Nature of magnetism in bilayer nickelate $La_3Ni_2O_7$ single crystals

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Abstract: **The recent discovery of high-temperature superconductivity in pressurized and thin film nickelates has generated intense interest, yet the nature of magnetism in their ambient-pressure parent phases remains poorly understood, despite its potentially crucial role in pairing. Here we use neutron scattering to resolve the spin order and dynamics of single-crystalline $La_3Ni_2O_7$, an ambient-pressure parent of this class. Well defined spin excitations are observed at Q = (0, 0.5, 2.5), featuring a ~5 meV spin gap and anisotropic in-plane dispersions, with zone-boundary softening along the transverse direction indicative of competing exchange interactions. The excitations exhibit pronounced out-of-plane modulations with bilayer periodicity, providing direct evidence for antiferromagnetic interlayer coupling. Their dispersion is well described by a bilayer Heisenberg Hamiltonian with strong interlayer exchange and competing in-plane couplings within a stripe-type magnetic order. Normalization of the spectra to absolute units reveals that, although the spin-wave bandwidth is only about 25% of that in cuprates, the local dynamic susceptibility at comparable energies is significantly enhanced, yielding a total fluctuating moment of comparable magnitude. These results highlight intense mid-energy spin excitations rooted in substantial electronic correlations as a defining feature of this family, establishing a magnetic framework distinct from cuprates and directly relevant to understanding superconductivity in this system.**

Magnetic structure, susceptibility, and spin dynamics of $La_3Ni_2O_7$.

