Max-Planck-Institut für Struktur und Dynamik der Materie

Max Planck Institute for the Structure and Dynamics of Matter

Tuesday, June 11th 2019 – 11:00
CFEL Seminar room IV (Bldg. 99)

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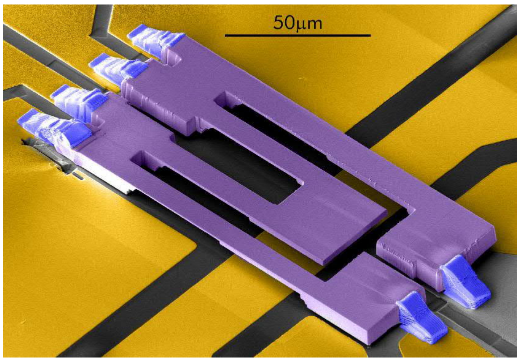
Tuning quantum materials out of equilibrium: A FIB-microstructuring approach

“Quantum materials” loosely defines a broad collection of materials whose ground states are defined by unusual quantum properties. This research largely focuses on macroscopic single crystals, yet naturally interesting quantum phenomena lie beyond their equilibrium state. My group works towards reducing the sample size onto the sub-μm length scale, following the general idea that small samples can be driven more strongly and react faster than on the macro scale. Our main tool is Focused Ion Beam machining capable of cutting single crystals into high quality quantum devices.

I will present two concrete research projects showcasing how new quantum states out of equilibrium can be accessed and investigated in FIB-prepared microcrystal structures. The first concerns the heavy fermion superconductor, $CeIrIn_5$ (T_c~400mK). When a μm-sized structure is firmly coupled to a mm-sized substrate of different thermal expansion, the microstructure is under significant strain at low temperatures. By precisely controlling its shape, the emergent strain field can be controlled. The key difference to other approaches, such as uniaxial strain, is that complex, yet well-controlled, spatially varying strain fields can be achieved. In collaboration with Katja Nowack (Cornell), we have experimentally mapped out the resulting superconducting landscape in the devices using scanning-SQUID microscopy, and show that this spatial modulation can be well captured by finite element simulations. [1]

Second, I will present our ongoing efforts to experimentally identify pseudo-magnetic fields in 3D Dirac semi-metals [2,3]. Owing to their Dirac dispersion, deformation of the crystal structure does not open a gap at the nodes, but shifts the location of the nodes in k-space and hence playing the role of a “pseudo-magnetic field”, B_5. I will show how microstructuring gives us unprecedented control of such a process, and discuss how future.

[1] M.D. Bachmann et al., arXiv:1807.05079;
[2] A.G. Grushin et al., PRX 6, 041046 2016);
[3] D.I. Pikulin, R. Ilan, arXiv:1802.00512



Host: Andrea Cavalleri

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