# Electron-Phonon Coupling in the Presence of Charge-Orbital Ordering in Magnetite FE3O4

At the Verwey transition temperature TV = 122 K the resistivity of Fe3O4 jumps by two orders of magnitude from a metallic to an insulating state accompanied by a structural symmetry change. Resonant x-ray scattering has shown that the charge and orbital orderings set in at temperatures above TV [1]. This suggests that the electronic energy is released into a lattice relaxation on lowering the temperature across TV. The transition is of first order with no single symmetry element connecting the high temperature and low temperature phases, while combination of X3 and Δ5 can parameterize the transition [2].

We have measured the phonon dispersion of low-lying branches connecting to X3 and X4 along the Δ and Σ directions at various temperatures above TV by inelastic x-ray scattering. The Δ5-X4 branch has anomalously large phonon widths at room temperature that broaden further on lowering the temperature to TV. The X3 phonon shows the normal behaviour of sharpening up with lowering the temperature.

Calculations of the lattice dynamics using local density approximation (LDA) and its extension to on-site electron-electron correlations (LDA+U) using U = 4 eV show strong anharmonicity in the X4 branch while the X3 branch is only mildly anharmonic. The anharmonicity disappears for U = 0. We thus conclude that the electron-phonon coupling is strongly influenced by the electron-electron correlations. This effect of correlations explains the large difference in width in the two branches we observed and may account for the electron-lattice coupling manifest in the structural phase transition. This result demonstrates that the Verwey transition is a cooperative phenomenon which involves strongly correlated electrons coupled to lattice degrees of freedom.

[1] J. E. Lorenzo et al. Phys. Rev. Lett. 101, 226401 (2008).
[2] P. Piekarz, K. Parlinski, and A. M. Oleś, Phys. Rev. Lett. 97, 156402 (2006).

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