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Dynamic spin-state order in perovskite-like $LaCoO_3$

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$LaCoO_3$ exhibits two crossovers at $T_{SS} \approx 100$ K and $T_{MI} \approx 500$ K observed in various physical properties such as thermal expansion and electric susceptibility. These crossovers are typically associated with the temperature dependent population of excited spin states of the Co^{3+} ion, which evolves upon heating from the low-spin (LS), S = 0, to high-spin (HS), S = 2, configuration. Since the CoO_6 octahedra expands around the larger HS sites, a static LS-HS order was proposed by Goodenough in the 1960's [1] but was never confirmed experimentally. More recent models suggest that spin states form a 3D checkerboard-type short range order near the room temperature, which is formed due to different sizes of these spin states [2-4]. A corresponding dynamic distortion of the crystal lattice mimics closely the Co-O breathing mode. Using inelastic neutron scattering to study the lattice dynamics of $LaCoO_3$ over a wide temperature range, 5 K ≤ T ≤ 700 K, we find strong phonon renormalization of low- as well as high-energy phonon modes with periodicities corresponding to the proposed superlattice.
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[3] V. Křápek et al., Physical Review B 86, 195104 (2012).
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