Scaling of the Kondo zero bias peak in a hole quantum dot at finite temperature

O. Klochan[1], A. Micolich[1], A. Hamilton[1], D. Reuter[2], A. Wieck[2], F. Reininghaus[3], M. Pletyukhov[3], H. Schoeller[3]

[1] *School of Physics, University of New South Wales, Sydney NSW 2052, Australia*
[2] *Angewandte Festkörperphysik, Ruhr-Universität Bochum, D-44780 Bochum, Germany*
[3] *Institut für Theorie der Statistischen Physik and JARA - Fundamentals of Future Information Technology, RWTH Aachen, 52056 Aachen, Germany*

The Kondo effect is a classic example of the importance of electron-electron interactions in solids, and has been extensively studied in quantum dots [1]. The strength of these interactions is characterized by a single parameter - the Kondo temperature T_K. The usual method for measuring T_K in a quantum dot is to study the temperature dependence of the conductance and compare to theory with T_K as a fitting parameter [2]. Recently a much simpler technique has become available based on analyzing the differential conductance G′ as a function of source-drain bias $V_{SD,}$ rather then temperature T [3]. The theory provided numerical results for the bias dependence of G′ in the limit of T=0, and in recent experiments has been used to extract values of T_K and compare to the values obtained from the temperature dependence of the conductance [4]. However this theory is only valid for T=0, i.e. $T/T_K \approx 0$.

In this work we extend the study of the Kondo effect at finite bias to the regime where $T/T_K>0$. The sample used here is a spin-3/2 hole quantum dot in a GaAs/AlGaAs heterostructure [5]. We scale the zero bias conductance peak as a function of V_{SD} and compare to theory in the limit of T=0 and at finite T as shown in Fig.1. We observe deviations between our experimental data (circles) and the T=0 theory (blue dashed line, top x-axis). These deviations can be eliminated by using newly available finite T theory (solid red line, bottom x-axis). Our analysis shows that even though T/T_K is small in our experiments, there are significant deviations from the T=0 theory [6].

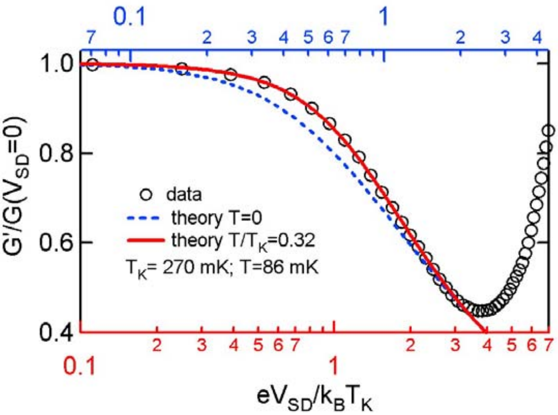

Figure 1. The excess Kondo conductance $G'/G(V_{SD}=0)$ through the dot as a function of scaled bias eV_{SD}/k_BT_K. T_K is used as a fitting parameter to scale experimental data (circles) to theoretical calculations for T=0 (blue dashed line) and T >0 (red solid line).

[1] L. Kouwenhoven and L. Glazman, Physics world 33 (2001).
[2] D. Goldhaber-Gordon *at el.*, Phys. Rev. Lett. **81**, 5225 (1998).
[3] M. Pletyukhov, H. Schoeller, Phys. Rev. Lett. **108**, 260601 (2012).
[4] A.V. Kretinin *at el.*, Phys. Rev. B **84**, 245316 (2011).
[5] O. Klochan *at el.*, Phys. Rev. Lett. **107**, 076805 (2011).
[6] O. Klochan *at el.*, submitted to Phys. Rev. B (2013).