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Dynamical investigations of multiferroics: hexagonal manganites and a hexaferrite.[1]

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The electrodynamic response of magnetoelectric multiferroics can provide significant insight in the microscopic origin of multiferroicity. Hexagonal manganite $HoMnO_3$ is a robust room temperature ferroelectric with frustrated triangular antiferromagnetic order of Mn spins setting in at 72 K. Strong magnetoelectric effects were observed in $HoMnO_3$ and related hexa-manganites, the most intriguing of which is the control of magnetization by an applied electric field. The magnetic exchange interaction between the Ho and Mn ions was identified as a possible mechanism responsible for the observation, even though the detailed knowledge about this interaction was lacking. To fill this void, we studied magnetic excitations in $HoMnO_3$ by far-infrared spectroscopy and elucidated the ferromagnetic nature of the rare-earth/Mn exchange. Hexaferrites that display room-temperature magnetic order are also good candidates for room temperature multiferroics. We present a study of magnetic excitations in the hexaferrite $Ba_{0.6}Sr_{1.4}Zn_2Fe_{12}O_{22}$ using optical pump-probe spectroscopy. Pump-probe spectroscopy is known as an excellent tool for manipulating and probing magnons and phonons and for studying dynamic magnetoelectric effects. In $Ba_{0.6}Sr_{1.4}Zn_2Fe_{12}O_{22}$, we have observed a magnetic resonance using time domain pump-probe reflectance spectroscopy, revealing a modulation of the dielectric tensor by magnetization precession. The magnetic motion in the hexaferrite modifies the dielectric constant at visible wavelengths, providing a novel manifestation of the dynamic magnetoelectric coupling and a new way of detecting magnetic motion in multiferroics. Our results highlight that magnetoelectric dynamics manifests from the far-infrared through the visible and that both time-integrated and time-resolved spectroscopy are important tools in elucidating the microscopic properties of multiferroics.

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