Interacting two-electron states in bilayer graphene quantum dots

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Successfully utilizing the properties of two-dimensional materials in quantum nanostructure devices could lead to unprecedented electronics applications. We study the possible states of two interacting electrons in a quantum dot electrostatically confined in gapped bilayer graphene. The properties of the material's electronic structure, such as the three minivalleys around each valley, and the corresponding orbital magnetic moment, translate into the features of the dot states. For two electrons in the dot, the long-range part of the screened Coulomb interaction defines the orbital configuration of the interacting two-particle state, while short-range contributions breaking the symmetries on the lattice scale determine the ordering in spin and valley space. We identify the set of orbital, spin, and valley levels of the interacting two-particle states in different parameter ranges. In the weakly gapped case, the single-particle level scheme is that of an almost quadratic band, featuring a singly-degenerate ground state and angular momentum duplet degeneracies. For a sufficiently strong gap, threefold degenerate "minivalley triplets" emerge. These spectral features survive in the limit of weak interaction and may entail splittings between different spin and valley states induced by inter-valley scattering. For sufficiently strong interactions, the state structure fundamentally changes and is dominated by the exchange interaction. We discuss implications of different ground state structures for quantum transport through a bilayer graphene quantum dot, as well as for other nanostructure in bilayer graphene, such as quantum wires.

References

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