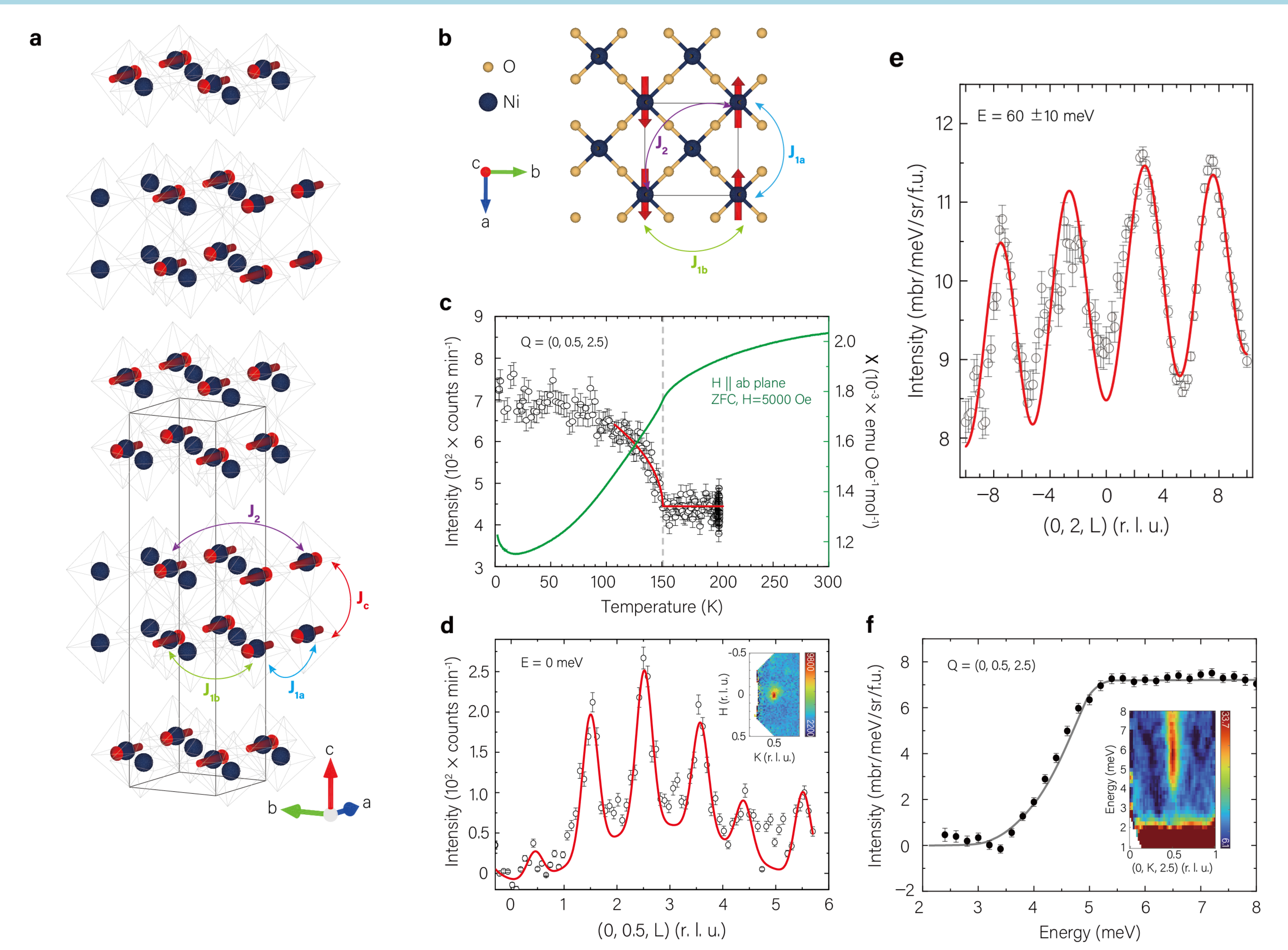
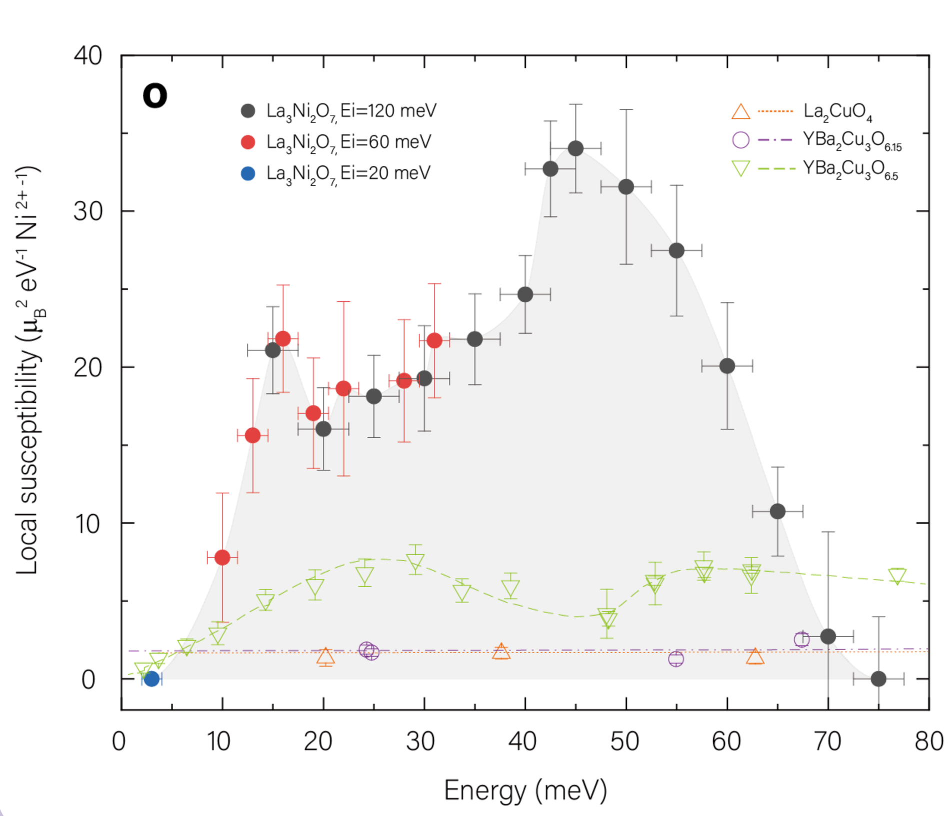


