Kondo chessboard pattern in the conduction of a quantum dot

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When a finite net electron spin on a quantum dot is strongly coupled to the leads, enabling higher-order co-tunneling processes, the Kondo effect is possible to occur. A series of recent experiments on Kondo quantum dots has shown a clear deviation from the standard Kondo effect as described by the spin-1/2 Anderson impurity model [1]. In particular, the observation of a "chessboard pattern" in the dot conductance as a function of magnetic field, B, and gate voltage, V_g, has received much interest. This pattern is characterized by the alternation of low and high valley conductance regions as a function of B within the same Coulomb valley, i.e. for constant N. Additionally, the conductance also alternates when N is changed by sweeping V_g for fixed B. The regions in the V_g,B plane of either low or high conductance are associated with the fields of a chessboard due to its similar appearance when the conductance is plotted in color scale. Experimentally, the enhanced conductance in certain Coulomb blockade regions can be ascribed to the Kondo effect, for both N odd *and* even.

Here, we present our experimental data on a single lateral quantum dot clearly exhibiting the chessboard pattern [2]. We first quantitatively explain the main features of the Kondo chessboard pattern in terms of a constant-interaction double quantum dot model [3]. We show that the analogy with a double dot holds down to remarkably low magnetic fields (few tenths of a tesla). The analysis is extended by full 3D spin density functional calculations [4]. Introducing an effective Kondo coupling parameter, the chessboard pattern is self-consistently computed as a function of magnetic field and electron number, which enables us to quantitatively explain our experimental data. Our spin density functional calculations give, for the first time, a connection between the many-body state of the Kondo effect on the one hand, and the detailed electronic structure of a nanoscale device on the other hand [2].

References

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