X-ray ferromagnetic resonance spectroscopy: a double resonance technique and its application to the study of time-invariant spin and orbital moment precession.

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Efforts to investigate magnetization dynamics using x-rays mainly concentrate on three types of excitations: laser pulses, magnetic field pulses, or continuous-wave microwave (MW) fields. Here, we focus on the latter approach [1-4], discussing time-invariant element-resolved ferromagnetic resonance measurements performed in the soft x-ray regime. We show that double-resonance spectra recorded during the simultaneous absorption of x-ray and MW photons are a fingerprint of the perturbed electronic configuration of atomic species driven to ferromagnetic resonance [5,6]. X-ray absorption measurements performed as a function of x-ray energy and polarization over the Fe $L_{2,3}$ edges of single-crystal yttrium-iron garnet reveal MW-induced multiplet features related to angular momentum transfer from the MW field to localized Fe 3d magnetic sublevels. O *K*-edge absorption spectra demonstrate the formation of dynamic 2p-orbital magnetization components at O sites coupled to the Fe magnetic moments at tetrahedral and octahedral sites. These results are compared with double-resonance x-ray absorption spectra of permalloy, showing that the MW transition probability is distributed according to the hybridization character of the 3d states [6]. Finally, we discuss the application of the XMCD sum rules to transmission measurements [7] in order to extract quantitative information on the precessing spin and orbital magnetic moments.

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