Canadian Association of Physicists
Association canadienne des physiciens et physiciennes

Contribution ID: **170** Type: **Poster (Non-Student) / Affiche (Non-étudiant(e))**

(POS-13) Resonant Soft X-ray Scattering and Reflectometry for Quantum Materials at the REIXS beamline

Tuesday 10 June 2025 18:06 (2 minutes)

Resonant soft x-ray scattering (RSXS) has established itself to be one of the most powerful techniques for studying complex electronic ordering phenomena in quantum materials. Different from conventional x-ray scattering, RSXS merges diffraction methods and x-ray absorption spectroscopy, providing not only a unique elemental, site, and valence specificity, but also an enhanced sensitivity to spatial modulations of charge, spin, and orbital degrees of freedom at nanoscopic length scales. With such exceptional capabilities, the interest in exploiting this technique on 3d transition metals and 4f rare earth compounds has been intensified during the recent decades. Prominent examples are incommensurate charge density waves in cuprate superconductors, spin and orbital ordering in colossal magneto-resistive manganite, as well as orbital reconstruction at the interface of oxide heterostructures using resonant x-ray reflectometry (RXR). Here we will highlight a few recent scientific outcomes from the RSXS endstation [1] at the Resonant Elastic and Inelastic X-ray Scattering (REIXS) beamline. In the first case, a new class of material, an infinite-layer nickelate superconductor has spurred much attention in particular after the charge ordering was reported to exist in its parent compounds. By virtue of an energy-resolved Silicon drift detector, the substantial oxygen fluorescence background could be separated out, confirming a clear absence of the charge ordering in the pristine $NdNiO_2$. For the partially reduced $NdNiO_2$, the ordering has instead been linked to the structural modulation consisting of oxygen deficiencies [2]. Next, the RSXS study on the lanthanum-based cuprates under a uniaxial pressure will be shown. Here the asymmetric response of charge ordering parallel versus perpendicular to the applied uniaxial stress is observed despite the lack of significant change of the onset transition temperature of the orderings [3]. Lastly, electronic reconstructions at the complex oxide $LaAlO_3/SrTiO_3$ interface have been revisited using RXR. By eliminating the extrinsic factor of oxygen vacancies, the existence of the half charge at a confined reconstructed interface is elucidated. This is fully consistent with the theory of polar catastrophe [4].
[1] D. Hawthorn, et al., Rev. Sci. Instrum. 82, 073104 (2011)
[2] C. Parzyck, et al., Nat. Mater 23, 486 (2024)
[3] N. Gupta, et al., PRB 108, L121113 (2023)
[4] R. Green, et al., Phys. Rev. Mater. 5, 065004 (2021)

Keyword-1

Resonant soft x-ray scattering

Keyword-2

Quantum materials

Keyword-3

Resonant x-ray reflectometry

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Session Classification: DCMMP Poster Session & Student Poster Competition | Session d'affiches DPMCM et concours d'affiches étudiantes (13)

Track Classification: Technical Sessions / Sessions techniques: Condensed Matter and Materials Physics / Physique de la matière condensée et matériaux (DCMMP-DPMCM)