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Multiferroic RMn_2O_5 ($\text{R} = \text{Y}, \text{Tb}, \text{Ho}$) and isotopically substituted $\text{TbMn}_{16/18}\text{O}_3$, $\text{Dy}_{16/18}\text{MnO}_3$: A comprehensive Raman light scattering and neutron scattering investigation

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Multiferroic materials demonstrate excellent potential for next-generation multifunctional devices, as they exhibit coexisting ferroelectric and magnetic orders. At present, the underlying physics of the magnetoelectric coupling is not fully understood, and competing theories exist with partly conflicting predictions. Therefore, we have investigated isotopically substituted $\text{TbMn}_{16/18}\text{O}_3$, $\text{Dy}_{16/18}\text{MnO}_3$, and RMn_2O_5 ($\text{R} =$ magnetic Tb, Ho and non-magnetic Y) by Raman light scattering and neutron diffraction to elucidate the spin-phonon coupling and crystallographic as well as magnetic phase diagrams in order to shine light on the multiferroic coupling mechanism in both compounds.

Raman light scattering allows for the detection subtle changes in phonon energy and lifetime at magnetic and ferroelectric phase transitions through interactions of the lattice vibrations with the electronic systems. This offers valuable information on the mechanisms behind the magnetoelectric properties. For example, our experiments on RMn_2O_5 did demonstrate that the magnetic and ferroelectric phases in RMn_2O_5 with magnetic $\text{R} = \text{Tb}, \text{Ho}$ are distinct from the phases in non-magnetic YMn_2O_5 , demonstrating the importance of the rare earth element on the multiferroic properties.

Our neutron diffraction investigations did yield additional complementary information in the crystallographic and magnetic structures. Our combined neutron and high resolution X-ray synchrotron investigation on $\text{Dy}_{16/18}\text{MnO}_3$ did allow for the detection of atomic displacements at the ferroelectric phase transition, possible responsible for the creation of the ferroelectric moment. Opposite to the behavior in other transition metal oxides, oxygen isotope substitution only had a minor effect on the magnetic properties. This provides valuable information on effects behind the magnetoelectric coupling mechanisms in these multiferroic materials.

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