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Measurement of Kondo scattering phase with a true two-path interferometer

Abstract :
The Kondo effect in a quantum dot has been intensively studied since it is an archetype for correlated many-body effects. In particular, the phase shift of an electron when scattered off a quantum dot with Kondo correlation has attracted special interest as the observation of the theoretically predicted π/2-phase shift gives direct evidence of the many-body singlet ground state. Although two pioneer groups from Israel and Japan reported the transmission phase shift through Kondo correlated quantum dots embedded in AB ring structures, their results are still somewhat controversial.
Here we report on direct and unambiguous observation of the transmission phase shift through a Kondo correlated quantum dot employing a new type of two-path interferometer realized in an AB ring with tunnel-coupled wires [1]. We first examine the transmission phase shift through a normal Coulomb peak without Kondo correlation and observe a π - shift as expected from Friedel's sum rule. In the Kondo regime and at low temperatures ($T/T_K < 1$) the total phase shift accumulated when scanning through two consecutive Coulomb peaks is close to π with a clear plateau locked at π/2 in between the two Coulomb peaks. Increasing the temperature with respect to T_K, the phase shift in the Kondo valley already deviates from the π/2-plateau for temperatures of the order of $T/T_K \sim 1$. For $T/T_K >> 1$ the phase shift evolves into an S-shape locked around π/2 as expected from theory and in contrast with previously reported results.

[1] M. Yamamoto, S. Takada, C. Bäuerle, K. Watanabe, A. D. Wieck and S. Tarucha, Nature Nanotechnology 7, 247-251 (2012).