Structural Origin of the Magnetic Field-Induced Electric Polarization of $GdMn_2O_5$

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We investigate the magnetoelectric coupling of $GdMn_2O_5$, a multiferroic where the electric polarization and magnetic order are strongly coupled [1]. The compound exhibits a magnetic field-induced electric polarization, where the component along the crystallographic *a* axis persists and even increasing after removal of the magnetic field, suggesting access to a novel, path-dependent ground state [2]. The microscopic mechanism behind this persistent polarization remains unclear and resolving it requires a direct structural probe to track the lattice response in the presence of high magnetic fields.
The emergence of an electric polarization is believed to result from atomic displacements caused by changes in magnetic ordering through magnetoelastic coupling. Our experiments using the new pulsed magnet setup at the SwissFEL Cristallina-Quantum experimental station are guided by density functional theory simulations covering scenarios, ranging from simple atomic displacements of the magnetic Gd ions to lattice relaxation driven by changes of the magnetic order. These models predict intensity variations of specific lattice Bragg peaks, providing a direct experimental benchmark for the structural origin of the magnetic field-induced electric polarization.

[1] G. Yahia *et al*. Recognition of exchange striction as the origin of magnetoelectric coupling in multiferroics. Phys. Rev. B **95**, 184112 (2017).
[2] V. Balédent *et al*. Electronic ground-state hysteresis under magnetic field in $GdMn_2O_5$. Phys. Rev. B **108**, 104419 (2023).