«X-ray scattering at high pressures and low temperatures: Squeezing cool electrons»

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This lecture will focus on x-ray scattering experiments at cryogenic conditions as a function of external pressure. After a first motivation for such experiments, technical aspects and realisations of the corresponding sample environments for synchrotron and laboratory instruments will be discussed.

It will then be described how non-resonant and resonant x-ray scattering experiments can be used to clarify the many-body behaviour of interacting electron systems. In such systems one cannot -as it is often done- treat the electrons as independent entities. Rather the behaviour of a given electron depends in a non-trivial way on other electrons and, on top of that, may also be influenced by the lattice. Under these circumstances pronounced many-body physics can emerge and result in what is called a collective electronic quantum state. Famous representative phenomena are (unconventional) superconductivity, spatial charge and orbital order, long-range magnetic order or spin-liquids. Indeed, collective electronic quantum states of this kind constitute central unsolved puzzles of today's condensed matter physics. Here experiments as a function of hydrostatic pressure at low temperature can help to solve them: Non-resonant x-ray diffraction can be used to study the lattice structure at a given pressure and temperature, while resonant x-ray scattering provides a means to investigate spatial electronic order and collective electronic excitations at the same conditions. This will be illustrated in particular by recent research on charge density wave [1,2] and spin-liquid systems [3].

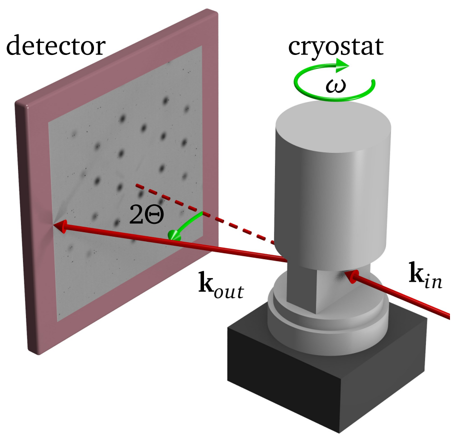

Figure 1: Schematic experimental setup for low temperature x-ray diffraction as a function of external pressure. The is sample inside a diamond anvil cell, which is situated within the cryostat.

References

[1] Pressure dependence of the charge density wave in 1T-TaS_2 and its relation to superconductivity, T. Ritschel *et al.*, Phys. Rev. B **87**, 125135 (2013)

[2] Orbital textures and charge density waves in transition metal dichalcogenides, T. Ritschel *et al.*, Nat. Phys. **11**, 328 (2015)

[3] Pressure-induced dimerization and valence bond crystal formation in the Kitaev-Heisenberg magnet $RuCl_3$, G. Bastien et al., Phys. Rev. B **97**, 241108 (2018)