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Probing intertwined electronic instabilities in superconducting Ruddlesden-Popper nickelates through chemical and structural tailoring

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Ruddlesden-Popper nickelates have recently emerged as a compelling system for exploring unconventional superconductivity and intertwined electronic and magnetic orders. Ongoing studies aim to map out spin density wave (SDW), charge density wave (CDW), and superconducting phases across different compositions and structural motifs. By tailoring the chemical composition and tuning structural features through external parameters such as temperature and pressure, it becomes possible to influence the balance between these competing ordering phenomena. We present an overview of the current state of research on these systems, with particular emphasis on the role of chemical substitution influence over the structural transformations and the evolution of SDW, CDW, and superconducting phases. We address future directions that may help uncover the mechanisms driving superconductivity in these complex oxide systems. The exploration of novel chemical variants and their associated magnetic structures is outlined together with current limitations in synthesis and characterization, with the goal of clarifying the superconductivity mechanisms and their interplay with competing orders.