Visualizing strong electron correlations in Fe-based superconductors

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Short description of the project:

Strong electronic correlations often produce intertwined phases where multiple length scales coexist. These produce spatially varying electronic properties containing unique insight that determine the emergence of novel collective behavior. Addressing the problem of electron correlations requires powerful microscopes probing electronic properties down to atomic scale.

A major challenge in electron correlated materials is to understand the emergence of high critical temperature (HTc) superconductivity. Fe-based superconductivity offers ultra-pure materials easily tunable through relevant phases emerging from electron correlations (antiferromagnetism, nematicity and superconductivity), providing a tremendous opportunity to unveil the microscopic pairing mechanism behind HTc superconductivity.

High magnetic fields are needed to disentangle the electronic correlations, because they enable comparison between normal and superconducting phases and unveil quantum critical behavior and vortex physics.

In this project, we propose the experimental study of the electronic correlations in two Fe-based superconducting systems: $CaK(Fe_{1-x}Ni_x)_4As_4$ [1,2] and FeSe[3,4]. Superconductivity only coexists with antiferromagnetism in $CaK(Fe_{1-x}Ni_x)_4As_4$ and with nematicity in FeSe. Therefore, these materials offer a great opportunity to dissentalgle influence of spin (antiferromagnetic) and orbital (nematic) order on the the electronic correlations behind the microscopic mechanism of HTc superconductivity in Fe-based superconductors. The experiments will be performed using a Scanning tunneling microsope working at tempeatures below 0.1 K and mangetic fields up to 22 T [5]. More info in www.lbtuam.es and here.

References:

[1] W.R. Meier et al., npj Quantum Materials **3**, 5 (2018).

[2] A. Fente et al, Phys. Rev. B **97**, 134501 (2018).

[3] P.O. Sprau et al., Science **357**, 75-80 (2017).

[4] C-L. Song et al., Science **332**, 1410-1413 (2011).

[5] I. Guillamón et al., Nature Physics **10** 851-856 (2014).