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Magnetic Polarons and Bipolarons in Quantum Dots[1]

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Magnetically doped (typically by Mn) semiconductor quantum dots (QDs) allow a control of magnetic ordering in ways not available in the bulk. For example, onset of magnetism can be realized by adding a single carrier or changing symmetry of the quantum confinement, even at a fixed carrier number [1]. Recent experiments revisit the concept of magnetic polaron [2], formed when a single carrier added to a QD aligns the Mn spins through exchange interaction. The experiments [3,4] show that the induced magnetization persists at relatively high temperatures. First, we discuss a QD system, in which the experimental magnetic polaron energy, in addition to its relatively high value, shows a surprisingly weak temperature dependence [4]. We explain this effect by magnetic anisotropy of the QD. Next, we turn to the case where a magnetic QD contains two carriers. We find theoretically that Mn spins align, forming a magnetic 'bipolaron', even when the ground state has zero carrier-spin [5]. The corresponding state breaks spatial symmetry, unlike in the case of a single magnetic polaron. We propose experimental tests of our prediction. We also explore the stability of the broken-symmetry state with zero net magnetization versus other patterns of magnetization [6]. Finally, we show some interesting consequences of diffusive coupling of a magnetic QD to a reservoir of carriers [7]. This work was done in collaboration with P. Stano, J. Pientka, A. Petukhov, and I. Zutic.

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