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Long-range Kondo signature of a single magnetic impurity[1]

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Scanning tunneling spectroscopy (STS) has provided an approach to study the Kondo effect - one of the oldest many particle phenomena known in condensed matter physics - in real space. In spite of the high spatial resolution of scanning tunneling spectroscopy, experiments performed on single magnetic atoms on metal surfaces, have shown that the fingerprint of the Kondo effect is only visible if the tip is placed directly above the impurity (e.g. [1]). In the present work we follow a novel route and investigate single isolated Co and Fe impurities not on top but buried below a Cu(100) surface. It has been shown recently [2] that the anisotropy of the copper Fermi surface leads to a strongly directional propagation of quasi particles called electron focusing which gives access to individual bulk impurities in a metal. We have studied the energy-dependent scattering characteristics for single isolated atoms of Ag, Co and Fe buried under a Cu(100) surface using low temperature scanning tunnelling spectroscopy (STS). For the case of a non-magnetic Ag impurity a Friedel oscillation in the local density of states is observed. For both magnetic impurity atoms we observe, in contrast to previous works, a long range Kondo signature which is periodic with the distance to the impurity [3]. The comparison of Co and Fe atoms demonstrates that both impurity species show similar behavior on completely different energy scales, which is determined by the Kondo temperature. We investigate the scattering amplitude as well as the phase. A theoretical interpretation based on a combined approach of band structure and many-body numerical renormalization group calculations is able to describe the rich spatially and spectroscopically resolved experimental data.

[1] M. Ternes et al., Journal of Physics: Condensed Matter 053001 (2009)
[2] A. Weismann et al., Science 323, 1190 (2009)
[3] H. Prueser et al., Nature Physics 7,203 (2011)

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