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Ultrafast lattice and electronic dynamics in magnetite and the formation of a novel transient phase

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More than 70 years after its discovery, the Verwey transition in magnetite (Fe3O4) and the character of the low-temperature phase of this material remains an active and controversial topic. Upon cooling below 123 K, magnetite undergoes a first order transition from cubic to low symmetry accompanied by an increase of the electric resistivity by two orders of magnitude. Different models have been proposed to explain this effect involving charge, orbital and lattice degrees of freedom. In order to understand the coupling between electronic and structural degrees of freedom in the Verwey transition better, we studied their dynamics with time-resolved resonant soft x-ray diffraction. We find that charge and orbital order as well as the low-temperature structural distortion all melt under the influence of an infrared pump pulse within our temporal resolution of about 250 fs. Our finding indicates a strong coupling between structural and electronic degrees of freedom in magnetite. For intermediate pump fluences a novel transient state is formed, which is characterized by a drastic energy shift of the oxygen-K resonance threshold indicating a strongly reduced band gap.

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