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Resolving spin density wave order in layered nickelates $\text{La}_3\text{Ni}_2\text{O}_7$ and $\text{La}_2\text{PrNi}_2\text{O}_7$ via neutron diffraction

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Layered nickelates, particularly $\text{La}_3\text{Ni}_2\text{O}_7$ and its derivatives, have emerged as a compelling platform for exploring unconventional superconductivity [1, 2]. These materials exhibit high-temperature superconductivity under pressure, placing them among the few transition-metal oxides with such properties alongside cuprates and iron-based superconductors. The intricate interplay of spin density waves (SDWs) [3], charge density waves (CDWs), and electronic correlations in these systems highlights their potential as key candidates for elucidating the mechanisms of unconventional superconductivity.

In this study, I present direct evidence of long-range SDW order in bilayer nickelates $\text{La}_3\text{Ni}_2\text{O}_7$ and $\text{La}_2\text{PrNi}_2\text{O}_7$ using high-intensity neutron powder diffraction (NPD) [4]. Magnetic Bragg reflections were observed below 150 K at propagation vectors $\mathbf{q}_1 = (0, \frac{1}{2}, 0)$ for both compounds and an additional vector $\mathbf{q}_2 = (\frac{1}{2}, \frac{1}{2}, 0)$ exclusively in undoped $\text{La}_3\text{Ni}_2\text{O}_7$. Representation and magnetic symmetry-guided analysis revealed spin-structures with alternating low- ($0.05\text{--}0.075\ \mu\text{B}$) and high-moment ($\sim 0.66\ \mu\text{B}$) stripes within single Ni layers, forming bilayers through antiferromagnetic stacking along the c -axis. The proposed models are substantiated by the muon spectroscopy data. The coexistence of two distinct magnetic stacking polymorphs corresponding to \mathbf{q}_1 and \mathbf{q}_2 in $\text{La}_3\text{Ni}_2\text{O}_7$ further underscores the quasi-2D nature of its magnetic order.

These findings provide critical insights into the magnetic ground state of layered nickelates and establish a foundation for understanding their role as precursor states to superconductivity. Future studies will be important to unravelling the connection between SDW suppression and superconducting onset, potentially confirming SDWs as competing or complementary instabilities in these systems. This work advances our understanding of nickelate physics while channelling the way for targeted exploration of superconductivity mechanisms in transition-metal oxides.

[1] M. Wang, H.-H. Wen, T. Wu et al. Chinese Physics Letters, 41, 077402 (2024).

[2] N. Wang, G. Wang, X. Shen et al. Nature, 634, 579–584 (2024).

[3] R. Khasanov, T. J. Hicken, D. J. Gawryluk et al. Nature Physics, 21, 430–436 (2025).

[4] I. Plokhikh, T. J. Hicken, L. Keller et al. arXiv:2503.05287 [cond-mat.supr-con] (2025).

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