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Jahn-Teller distortion driven magnetic polarons in magnetite

HSIAO-YU HUANG, ZHI-YIN CHEN, National Synchrotron Radiation Research Center, RU-PANG WANG, FRANK M. F. DE GROOT, Utrecht University, WENBIN WU, JUN OKAMOTO, ASHISH CHAINANI, National Synchrotron Radiation Research Center, JIANSHI ZHOU, University of Texas at Austin, HORNG-TAY JENG, National Tsing Hua University, GUANG-YU GUO, National Taiwan University, JE-GEUN PARK, Seoul National University, LIA HUO TJENG, Max Planck Institute for Chemical Physics of Solids, CHIEN-TE CHEN, DI-JING HUANG, National Synchrotron Radiation Research Center — The first known magnetic mineral, magnetite (Fe_3O_4), has unusual properties which have fascinated mankind for centuries; it undergoes the Verwey transition at $T_V \sim 120$ K with an abrupt change in structure and electrical conductivity. The mechanism of the Verwey transition however remains contentious. Here we use resonant inelastic X-ray scattering (RIXS) over a wide temperature range across the Verwey transition to identify and separate out the magnetic excitations derived from nominal Fe^{2+} and Fe^{3+} states. Comparison of the RIXS results with crystal-field multiplet calculations shows that the spin-orbital dd excitons of the Fe^{2+} sites arise from a tetragonal Jahn-Teller active polaronic distortion of the Fe^{2+}O_6 octahedra. These low-energy excitations, which get weakened for temperatures above 350 K but persist at least up to 550 K, are best explained as magnetic polarons.

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