ESRF	**Experiment title:** Distinguishing the single-**k**, double-**k**, and triple-**k** magnetic structures using resonant x-ray magnetic scattering	Experiment number: *HE-1050*
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The aim of this experiment was to determine if there is a signature of the commensurate triple-**k** magnetic structure in its diffraction pattern. The triple-**k** structure is made up of 3 orthogonal vectors, $\mathbf{k}_1$ = [1, 0, 0], $\mathbf{k}_2$ = [0, 1, 0], and $\mathbf{k}_3$ = [0, 0, 1], propagating from the Bragg points, and the resultant moments are orientated along the set <1, 1, 1> directions. In our previous experiment [1] we observed magnetic satellites at both the $\mathbf{k}_i+\mathbf{k}_j$ and $\mathbf{k}_i+\mathbf{k}_j+\mathbf{k}_k$ positions, where ($i\neq j\neq k$), which are extra features of the standard magnetic diffraction pattern of such a magnetic structure. Our previous measurements showed that the $\mathbf{k}_i+\mathbf{k}_j+\mathbf{k}_k$ satellite only exists for the triple-**k** structure. The origin of a magnetic satellite can be determined from its azimuthal dependence. We therefore set out to study the azimuthal dependence of the x-ray scattering of these magnetic satellites of $UAs_{0.8}Se_{0.2}$, at the U M_4 edge.

We first measured the azimuthal dependence of the $\mathbf{k}_i+\mathbf{k}_j$ satellites. These satellites are thought to originate from the *second order* terms in the resonant amplitude [2] for multi-**k** structures, and their existence distinguishes the single-**k** structure from a multiple-**k** structure. Fig. 1 shows the measured azimuthal dependence of such a satellite, which confirms that it originates from the second order terms in the resonant cross section.

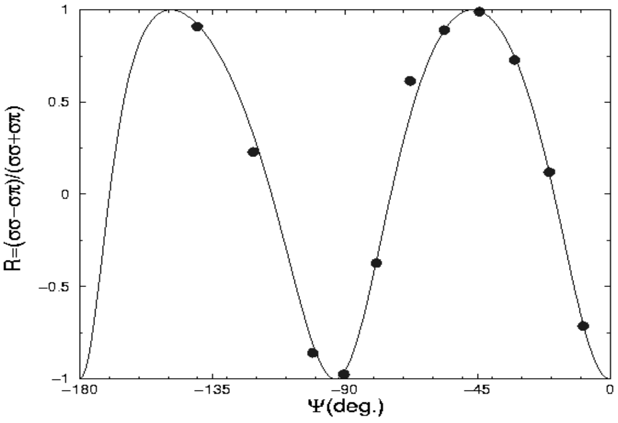

Figure 1
The asymmetry ratio of the two polarization states of the (1/2, 1/2, 2) second order resonant harmonic satellite as a function of the azimuth angle for $UAs_{0.8}Se_{0.2}$. The solid line is the azimuth dependence calculated from the cross section with no adjustable parameters.

Fig. 2 shows the azimuthal dependence of the $\mathbf{k}_i+\mathbf{k}_j+\mathbf{k}_k$ type satellites. Resonant scattering was only observed in the σ-π polarization channel. The azimuthal dependence is that of a *first order* resonant harmonic with the moments projected to the $\mathbf{k}_i+\mathbf{k}_j+\mathbf{k}_k$ position. There is only one mechanism by which a first order magnetic satellite can exist at this position in this material: Actinide materials with the rock-salt crystal structure typically exhibit magnetostrictive effects that are the result of the coupling of the orbital moments to the crystal lattice, which produce charge modulations at twice the magnetic wave vector, $2k$. For triple-**k** magnetic structure these lattice modulations exist in the same domain and therefore interfere with each other to form additional *charge satellites* at $\mathbf{k}_i+\mathbf{k}_j$, call this **G**. These satellites may be considered to be additional reciprocal lattice points with magnetic satellites, $\mathbf{G}+\mathbf{k}_k$. If the $\mathbf{k}_i+\mathbf{k}_j$ charge, and $\mathbf{k}_k$ magnetic, satellites all exist in the same domain then *first order* magnetic satellites will exist at (1/2, 1/2, 1/2) type positions. We propose that the $\mathbf{k}_i+\mathbf{k}_j+\mathbf{k}_k$ satellites are a "signature" of the triple-**k** magnetic structure.

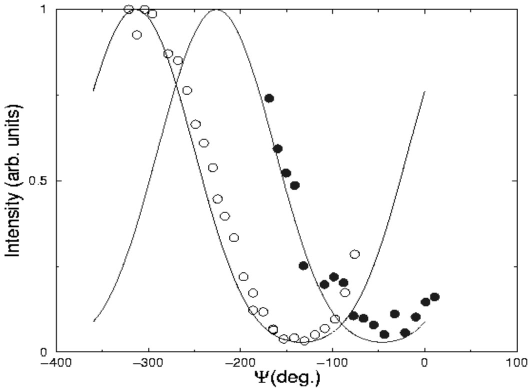

Figure 2
The azimuthal dependence of the (-1/2, 1/2, 5/2) and (+1/2, 1/2, 5/2) magnetic satellites (open and close symbols, respectively) for $UAs_{0.8}Se_{0.2}$. The solid lines are the azimuth dependencies calculated from the cross section with no adjustable parameters.

This scattering technique only probes about the first 1000Å below the crystal surface, and it is therefore important to check for surface effects. Reciprocal lattice scans perpendicular to the crystal surface at different azimuth angles show the same long range magnetic order, confirming that the change in intensity is related to the scattering amplitude and not the volume of crystal probed.

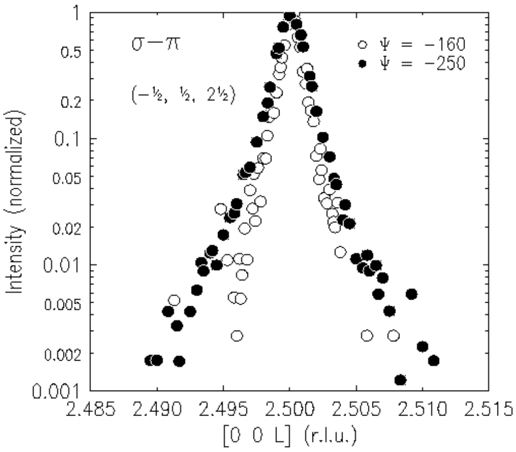

Figure 3
Reciprocal space scans about the (-1/2, 1/2, 5/2) magnetic satellite along the [0, 0, L] direction at two different azimuth angles.

[1] Longfield *et. al.* ESRF report HE-819; J. M. M. M. 233, 53 (2001)
[2] Hannon *et. al.*, Phys. Rev. Lett. 61, 1245 (1988)