabling the observation of the Kondo-effect in bilayer graphene quantum dots.
Here, we use finite bias spectroscopy to study and identify the single-particle and many-body ground- and excited states electrostatically-defined quantum dots in bilayer graphene trapping only one or two charge carriers [3]. While the properties of the material bear similarities to carbon nanotubes and silicon because of the two-fold valley and spin-degeneracies, the results of our experiments allow us to propose a remarkably clear level scheme for two-particle spectra, in which the spin- and valley-entanglement, as well as exchange interactions play a crucial role.

References

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Figures

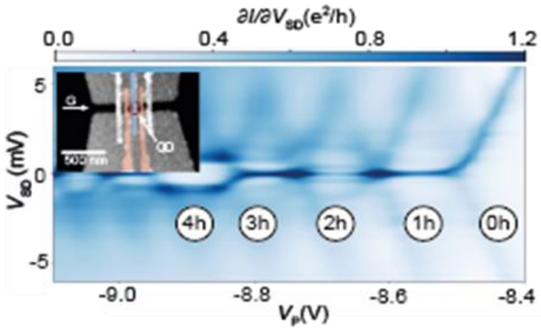

Figure 1: Finite bias spectroscopy of a quantum dot in bilayer graphene. An increased conductance is observed in the Coulomb blockade region (Kondo resonance).