ESRF	**Experiment title:** Magnetic structure and ATS scattering of UNiGe	**Experiment number**: HE2175
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Report:

X-ray resonant scattering (XRS) study of UNiGe was undertaken to answer several questions:

- Details of the magnetic structure (basically determined previously from neutron diffraction), in particular measurement of the out-of-plane tilt of U magnetic moments. The two magnetically ordered phases of UNiGe are of interest.
- Search for a possible resonant signal on Ni K-edge that would originate from a magnetic moment on the Ni site. Both features would point to a strongly anisotropic exchange interaction in UNiGe.
- Search for anisotropic tensor susceptibility (ATS) scattering. The tensorial character of the scattering amplitude at the resonance can be studied in the case of non-symmorphic crystal structure at scattering vectors corresponding to forbidden Bragg reflections. Question of the quadrupolar order origin of this contribution was also addressed.

In the present experiment a sample of UNiGe with (001) normal was mounted on the cold finger of the He flow cryostat (base temperature 10 K) and aligned at E = 8.5 keV. Then the incident beam energy was tuned to 3.728 keV (U M_4 edge) and Au (111) crystal was used for scattered beam polarization analysis.

The energy dependence of the resonance was measured at several scattering vectors $\boldsymbol{Q}$ = (0, 0.5, 2.5), (1, 0.5, 2.5), corresponding to the AF order at low temperature (T_{meas} = 10 K), in the intermediate incommensurate AF phase at $\boldsymbol{Q}$ = (-1,1/3, 10/3) and at $\boldsymbol{Q}$ = (0,0,3), a forbiden Bragg reflection where ATS signal was expected. Absorption correction of all spectra was done using reference fluorescence spectra.

Azimuthal scans of magnetic reflections of type (h, k+½, l+½), were recorded at $\boldsymbol{Q}$ = (0, 0.5, 2.5), $\boldsymbol{Q}$ = (1, 0.5, 2.5), $\boldsymbol{Q}$ = (-1, 0.5, 2.5), $\boldsymbol{Q}$ = (0, –0.5, 2.5), $\boldsymbol{Q}$ = (0, 0.5, 3.5) and $\boldsymbol{Q}$ = (0, -0.5, 3.5). Because of geometrical restrictions (due to off-specularity of the studied reflections) the whole 360° azimuthal range could not be studied for neither of reflections. Data analysis excludes a simple model of in-plane magnetic moments on uranium. More complex models including different symmetry-restricted out-of-plane tilts is now envisaged.

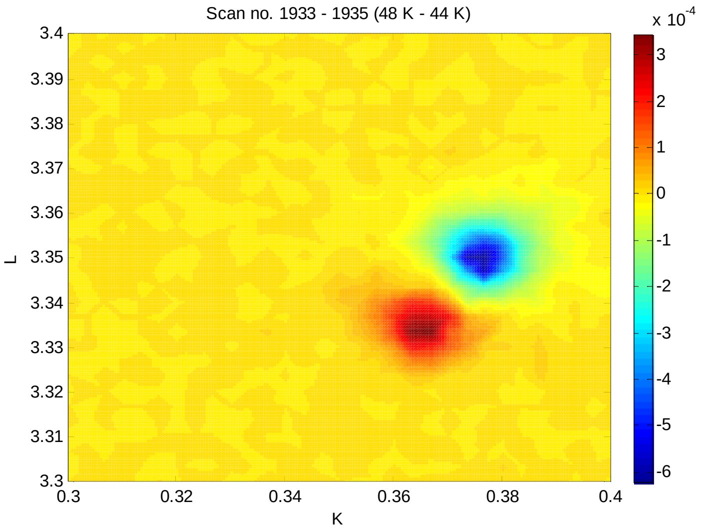
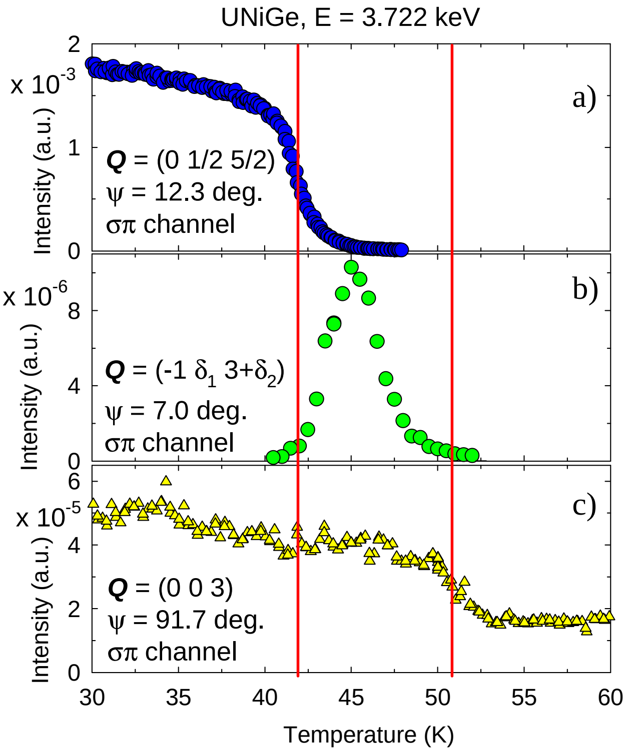