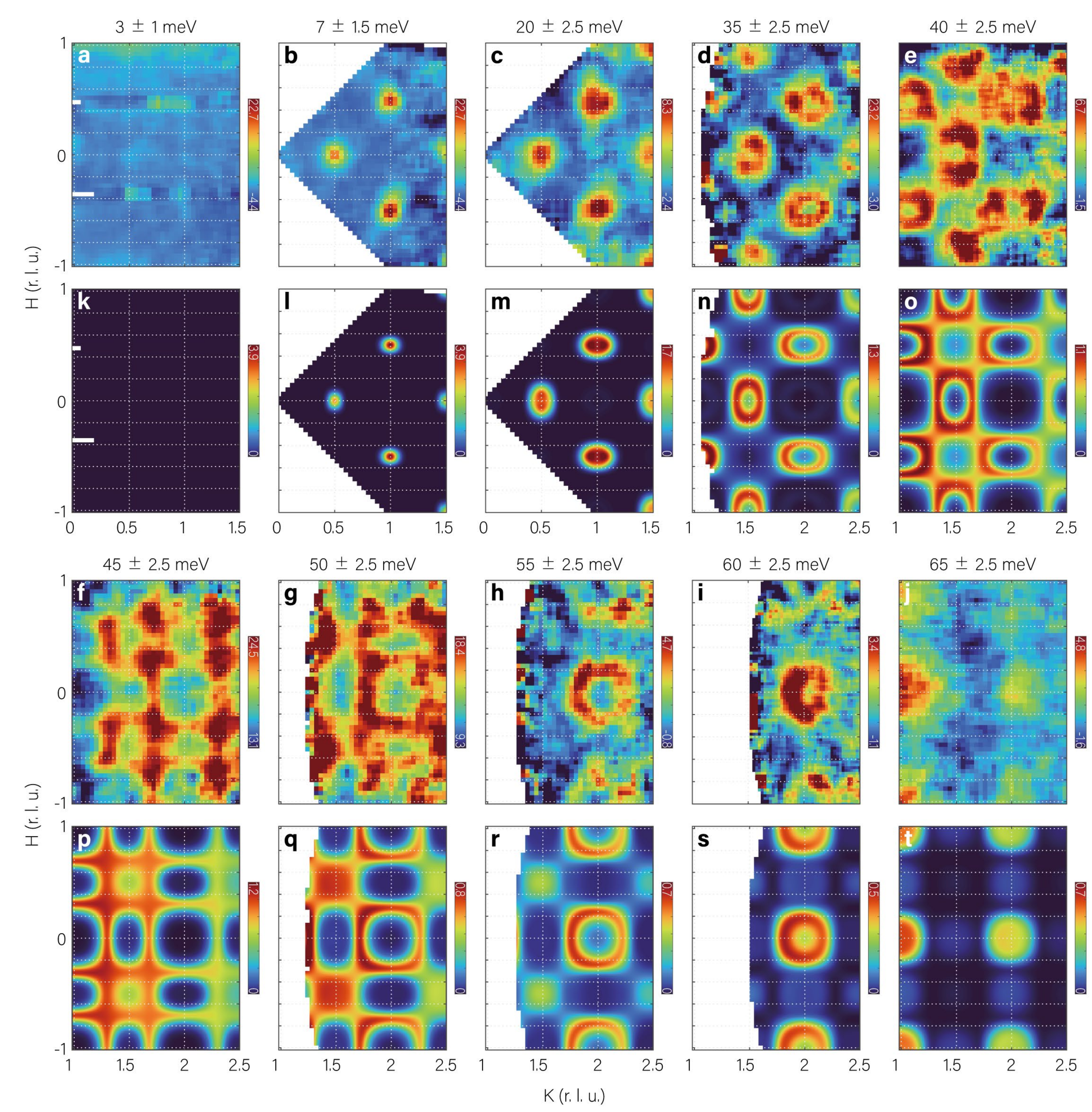
FIG (a-b) Schematics of the stripe-type magnetic structure and in-plane exchange interactions. Red arrows denote ordered Ni moments. SJ_c=39.86±0.85, SJ_{1a}=2.36±0.22, SJ_{1b}=3.71±0.44, SJ_2=4.63±0.18 and SA=-0.07±0.015 meV (c) Temperature dependence of in-plane magnetic susceptibility at 5000 Oe and the (0, 0.5, 2.5) magnetic Bragg peak intensity, yielding T_N = 151 K and a critical exponent β= 0.24±0.03. (d) Background-subtracted magnetic Bragg peaks along Q = (0, 0.5, L) at 3.6 K. (e) L-dependent magnetic excitation intensity at 60±10 meV, displaying a bilayer periodic modulation proportional to $\sin^2(q_z d/2)$ (d: distance between adjacent NiO_2 layers). (f) Background-subtracted energy scan at Q = (0, 0.5, 2.5) revealing a ~5 meV spin gap.

