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Neutron studies in high static magnetic fields: Application to some Uranium systems

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Magnetic field is a fundamental thermodynamical parameter having a potential to change the miscroscopic arrangement of magnetic moments or even to create them in the first place. To disclose the spatial arrangement, nature and magnitude of magnetic moments involved in a long-range magnetic order, neutron diffraction is still the method of choice. However, the relatively weak interaction between the magnetic moments within the studied substance and the neutron's own magnetic moment makes neutron experiments in strong magnetic fields lengthy, complicated and costly. This holds for diffraction experiments and even more for inelastic scattering experiments. Moreover, in order to generate high magnetic fields, magnet coils tend to be large and highly obscuring neutron beam. Thus, there is always trade between the maximum field strength acting on the system under study and geometrical restrictions. While pulsed magnets offer higher magnetic fields at low energy costs and moderate requirements for technical infrastructure enabling diffraction experiments up to ~40 T, steady magnetic fields, although of lower strength, require enormous technical infractructure and running costs but enable also inelastic studies.

In this contribution several high-field neutron diffraction and scattering experiments on U-based systems performed at Helmholtz-Zentrum Berlin using steady magnetic fields up to 26 T will be summarized. A complicated field-induced non-collinear magnetic structure in the Shastry-Shuterland system U2Pd2In that appears above a critical field of ~25 T applied along the a-axis direction serves as an example for a magnetic state that was not anticipated from bulk magnetic measurements. Field-induced magnetic state in 8%-Rh doped URu2Si2 that appears for the c-axis direction above ~22 T documents that magnetic field can induce substantial magnetic moments and even create a long-range magnetic order - an uncompensated antiferromagnetic order. No doubt that such studies could be performer also in pulsed magnetic fields. This, however, does not hold for two other experiments described in this contribution – inelastic experiments on a pristine and 8%-Rh doped URu2Si2. Despite a limited Q-range available during these experiments it is shown that the effect of the magnetic field on the inelastic signal in the two systems is distinctly different. The observation is brought into a context with the different ground state of the two systems.

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