Fig. 1
*Reciprocal space mesh around **Q** = (-1 δ_1 3+δ_2) at E = 3.722 keV, σπ channel. The difference plot (48K data – 44K data) shows a clear change of the propagation vector **Q**.*

In the intermediate temperature range (42 K < T < 47 K) the incommensurate AF phase was studied. Taking advantage of the high resolution of XRS at low incident energy the propagation vector was determined to be $\boldsymbol{q}_2 = (0, \delta_1, \delta_2)$ with both δ_1 and δ_2 close to ⅓ but $\delta_1 \neq \delta_2$ and temperature dependent δ_1 and δ_2 (see Fig. 1 for details). Due to the lack of time only reflection $\boldsymbol{Q} = (-1, \delta_1, 3+\delta_2)$ was studied using azimuthal technique.

At the same time the ATS scattering was approached. For this, **Q** = (0, 0, 3) was studied. All the signal was found in the σπ channel but with energy dependence very different from the one at magnetic peaks (one peak structure vs. two peaks in magnetic reflections). The forbidden lattice peak is present at all temperatures, its intensity is higher in the magnetically ordered phase (not depending on the actual propagation). Again, azimuthal scan (in the range of 90°) was recorded. The resonance profile (energy dependence) of the studied reflections is still not completely understood.



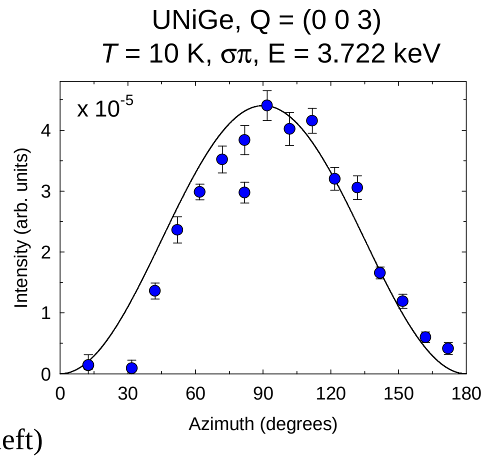


Fig. 2 (left)
*Temperature dependence of two representative magnetic reflections (panels a and b) and a Templeton peak at **Q** = (0,0,3), panel c.*
Fig. 3 (right)
*Azimuthal dependence of the ATS scattering at **Q** = (0,0,3) and a fit for a quadrupolar scattering tensor that transforms as B_{2g}, the only symmetry allowed quadrupolar transition.*

In the last part of the experiment, an attempt to find Ni resonance (Ni K-edge, E = 8.333 keV) was done. Unfortunately, our data show enormous multiple scattering that overlap with any possible (weaker) signal.

A short test at the U M_5 edge (E = 3.548 keV) was done on a magnetic reflection **Q** = (0, 0.5, 2.5). Surprisingly, this reflection has only one peak in the energy scan but its azimuthal dependence corresponds to the one observed at U M_4 edge. The intensity at a forbidden lattice reflection **Q** = (0, 0, 3) was too low to be studied in detail.