Highlights

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Zigzag and Checkerboard Magnetic Patterns in Orbitally Directional Double-Exchange Systems

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The formation of spin-charge density modulations is strongly related to the orbital character of the electronic system as demonstrated by the dominant role of lattice distortions in itinerant e_g systems compared with the spin-orbital exchanges in models of insulating t_{2g} electrons. More unexplored is the case of partially localized t_{2g} electrons in systems with low dimensionality and competing magnetic correlations. In this context, new phenomena have recently been observed and investigated in hybrid oxides with partial substitution of inequivalent transition metal ions.

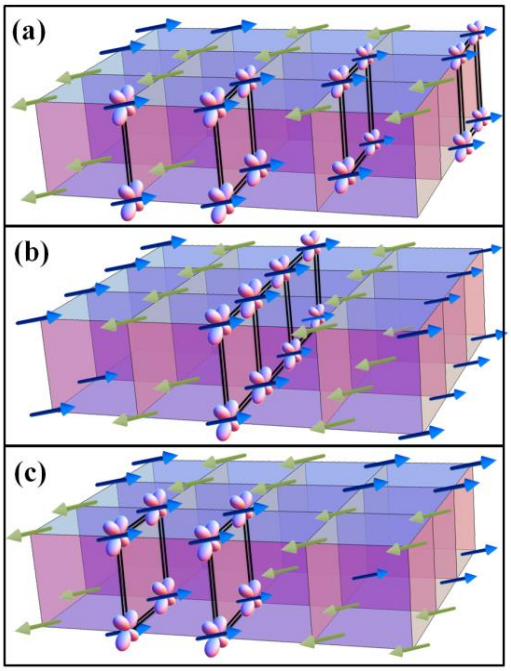

Figure: Schematic view of layered t_{2g} systems with $d_{xz\text{-}yz}$ itinerant degrees of freedom and different antiferromagnetic and orbital patterns: (a) two-site segment zigzag (E phase), (b) straight stripes, and (c) 2 × 2- cell checkerboard.

We analyze a t_{2g} double-exchange (DE) system where the orbital directionality of the itinerant degrees of freedom is a key dynamical feature that self-adjusts in response to doping and leads to a phase diagram dominated by two classes of ground states with zigzag and checkerboard patterns.

The DE mechanism is known to be at the origin of itinerant ferromagnetism in e_g systems and to yield exotic magnetic structures and quantum states based on electronic self-organization. In the orbitally directional DE system, we show that the prevalence of distinct quantum orderings (Figure) is tied to the formation of orbital molecules that in one-dimensional paths make insulating zigzag states kinetically more favorable than metallic stripes, thus allowing for a novel doping-induced metal-to-insulator transition. We demonstrate how the breaking of the orbital directionality as well as the inclusion of the Coulomb interaction can significantly affect the zigzag-checkerboard competition and lead to orbital or charge ordering in the ground state.