Depth-Resolved Profile of the Interfacial Ferromagnetism in $CaMnO_3/CaRuO_3$ Superlattices

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Interfacial magnetism in complex oxides presents a rich platform for tuning electronic and magnetic properties, with implications for spintronic and data storage applications. In this study, we investigate the emergence of interfacial ferromagnetism in oxide superlattices containing antiferromagnetic $CaMnO_3$ and paramagnetic $CaRuO_3$ using a combination of synchrotron-based X-ray spectroscopy and X-ray Resonant Magnetic Reflectivity (XRMR) measurements to uncover the depth profile of the interfacial magnetism. Our findings reveal that the emergent interface ferromagnetism exhibits an asymmetric distribution between the top and bottom interfaces and may extend beyond the immediate interface into the nominally antiferromagnetic $CaMnO_3$ layers, suggesting more complex interface interactions than previously assumed.

To understand the microscopic origin of this behavior, we employed density functional theory calculations, which indicate that the observed interfacial ferromagnetism is driven by a double exchange mechanism facilitated by charge transfer from Ru to Mn ions. Furthermore, defect chemistry, such as the presence of oxygen vacancies, may influence the local magnetic moments at the interface and contribute to the asymmetry in the ferromagnetic depth profile.

These results highlight the role of charge transfer and defect engineering in tailoring emergent interfacial properties. By providing a deeper understanding of how interfacial magnetism can be controlled at the atomic level, this work offers new strategies for designing functional oxide heterostructures with tunable magnetic properties [1].

[1] *J. Paudel* et al., Nano Lett. **24** (48), 15195-15201 (2024).

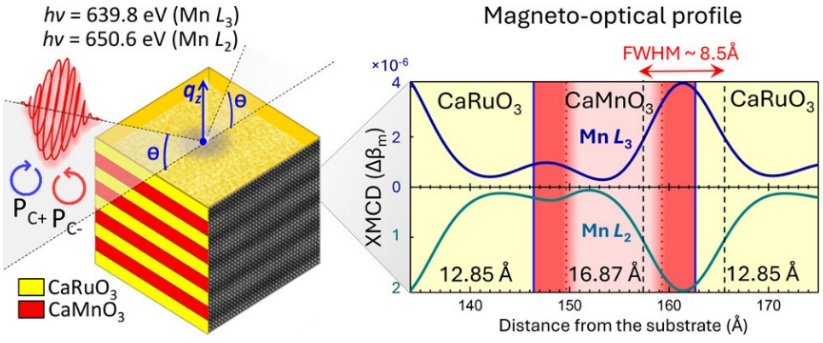

Figure 1. XRMR measurement geometry of the $CaMnO_3/CaRuO_3$ superlattices (left) and the derived magnetic depth profile of a single $CaMnO_3$ layer sandwiched between $CaRuO_3$ (right).