Probing the coulomb interaction of the unconventional superconductor $PuCoGa_5$ by phonon spectroscopy

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Given its characteristic energy scales, the unconventional superconductor $PuCoGa_5$ (Tc =18.5 K) is playing the central role of a missing link between the canonical heavy fermion superconductors and the high-Tc cuprates [1]. While a magnetic mechanism for the electron pairing is strongly suggested, the study of the phonon spectrum is nonetheless of interest. This is partly due to tremendous progresses in band structure calculations that allow to compute accurate phonon spectrum of strongly correlated electron systems.

We measured the phonon dispersion curves of single crystalline $PuCoGa_5$ samples along the [100], [110] and [001] directions by Inelastic X-ray Scattering (IXS) on ID28 at room temperature. The IXS data are compared with a density functional theory (DFT) ab-initio calculation using the Generalized Gradient Approximation with finite U (GGA+U) method [2]. We concluded that the inclusion of a finite on-site Coulomb repulsion between f electrons, U, of approximately 3 eV is essential to describe quantitatively the lattice dynamics of $PuCoGa_5$. This conclusion is primarily drawn from the sensitivity of the lowest transverse optic modes to the Coulomb repulsion that undergo up to 30% change in energy between the calculation with U = 0 and U = 3 eV. Our results give thus support to the existence of localized degrees of freedom in $PuCoGa_5$ in line with photoemission results [3].
In contrast, it was found that the phonon spectrum of the itinerant electron paramagnet $UCoGa_5$ is better described with U = 0 [4]. Our study shows that phonon spectroscopy is an alternate way of probing electronic properties of strongly correlated electron systems.

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