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Magnetic and magnetoelectric excitations in hexagonal multiferroics RMnO3 probed by neutron scattering and THz spectroscopy

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Broadband THz spectroscopy is a very useful tool to study complex magnetic/electric order in condensed matter i.e. in multiferroic compounds since both magnetic (magnons) and electric (optical phonons) excitations lie in this energy range. When cross coupling between magnetic and electric order occurs, new kind of excitations may emerge: these are called electro-magnons.
Coupling two complementary experimental techniques, THz/FIR spectroscopy on synchrotron source and inelastic neutron scattering, we have focused on two members of the multiferroics hexagonal manganites RMnO3, with R=Er and Ho. These compounds order electrically below 800 K and magnetically around 80 K with a 120° frustrated arrangement of the Mn3+ ions. We have fully characterized the low energy spectra (magnon, phonon, crystal field transitions) of these compounds and their excitation rules as regards the electric and magnetic fields of the THz wave. In ErMnO3, we have observed the complete loss of the magnetic character of a magnon transmuted into an electroactive excitation [Chaix, et al. Phys. Rev. Lett. 112, 137201 (2014)]. We attribute this magnetoelectric dynamical process to the hybridization between a crystal field level transition of the Er magnetic rare earth and a Mn magnon. In HoMnO3, spectacular modifications of the Mn spin waves and Ho crystal field level transitions are observed at a temperature of 40 K when a spin reorientation of the Mn3+ magnetic moments occurs, together with the ordering of some Ho ions. At lower temperature, the spin waves dispersion perpendicular to the Mn triangular planes vanish, the Mn ordered structure being maintained in the molecular field of the rare earth ions. Both studies highlight the crucial role of the strong coupling between Mn and rare earth ions in the dynamical properties of these hexagonal manganites.

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