Exchange effects in the optical spectrum of $LuMnO_3$

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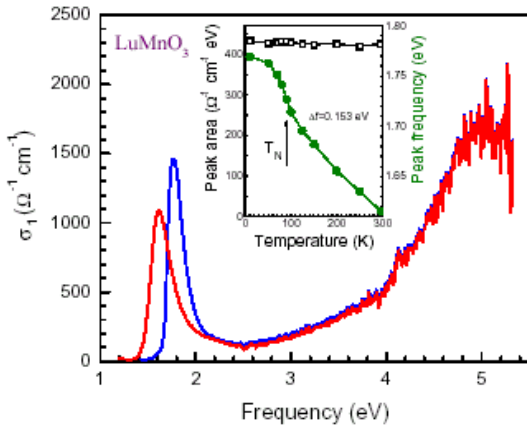
The colossal magnetoresistance compounds based on doped pseudo-cubic $LaMnO_3$ have excited much attention because of their interesting physical properties and potential applications. $LuMnO_3$ is a member of another series of $RMnO_3$ materials with smaller radius R^{3+} ions that crystallize in a hexagonal lattice. The hexagonal manganites are interesting as examples of multiferroics — they are both ferroelectric ($T_c \cong 900K$) and antiferromagnetic ($T_N \cong 90K$) with frustration [1]. The coupling between ferroelectric and magnetic order parameters in multiferroics opens the possibility to manipulate electric properties through magnetic fields and vice versa which, in turn, gives these materials potential for applications in spintronics and as read/write heads. These materials are also interesting because of their non-linear optical properties [2].



The optical conductivity spectrum of $LuMnO_3$ at 300 K (red) and 10 K (blue) for E⊥c. Inset: temperature dependence of the peak frequency of the ~1.7 eV feature.

The optical conductivity of $LuMnO_3$ was measured from 10 meV to 5 eV [3]. As shown in the figure the onset of interband transitions is a sharp feature at ~1.7 eV which is identified as an on-site d → d transition on the Mn^{3+} ion. The transition energy of this feature has a strong temperature dependence with an anomaly at T_N which is attributed to the effects of the nearest neighbor Mn-Mn exchange on the Mn energy levels.

Based on direct measurements of the real part of the dielectric function in the far and mid infrared, we find that the known anomaly in the temperature dependence of the quasi-static dielectric constant ε_0 below T_N is due to hardening of the lowest optical phonons via magnon-phonon interaction [3]. The lowest ~ 1.7 eV electronic excitation and spin-coupled phonons exhibit similar temperature dependent shifts in their resonance energies between 4 and 300~K with an inflection point at T_N. Both are related to the nearest neighbor spin-spin correlation function - $\langle S_i \bullet S_j \rangle$.

Antiferromagnetic resonance (E⊥c) and two-magnon absorption E||c give additional information on magnetic interactions in these hexagonal manganites [3]. Photoluminescence measurements show a spectral feature at ~1.4 eV which corresponds to the radiative recombination to a Jahn-Teller split level in the optical excited state [4]. Raman measurements show scattering from the 700 cm^{-1} oxygen bond stretch phonon mode is resonant with the 1.7 eV feature [4].

We have shown that optical measurements give important information about the exchange interactions and the lattice interactions in this material which is interesting both because of their close to the psuedocubic manganites and in their own right.

1. G. Smolenskii and I. Chupis, Usp. Fiz. Nauk 136-138,415 (1982 [Sov. Phys. Usp. 25, 475 (1982)]).
2. T. Iizuka-Sakano, E. Hanamura and Y. Tanabe, J. Phys.: Condens. Matter 13 3031–3055 (2001).
3. A.B. Sushkov, J.R. Simpson, D.B. Romero, M. Quijada, H.D. Drew, J.S. Ahn, H. Ishibashi, S.W. Cheong, and A. J. Millis, in preparation.
4. A. B. Sushkov, D. Romero, H. D. Drew, J.S. Ahn, H. Ishibashi, S.W. Cheong, in preparation.