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Electrical control of the spin-flip rate of an exciton in a semiconductor

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At the heart of the Kondo effect is a tunneling process in which a localised electron is exchanged with an electron in a Fermi sea. This process can flip the spin of the localised electron. We present here a novel application of this concept to an exciton, an electron-hole complex, in a quantum dot. By determining the temporal emission characteristics of a single self-assembled quantum dot, we show that the exciton spin can be reversed through an electron exchange with a Fermi sea in a neighboring n-doped layer. A very significant point is that the exciton spin flip completely changes the radiative properties of the exciton, either from dark to bright or from bright to dark. We can control the rate of the spin flip to be either much larger or much smaller than the radiative recombination rate of the bright exction simply with the voltage applied to the gate of our device. Calculations based on the Anderson Hamiltonian give excellent agreement with the experimental results. Our work has important consequences in two areas. First, the effect corresponds to the high temperature Kondo regime, motivating the possibility of observing a Kondo exciton in a semiconductor nanostructure for the first time. Secondly, the effect offers a way of manipulating the dark exciton and therefore a means of exploiting its long lifetime and long spin coherence time in quantum information processing.