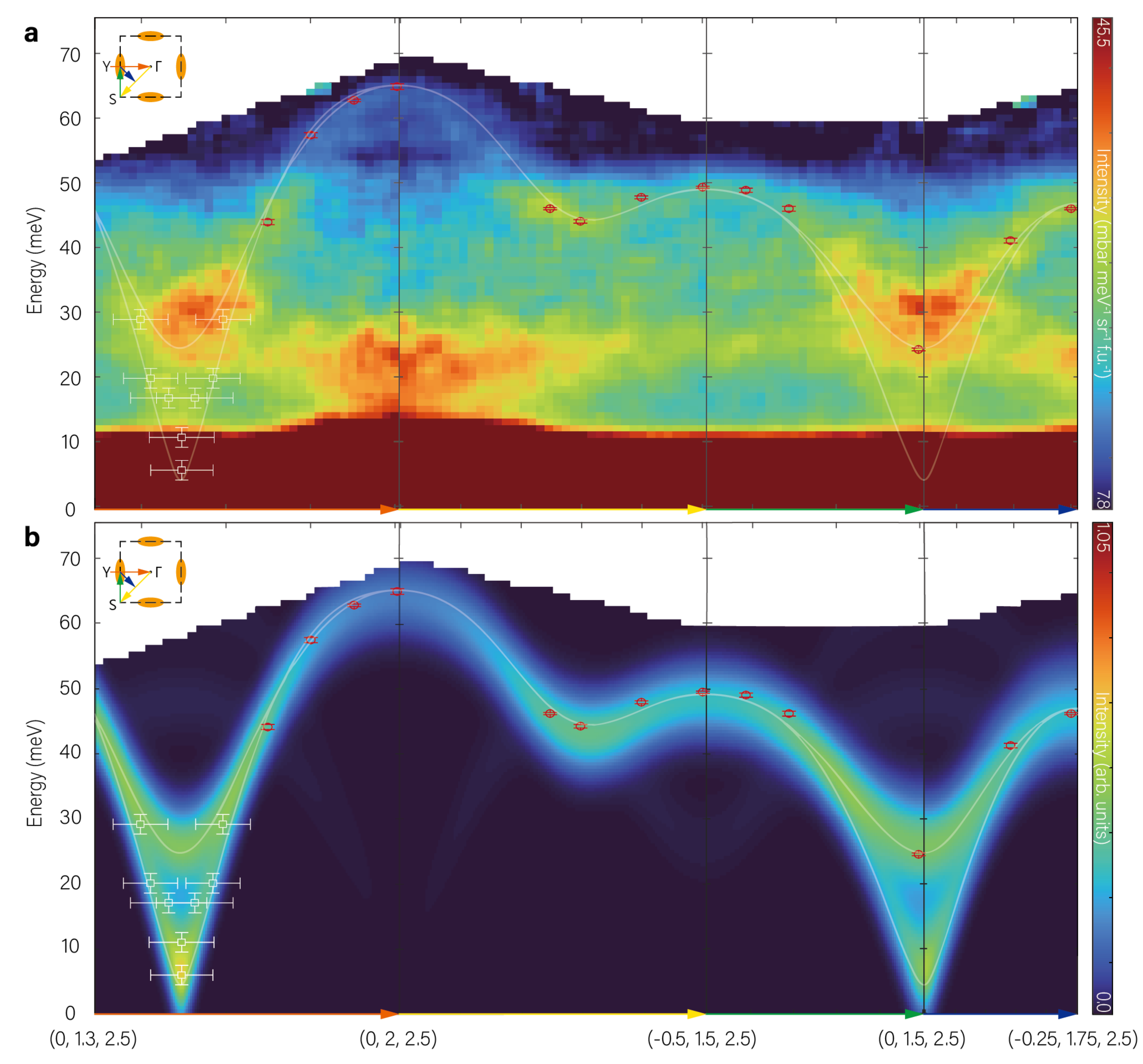
Energy dependence of dynamic local susceptibility χ at 6 K



Data are L-integrated to sum acoustic and optical branches. Horizontal/vertical error bars denote energy integration ranges/statistical uncertainties. Normalized literature cuprate data are plotted for comparison: parent compounds at 295 K (open triangles/circles) and normal-state $YBa_2Cu_3O_{6.5}$ at 60 K (open inverted triangles), with their acoustic and optical branches similarly summed.

Spin-wave dispersions and linear spin wave theory simulation of $La_3Ni_2O_7$ single crystal





Conclusion ☐ Resolved the stripe-type magnetic ground state of ambient-pressure $La_3Ni_2O_7$ single crystals using elastic and inelastic neutron scattering.

☐ Revealed well-defined spin excitations featuring a ~5 meV spin gap, anisotropic in-plane dispersions, and zone-boundary softening driven by competing exchange interactions.

☐ Identified pronounced out-of-plane modulations with bilayer periodicity, accurately described by a bilayer Heisenberg Hamiltonian featuring strong interlayer exchange.

☐ Discovered a significant enhancement in the mid-energy dynamic susceptibility, suggesting that these dense magnetic fluctuations may be intimately linked to the pairing mechanism for high-temperature superconductivity.

Reference

Chen, L. et al. Preprint at https://doi.org/10.48550/arXiv.2605.03448 (2026).