Orbital Ordering in Ca_2RuO_4

Beamline: 4ID-D (XOR-CAT, APS)

Technique: Resonant X-ray Scattering

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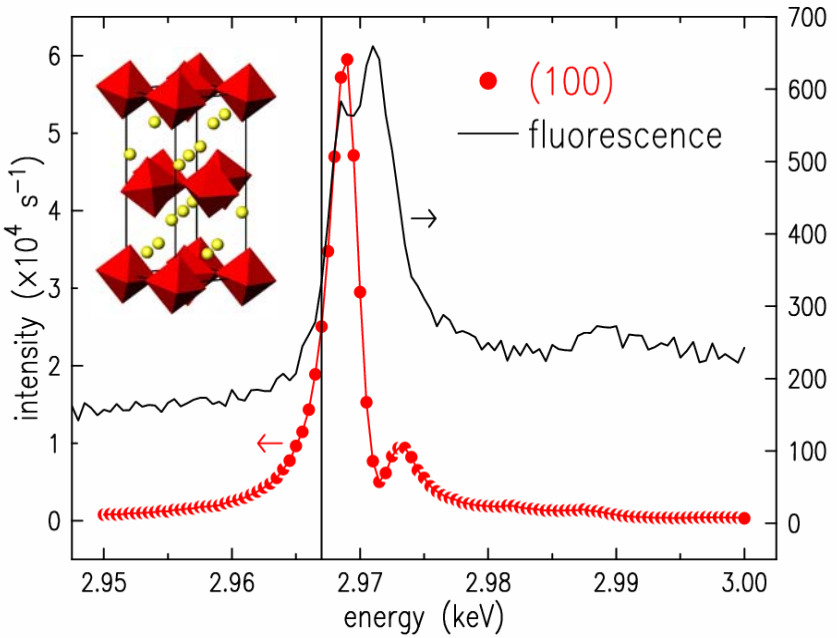
Motivation: The low-temperature phase of the single-layer perovskite $Ca_{2-x}Sr_xRuO_4$ ranges from anti-ferromagnetic insulating (x = 0) to superconducting (x = 2), with a crossover between predominantly antiferromagnetic and ferromagnetic correlations near x = 0.5. In order to study this rich system, we have used resonant x-ray scattering techniques at the Ru L_2 and L_3 edges. By tuning the incident photon energy near these edges, which are below 3 keV, we directly probe the 4d states through 2p → 4d dipole transitions and can obtain information about magnetic, orbital, and octahedral tilt ordering in this system.



Energy dependence of the (100) magnetic peak (•) and the fluorescence (—), measured at T = 13 K. The inset shows a schematic of the crystal structure, in which single layers of RuO_6 octahedra are separated by Ca ions.

Results: In Ca_2RuO_4, we have observed a peak scattering intensity of 60,000 counts/s at the (100) magnetic position. The polarization and azimuthal dependences of the scattering at this wavevector are consistent with the known low-temperature, antiferromagnetic ordering, which has been studied via neutron scattering (Braden *et al*., *Phys. Rev. B* 58, 847). But in addition, scattering at the (100) position is observed to persist above T_N, and exhibit a second transition at a temperature of 260 K. Both orbital ordering and octahedral tilt ordering are believed to produce the scattering intensity above T_N, and the transition at T = 260 K is attributed to the loss of long-range ordering of the 4d t_{2g} orbitals. We note that the absence of charge scattering due to a lattice distortion at the orbital ordering wavevector underscores the power of resonant x-ray scattering to probe such ordering phenomena that are only weakly coupled to the crystal lattice.