Observation of Cation-Specific, Antiferromagnetically-Coupled Precession in Manganese Ferrites

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The precessional phases of cation magnetic moments in $MnFe_2O_4$ have been measured by means of time-resolved X-ray Magnetic Circular Dichroism (tr-XMCD) combined with in-situ Ferromagnetic Resonance (FMR). XMCD is a core-level spectroscopic technique that enables specific elements or specific sites in the lattice to be targeted. An applied RF magnetic field, phase locked to the synchrotron electron bunches, is used to drive the oscillations of the magnetic moments in the sample. The crystal structure is of spinel type, $A^{2+}B^{3+}{}_2O^{2-}{}_4$, where Mn^{2+} mainly occupies A sites (tetrahedral symmetry) and Fe^{2+} and Fe^{3+} mainly occupy B sites (octahedral symmetry). At room temperature, Fe^{2+} and Fe^{3+} precess in phase with a phase lag of 180 degrees with respect to Mn^{2+}. The phase relation is invariant to measurements at low temperatures (-120 degrees C). One of the motivations for this experiment is to validate the valence exchange model used to describe damping in insulators. At lower temperatures, this model predicts a broadening of the line width due to matching between the thermal spin relaxation time and precession time. This line width obtains a maximum value at a finite temperature $T = T_{max}$.