Observation of quadrupolar waves in UO_2

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X-ray inelastic scattering, with a resolution of 3 meV, has been performed at the ID28 spectrometer at the ESRF to attempt to see the mixing of the acoustic quadrupolar wave with the transverse acoustic phonon using a single crystal of UO_2. Quadrupolar waves *cannot* be observed directly with either neutrons or X-rays (unless resonant techniques are employed in the latter case) so the observation depends on *mixing* with either phonons or magnons. The latter are not observed directly with X-rays, making the technique cleaner than using neutrons – at least theoretically.
We observe a strong TA phonon broadening across the Brillouin zone which persist well above TN, as shown in the figure.
Further experiments at high resolution will be necessary to disentangle the mixing between the acoustic phonon with the magnetic and quadrupolar excitations. A signature of the anticrossing between these branches have be detected at q=0.6, where the TA(100) phonon cross the quadrupolar and magnetic excitation branches.