Electromagnon spectra in multiferroic manganites $RMnO_3$

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The magnetoelectric (ME) effect, in which electric polarization (magnetization) are controlled by magnetic (electric) field, have recently attracted intensive attention. One of the materials which exhibits large ME effects is the manganites $RMnO_3$. In this presentation I focus on electromagnon excitations (in a wide sense). In those manganites, cycloidal spin structures create ferroelectricity through spin-orbit couplings. Originally, electromagnon is defined as a collective excitation of spins in such a way that rotation of the cycloidal plane is driven by the electrical field of light coupled to the ferroelectric moment. Spectra for electrically excited magnons are indeed reported in TbMnO$_3$, GdMnO$_3$, (Eu,Y)MnO$_3$ and DyMnO$_3$. However, the selection rule observed in these compounds ($E\omega \parallel a$, irrespective of the cycloidal planes) is inconsistent with the theoretical prediction. Alternatively, couplings between electric field and spins through spin-dependent local polarizations have been proposed. I show both one- and two-magnon excitation spectra, and clarify consistencies and discrepancies of the model with experimental data. Roles of phonons and orbital orders in these compounds are also discussed.