PhD opening in Nanoscience: Molecular quantum spintronics

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In lanthanide (*Ln*) compounds, the localized *4f*-electrons interact both, with the itinerant *spd* electrons as well as with each other, leading to a rich variety of unusual properties [1]. Spin-flip scattering of conduction electrons from these *4f* local moments may result in their collective magnetic screening below a characteristic temperature called the Kondo temperature T_K. In materials, where local moments are arranged in dense periodic arrays, forming a "Kondo lattice" the deconfinement of localized orbitals through their hybridization with the conduction electrons results in composite low energy excitations. Tuning the hybridization between *f* orbitals and itinerant electrons can destabilize the Fermi-liquid state towards an antiferromagnetically ordered ground state at a quantum critical point (QCP) [1,2].

However, the emergence of a coherent band of quasiparticles near the Fermi energy in a Kondo lattice system is still not well understood. Additionally, the vast majority of studies have been conducted on 3D bulk materials [1,2]. This PhD project therefore aims at studying quantum criticality in lower dimensions, where potentially larger fluctuations are expected. The scattering of quasiparticles, visualized by spectroscopic Fourier transform of scanning tunneling microcopy (STM) conductance maps is used to detect the emergence of quantum entanglement of itinerant substrate conduction and *4f*-electrons as a function of temperature in a family of 2D compounds made of arrays of self-organized *Ln*-atoms on metal substrates. The possibility of building a 2D lattice of *Ln*-atoms by monolayer deposition of atoms dressed by ligands, as well as their manipulation with the tip of the STM has been demonstrated by our team [3]. A zero-bias peak could be measured for the first time in the conductance spectrum acquired above the Tb^{3+} ion of an isolated *Tb*-complex. The lanthanide complexes with appropriate ligands are synthesized in the group of Prof. M. Ruben (INT, KIT), making it possible to fine tuning the hybridization between 4*f*-orbitals and the itinerant electrons of the metal substrate. The measurements are carried out in ultrahigh vacuum [3,4] by means of a dedicated low temperature (LT)-STM equipped with a vector magnetic field.

The candidate will participate in an ambitious multi-partner project between Strasbourg and Karlsruhe including theoretical support from both, IPCMS and KIT. Our PhD students, without exception, find a job in academics or industry at the end of their PhD.

[1] P. Coleman et al., *Nature*, **433**, 226 (2005); S. Sachdev, B. Keimer, *Phys. Today*, **64**, 29 (2011); F. Steglich, *Journal of Physics* : Conference Series **400**, 022111 (2012).
[2] P. Gegenwart, Q. Si, F. Steglich, *Nature Physics*, **4**, 186 (2008).
[3] A. Amokrane, S. Klyatskaya, M. Boero, M. Ruben, J.P. Bucher, *ACS Nano*, **11**, 10750 (2017).
[4] R. Tuerhong, F. Ngassam, S. Watanabe, J. Onoe, M. Alouani, J.P. Bucher, *J. Phys. Chem. C* 122, 20046 (2018).

The candidate's profile: We are looking for highly motivated candidates with a master degree in physics. The candidate for this PhD project must have strong background in solid-state physics and magnetism. Experience with ultrahigh vacuum and STM is welcome and proficiency in English is required. Interested candidates are invited to send a CV, a motivation letter, grades and ranking. The candidate will be selected in agreement with the application procedure of the QUSTEC PhD school.