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Report:

Experiments have been performed to detect the signature of the occurrence of the 2Q magnetic structure in UAs. We have combined non-resonant and resonant scattering data to analyze the couplings that lead to such a structure.

UAs orders antiferromagnetically below Tn = 126 K with a single Q structure characterized by a propagation vector (0 0 1) (type AF-I phase). Around 63.5 K, a new magnetic structure develops with a propagation vector q_i = (0 ½) (AF-IA phase); this low temperature phase has been shown to be a 2Q structure by neutron diffraction [1] where two distinct Fourier components associated with q_i and q_j combine to produce a non-collinear magnetic structure.

We first ran non-resonant scattering experiments at E_{ph} = 7.84 keV, in order to observe non-resonant magnetic x-ray scattering signal but also to detect any indication of charge scattering arising from the lowering of the crystal symmetry through the phase transition AF-I to AF-IA. Our results show that indeed charge peaks appear in the AF-IA phase at two different positions in reciprocal space:

i) at positions $2q_i$; this is consistent with the lowering of the lattice symmetry (loss of face centering.

ii) at positions q_i+q_j; this is a new result indicating the existence of an invariant in the Landau free energy [2,3].

Another of data was taken at the M4 edge of Uranium where the resonant enhancement of the magnetic signal is the largest [4]. In the AF-IA, we observed resonant enhancements at the two positions in reciprocal space mentioned above, much larger than expected from simple variation of the real and imaginary parts of the U structure factors; furthermore, the polarization of the scattered x-rays was partially rotated. This can be explained only by the occurrence of Templeton scattering arising from the lowering of the U site symmetry.

We have performed a group theory analysis [5] of the free energy in UAs associated with the (0 0 ½) propagation vector. We have determined the number and symmetry of 4-th order invariants that can lead to a 2Q-state. It turns out that such a structure cannot be stabilized by magnetic terms only; coupling through lattice modes are required. These lattice modes are responsible for the onset of charge scattering at the q_i+q_j positions. The symmetry of these invariants dictates the space group in the AF-IA phase and the local symmetry of the U sites. It appears the symmetry is low, not higher than C_{2v}. in such symmetry, the combined effects and magnetic resonance and crystal symmetry can lead to new resonant effects [6].

A full symmetry analysis of the resonant process is under way. One point of extreme importance is the influence of lattice site symmetry. In most cases, the analysis of resonant magnetic scattering experiments simply ignores the lattice effects, which are not taken into account by the existing model [7]. We do hope that our work will stimulate a theoretical reformulation of the problem.

References:

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