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Strong cooperative coupling of pressure-induced magnetic order and nematicity in FeSe

ANDREAS KREYSSIG, Ames Laboratory / Iowa State University

In iron-based superconductors, the lattice, magnetism and electronic system show a fascinating interplay. Nematic order breaks the tetragonal symmetry and yields an orthorhombic lattice distortion. The same symmetry is broken by the stripe-like antiferromagnetic order suggesting a symmetry-related coupling between both phenomena. The phase transitions in to both ordered states can be simultaneous and of first-order character like in $CaFe_2As_2$, or separated in temperature like in Co-doped $BaFe_2As_2$ with second or first-order character depending on the doping level. Stripe-type magnetic fluctuations are discussed as correlation-driven electronic mechanism of the nematicity and important for the superconducting electron pairing establishing a coupling mechanism. However, a universal picture has been confounded by measurements of FeSe where the nematic and magnetic transitions appear to be decoupled by the observation of the lattice distortion without antiferromagnetic order at ambient pressure.

In this talk I will present our recent study on the relation between the nematic and magnetic order in FeSe single crystals investigated by synchrotron-based high-energy x-ray diffraction and time-domain Moessbauer spectroscopy as function of temperature and pressure. Distinct nematic and magnetic transitions are observed for low pressures and merge into a single first-order transition for higher pressures reminiscent of what has been found for the evolution of these transitions in Co-doped $BaFe_2As_2$. Our results are consistent with a spin-driven mechanism for nematic order in FeSe and provide an important step towards a universal description of the interplay between the different ordering phenomena in the iron-based superconductors.

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