

Spin Excitations and Magnetic Interactions in Trilayer Nickelate $\text{La}_4\text{Ni}_3\text{O}_{10}$ Single Crystals



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Abstract: Pressurized Ruddlesden–Popper nickelates have recently emerged as a new family of high- T_c superconductors. The trilayer member $\text{La}_4\text{Ni}_3\text{O}_{10}$ becomes superconducting near 30 K under pressure, while at ambient pressure it hosts an intertwined density-wave order. As in the cuprates, the magnetism of this parent phase is widely believed to be intimately tied to electron pairing, yet the momentum- and energy-resolved spin correlations of $\text{La}_4\text{Ni}_3\text{O}_{10}$ have yet to be fully resolved. Here we use inelastic neutron scattering (INS) on co-aligned single crystals to map the spin excitations of trilayer $\text{La}_4\text{Ni}_3\text{O}_{10}$ across the Brillouin zone. Within a local-moment picture, the measured dispersions and intensities are well reproduced, to a good approximation, by a Heisenberg model evaluated using linear spin-wave theory (SpinW), from which we extract the dominant magnetic exchange interactions. Combined with absolute-unit normalization, this analysis yields the effective magnetic exchange Hamiltonian and the total fluctuating moment of the system.

Structures and Magnetic Interaction of $\text{La}_4\text{Ni}_3\text{O}_{10}$

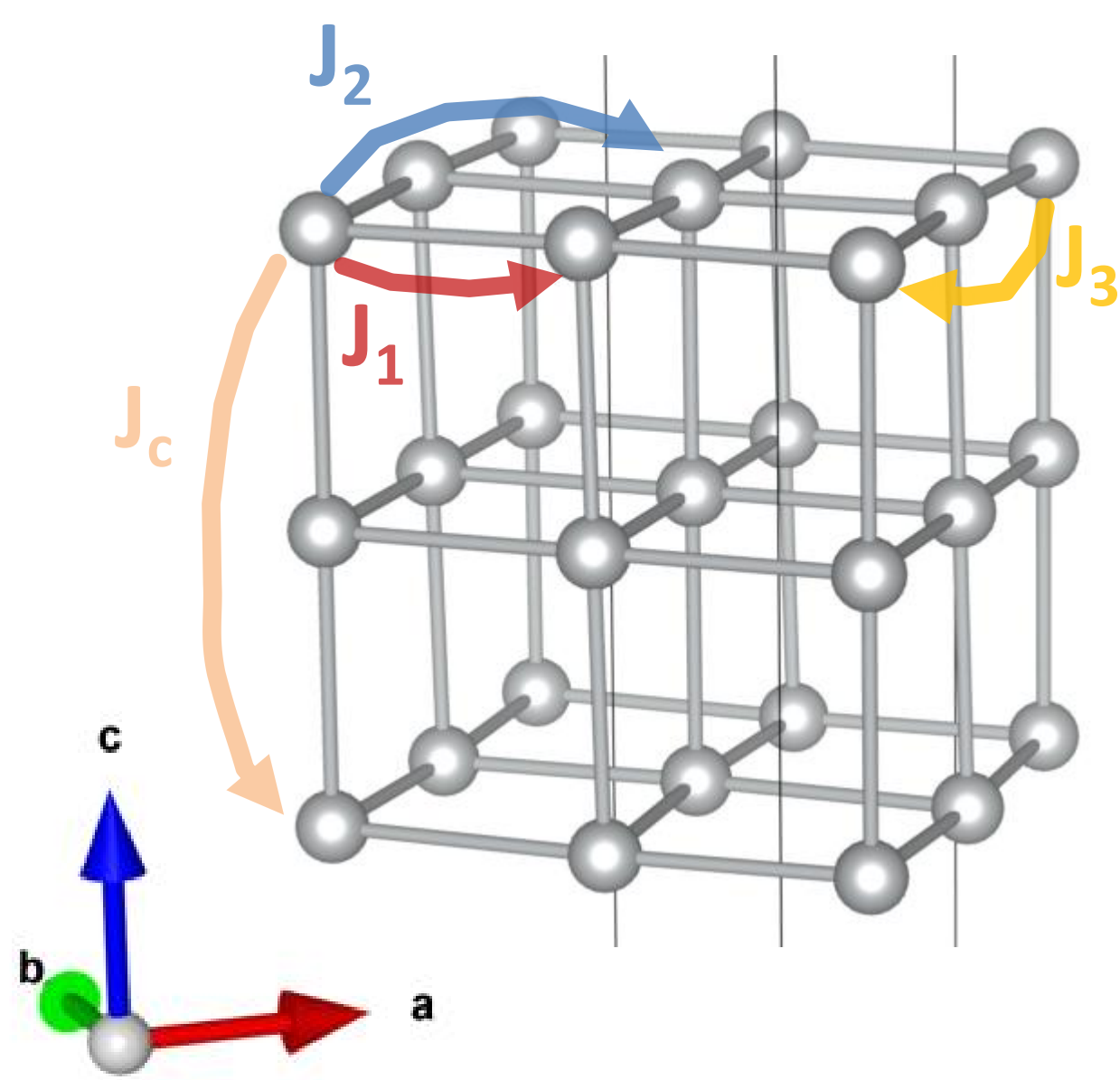


Fig. 1 | Crystal structure and magnetic exchange paths of $\text{La}_4\text{Ni}_3\text{O}_{10}$. The compound is monoclinic (space group $P2_1/a$) with lattice parameters $a = 5.41 \text{ \AA}$, $b = 5.46 \text{ \AA}$, $c = 27.985 \text{ \AA}$. For clarity, only the Ni ions are shown.

1D Constant-Energy Cuts and Magnetic Dispersion Evolution

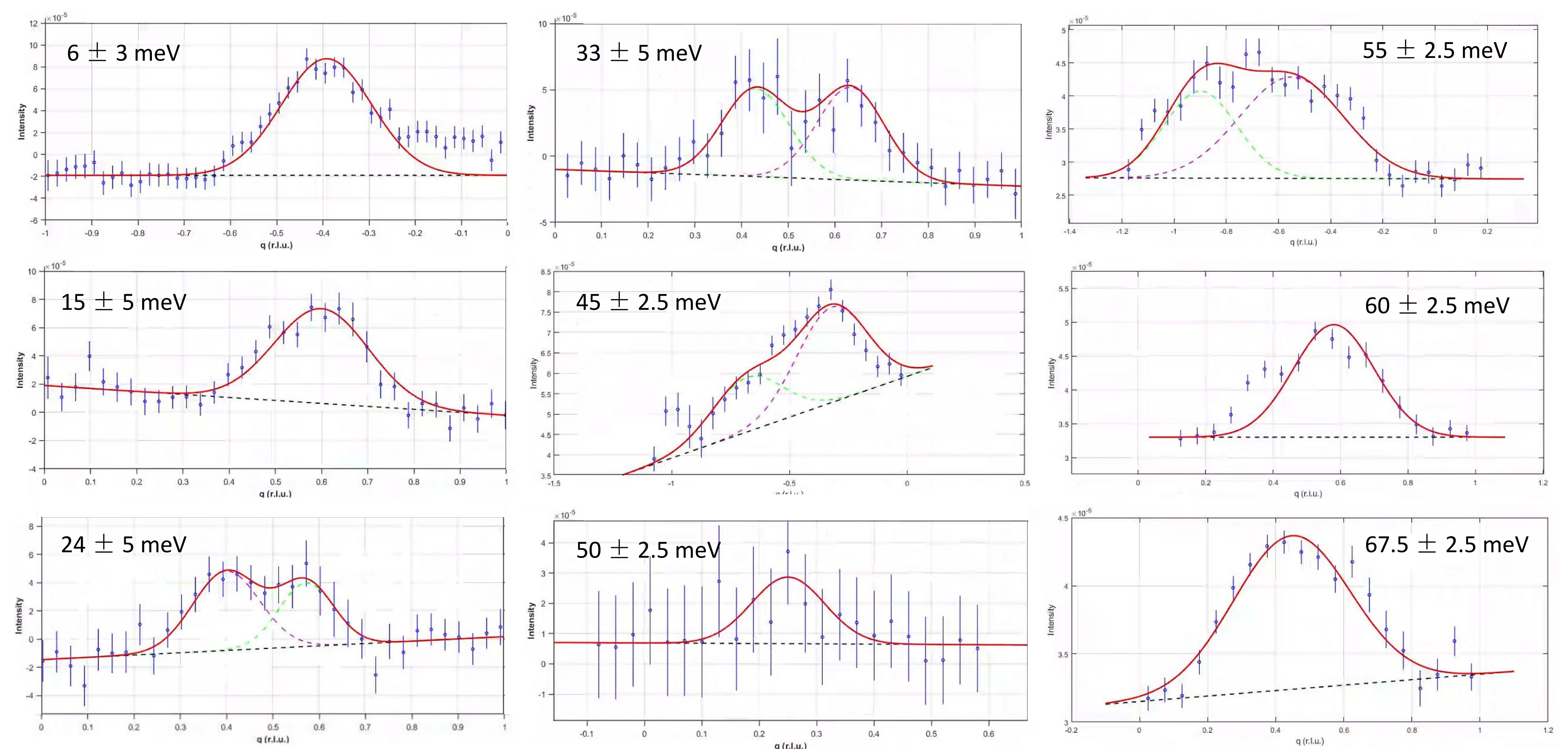


Fig. 2 | 1D Cuts of Magnetic Excitations. Representative cuts from the 0–72 meV dispersion, fitted with pseudo-Voigt peaks and a linear background. The excitation emerges from $q = 0.61$ as a single peak, splitting into a double peak near 30 meV due to anisotropic expansion. At 45 meV, the lower branch vanishes at the zone boundary, leaving a single peak that ultimately dissipates near 70 meV.

