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## Coherent x-ray studies of spontaneous fluctuations in rare earth nickelates

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Rare-earth nickelates ( $\text{RNiO}_3$ ) exhibit a rich interplay of electronic, magnetic, and structural phase transitions, including a metal-to-insulator transition (MIT), charge ordering, and a symmetry change from orthorhombic to monoclinic structure [1]. While these transitions have been widely studied, the spatio-temporal nature of spontaneous fluctuations across the phase boundary remains largely unexplored. Such fluctuations are increasingly recognized as crucial for stabilizing emergent magnetic textures and for enabling stochastic functionality in neuromorphic computing. Here, we employ X-ray photon correlation spectroscopy (XPCS) [2-3] to directly probe the dynamics of structural and magnetic fluctuations in epitaxial thin films of  $\text{NdNiO}_3$  and  $\text{SmNiO}_3$ . For  $\text{NdNiO}_3$ , we observe a pronounced slowdown in fluctuation timescales—by an order of magnitude—near the Néel temperature, highlighting strong coupling between structural and magnetic order parameters, independent of epitaxial strain. In contrast,  $\text{SmNiO}_3$  shows no such slowdown, emphasizing the distinct dynamics. Unexpectedly, wavevector-dependent measurements reveal that short-range structural fluctuations are significantly slower (by a factor of 3–5) than long-range fluctuations [4]. Our results demonstrate the power of coherent X-ray techniques in capturing nanoscale fluctuation dynamics in quantum materials and provide new insight into the role of fluctuations near phase transitions in complex oxides.

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2. Sinha S. K., Jiang Z., Lurio L.B. X-ray photon correlation spectroscopy studies of surfaces and thin films. *Advanced Materials* 26, 7764 (2014)
3. Shpyrko O.G. X-ray photon correlation spectroscopy. *Journal of Synchrotron Radiation* 21, 1057 (2014)
4. Zhou Hagstroem, N. et al. Critical slowdown of spontaneous fluctuations in the vicinity of metal-insulator transition in rare earth nickelates, in review (2025).

**Presenter:** KUKREJA, Roopali**Session Classification:** Talks Tuesday Morning