ESRF	**Experiment title:** Interplay of magnetic multi-k structures and resonant scattering	**Experiment number:** HE-819
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Shifts: 18	**Local contact(s):** Dan Mannix	*Received at ESRF:*

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Report:

The aim of this experiment was to search for a signature of the triple-**k** magnetic structure using Resonant X-ray Magnetic Scattering (RXMS). The triple-**k** structure is made up of 3 orthogonal vectors, $\mathbf{k}_1$ = [1 0 0], $\mathbf{k}_2$ = [0 1 0], and k_3 = [0 0 1], propagating from the Bragg points, and the resultant moments are orientated along the <1 1 1> directions. In standard diffraction experiments an assembly of single-**k** domains cannot be distinguished from a triple-**k** structure. In RXMS the scattering amplitude contains terms that are proportional to integer powers of the order parameter. Quadrupole resonance gives rise to the 1**k**, 2**k**, 3**k** and **4k** harmonic satellites for a single-**k** magnetic structure, and dipole resonance gives rise to a second order term, which produces k_i+k_j ($i\neq j$) resonant harmonic satellites in a multi-**k** structure. The high-order resonant harmonic satellites distinguish the single-**k** structure from a multi-**k** structure.

In this experiment we have succeeded to distinguish between the double-**k** the triple-**k** magnetic structures using RXMS. The $UAs_{0.8}Se_{0.2}$ solid solution was chosen for this study because it has both double-**k** and triple-**k** magnetic phases. It is triple-**k** in the 60 K < T < 125 K temperature range, and double-**k** below 60 K. The x-ray energy was initially tuned close to the uranium M_4 edge, and aluminium (1 1 1) was used for polarization analysis (PA).

At a temperature of 70 K (in the triple-**k** phase) each of the $\mathbf{k}_3$, $\mathbf{k}_1+\mathbf{k}_3$ (and $\mathbf{k}_2+\mathbf{k}_3$), and $\mathbf{k}_1+\mathbf{k}_2+\mathbf{k}_3$ magnetic satellites were observed. **Fig. 1** shows the energy dependence of the first resonant harmonic (0 0 2 + k) and the (k k 2+k) peak, close to the U M_4 edge (3.728 keV). Intensities are given an ordinate axis and are arranged to coincide at the peak. The resonant line-shapes of these peaks are identical, and the resonant scattering from the $\mathbf{k}_1+\mathbf{k}_2+\mathbf{k}_3$ was dominant in σ - π. To confirm that the $\mathbf{k}_1+\mathbf{k}_2+\mathbf{k}_3$ peak is associated with the triple-**k** magnetic structure we measured its intensity whilst cooling the sample over the triple-**k** to double-**k** transition. **Fig. 2** shows the temperature dependence of the $\mathbf{k}_1+\mathbf{k}_2+\mathbf{k}_3$ peak. In agreement with the lattice symmetry (cubic; triple-**k**, tetragonal; double-**k**), the intensity of the $\mathbf{k}_1+\mathbf{k}_2+\mathbf{k}_3$ peak diminishes when the structure transforms from double-**k** to triple-**k**. The x-ray energy was then tuned to the uranium M_2 edge, and graphite (0 0 4) was used for PA. Again, the $\mathbf{k}_1+\mathbf{k}_2+\mathbf{k}_3$ magnetic satellite was observed in the triple-**k** phase and not in the double-**k** phase. These preliminary results suggest that the $\mathbf{k}_1+\mathbf{k}_2+\mathbf{k}_3$ peak is a signature of the triple-**k** magnetic structure. The origin of these weak peaks is undergoing further consideration.

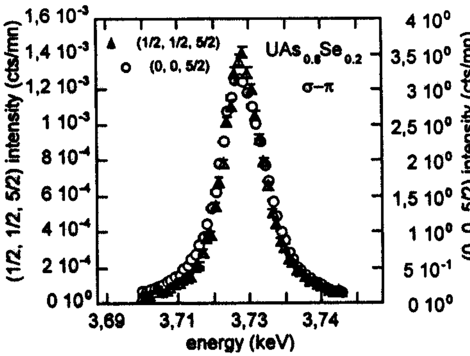

Fig. 1 Resonance of the (0 0 2+k) and (k k 2+k) peaks at the U M_4 edge

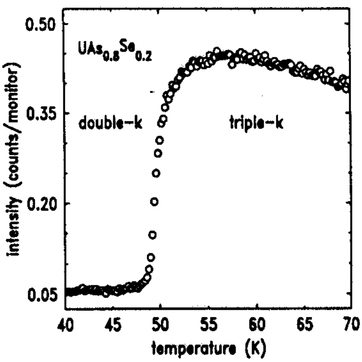

Fig. 2 Intensity of the (k k 2+k) peak over the triple-**k** to double-**k** transition