In-Plane Constant-Energy Maps: Data vs. Spin-Wave Simulation

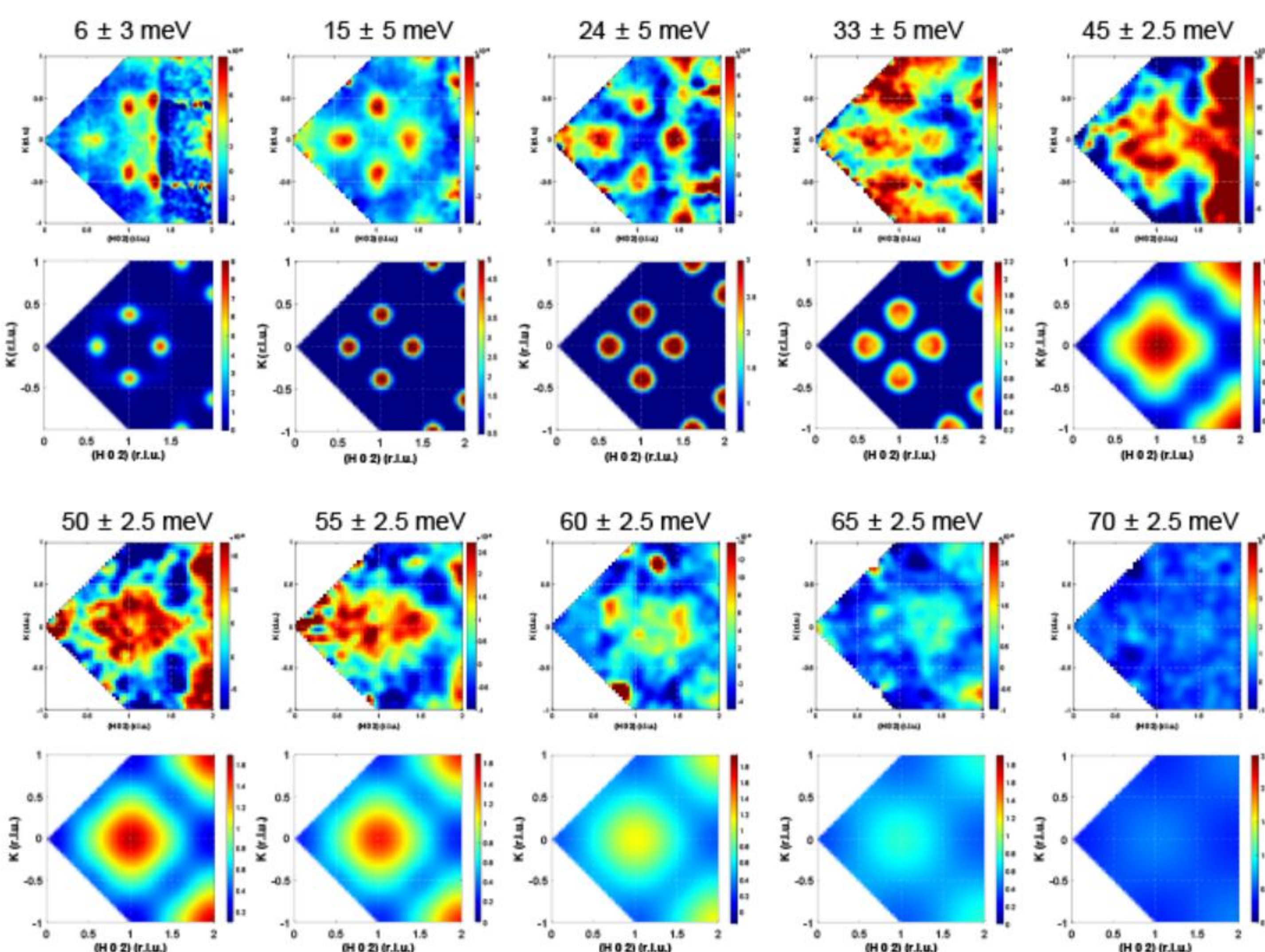


Fig.3 | In-Plane magnetic excitations and LSWT simulations. Upper and lower panels display measured data and corresponding simulations, respectively. Excitations emerge from 0.61 as b-elongated ellipses and expand anisotropically. The lower branch disperses toward (0, 0), forming a ring-like pattern that terminates at 45 meV. The higher branch continues toward (1, 0) up to a 57 meV band top. Above this, a high-energy optical branch disperses back toward (0, 0), creating a characteristic hourglass-like dispersion.

