High-Resolution Resonant Magnetic X-ray Scattering on $TbNi_2B_2C$: The Modulation Wavevector Determination in the Orthorhombic Phase

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A high-resolution resonant magnetic x-ray scattering experiment has been performed on $TbNi_2B_2C$ to uniquely determine the magnetic ordering in the orthorhombic phase. Previous neutron scattering studies determined that below approximately 15K the magnetic order may be characterized as a longitudinally modulated spin wave in the basal plane of the tetragonal structure. Subsequent high-resolution x-ray measurements, however, found that the low-temperature crystal structure was orthorhombic rather than tetragonal, presumably due to a magneto-elastic distortion that accompanies the antiferromagnetic ordering. Since the symmetry of the basal plane is broken in the orthorhombic phase, the direction of the magnetic wavevector can be uniquely determined with respect to the crystalline axes.

Single-crystal samples of $TbNi_2B_2C$ were grown by the flux growth method at Ames Laboratory.

The resonant x-ray scattering experiment was carried out on the MU-CAT undulator beam line in 6-ID at the Advanced Photon Source. Measurements were made at the Tb L_{III} absorption edge (E=7.514 keV). A pyrolitic graphite (006) analyzer, at a scattering angle of $2\theta_{analyzer}$ ~95 degrees, was used as a polarizer to select, primarily, the π-polarized component of the scattered radiation.

Careful reciprocal lattice space scans in the basal plane around the $(200)_{orth}$ and $(020)_{orth}$ charge peaks were performed to determine the spin modulation direction in the orthorhombic symmetry. These measurements, shown in Fig.1, revealed that the longitudinal magnetic modulation, is along the $[200]_{orth}$ direction in the reciprocal lattice, or the longer basal plane orthorhombic axis in real space.

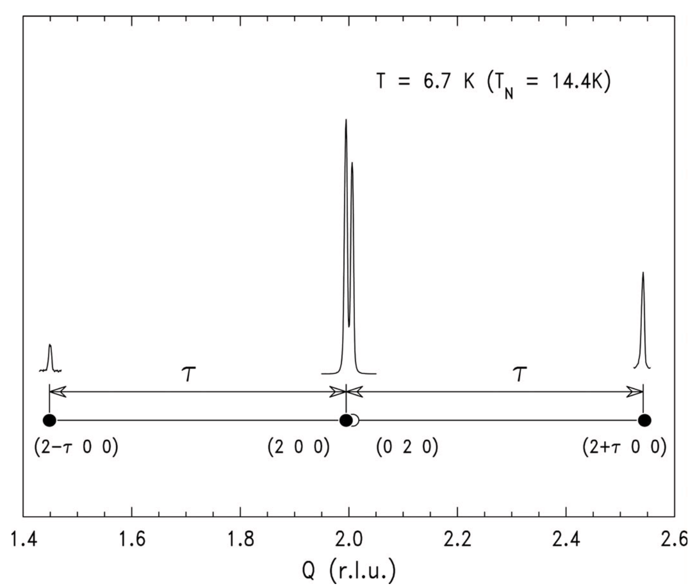

FIG. 1. Longitudinal scan with split charge peaks and magnetic satellites.

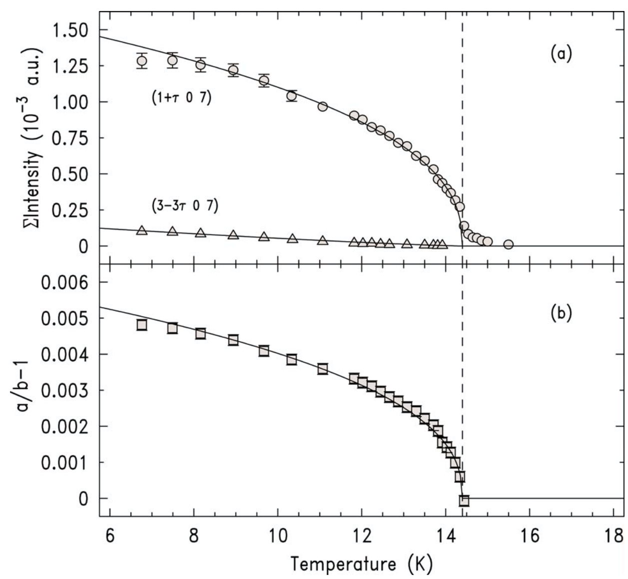

FIG 2. (a) Integrated intensities of magnetic satellites of (1+t 0 7) and (3-3t 0 7). (b) Orthorhombicity order parameter from the lattice distortion, a/b-1. The solid lines are power law fits.

The temperature dependence of the magnetic scattering intensity and the orthorhombic lattice distortion were compared and are shown in Fig. 2. The solid lines in Fig. 2a and Fig. 2b are fits using a power law in reduced temperature with the same exponent and T_N. The result that the same exponent describes the power law behavior of both the orthorhombicity, *a/b-1*, and magnetic scattering intensity, as well as the same transition temperature is consistent with the fact that both of these should scale with the square of the sublattice magnetization.

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