Gate-induced zero-field Kondo splitting in a quantum dot

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We report on measurements of the conventional spin-1/2 Kondo effect and a gate-induced zero-field splitting of the Kondo resonance for the N = 9 charge state of a single quantum dot formed in an InGaAs quantum well. Low temperature transport measurements showed a clear zero-bias conductance resonance, consistent with the spin-1/2 Kondo effect. From the width of the Kondo resonance in the differential conductance we determine a Kondo temperature of $T_K = 1.4$ K and from the Coulomb blockade peaks and Kondo valley conductance in the linear response regime we extract $T_K = 0.9$ K. We also study the effect of a decreased barrier gate voltage asymmetry on the $N = 9$ Coulomb diamond and observe an induced dip within the larger Kondo resonance. We identify two low-energy scales of this system, $K_B T_{K1} = 400$ μeV associated with the broad Kondo resonance and $K_B T_{K2} = 100$ μeV associated with the dip. We also observe a non-monotonic behavior of the zero-bias differential conductance as a function of both in-plane magnetic field and temperature with maximum conductance at $B_{max} = 225$ mT and $T_{max} = 300$ mK. The Zeeman energy of B_{max} and thermal energy T_{max} are in qualitative agreement, ~ 30 μeV, suggesting that the same physical mechanism give rise to the observed phenomenon. Our findings are in qualitative agreement with the two-stage Kondo effect.