Spin-dependent effects in the optical study of hexagonal $LuMnO_3$

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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. Another series of $RMnO_3$ materials, where R is one of the heavier lanthanides (Ho, Er, Tm, Yb, and Lu) have smaller radius R^{3+} ions and crystallize in the hexagonal lattice. The hexagonal manganites are interesting as a limiting case of a huge Jahn-Teller distortion of the orthorhombic MnO_6 complex, and they are examples of multiferroics — they are both ferroelectric (T_c~900 K) and antiferromagnetic (T_N~90 K) and the antiferromagnetism is strongly frustrated. One of the manifestations of coupling between ferroelectric and magnetic order parameters is an anomaly in the temperature dependence of the static dielectric constant. In the present work, we analyze the contributions of the phonons and the electronic transitions to the dielectric function. We find that the phonons are mainly responsible for the anomaly in the static dielectric constant. We also find that both Mn phonons and the lowest 1.7 eV electronic excitation exhibit identical temperature dependent shifts in their resonance energies and that these shifts have the character of the nearest neighbor spin-spin correlation function $<S_iS_j>$. We will also discuss the Mn d-level splitting in this system, the assignment of observed electronic transitions and the mechanism of their temperature dependencies.