Absolute Local Susceptibility $\chi''(E)$

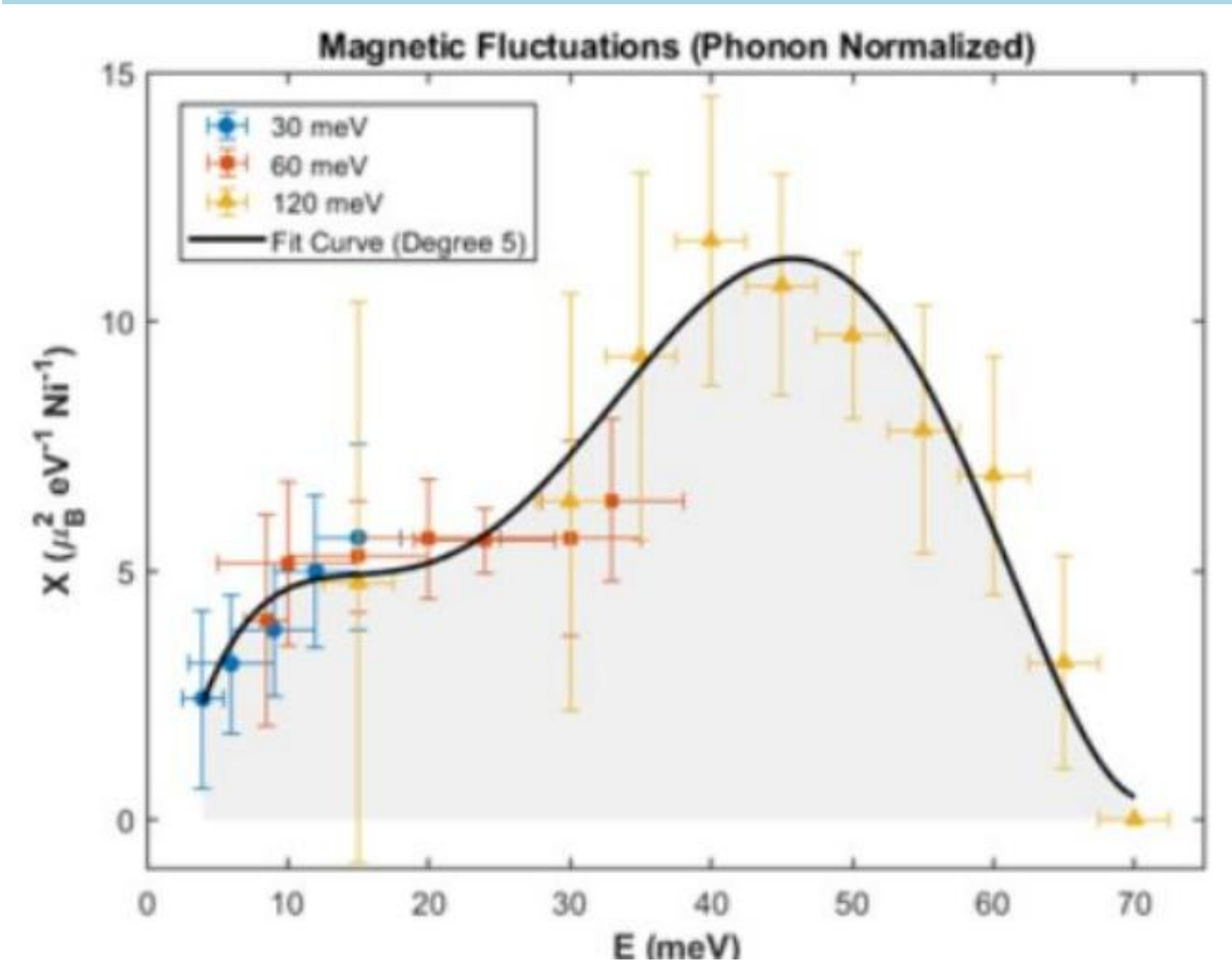


Fig. 4 | Combined spectra normalized to acoustic phonons. Energy integration yields a total fluctuating moment $\langle m^2 \rangle \sim 0.43 \mu_B^2/\text{Ni}$, showing the coexistence of strong correlations and itinerancy.

Discussion

1. We mapped the full spin excitation spectrum of trilayer $\text{La}_4\text{Ni}_3\text{O}_{10}$ using INS and modeled the dispersions using linear spin-wave theory (SpinW) within a local-moment Heisenberg picture.
2. Despite minor fit deviations arising from the strong itinerant nature of $\text{La}_4\text{Ni}_3\text{O}_{10}$, our work firmly establishes the presence of robust magnetic exchange interactions and fluctuations, which are likely to play a cooperative role in driving pressure-induced superconductivity.