Entanglement in Doped Spin-Orbital Mott Insulators: Orbital or Charge Dilution versus Spin-Orbital Polarons

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Spin-orbital entanglement [1] occurs when spin and orbital correlations cannot be factorized and one has to go beyond mean field factorization of the ground or excited states. We show that spin-orbital entanglement is induced on superexchange bonds by Ising spin-orbit coupling when either spin or orbital quantum fluctuations are finite [2]. The interplay of spin and orbital degrees of freedom is very well visible in the spectral properties of a charge (hole) injected into the spin-orbital system and provides a potentially simple experimental method of investigating the character of orbital order in the system [3]. Spin–orbital fluctuations weaken orbital order particularly in transition metal oxides with t_{2g} orbital degrees of freedom $\{c,a,b\} \equiv \{xy,yz,zx\}$ and provide novel mechanism of ferromagnetic spin coupling by $\{a,b\}$ orbital fluctuations. Here we compare two kinds of doping by charged defects in t_{2g} orbital systems and present various mechanisms of destabilizing orbital order. Substitutional doping of Ru(d^4)–systems by $3d^3$ ions results in orbital dilution and the exchange on hybrid d^4-d^3 bonds modifies locally (or globally) spin–orbital order [4]. Subtle effects may be also induced by the lattice. For instance, the structure of the d^3-d^4 spin–orbital coupling in the presence of octahedral rotations favors a distinct type of orbital polarization pointing towards the impurity and outside the impurity–host plane [5]. In contrast, doping by d^2 transition metal ions yields charge dilution and topological phases in the orbital model [6]. Finally, each charged (Sr,Ca) defect replacing R ion in R_{1-x}(Ca,Sr)$_x$VO$_3$ (R=La,Y) generates a spin–orbital polaron in the defect cube. We show that $\{a,b,c\}$ orbital rotations are then induced—they disturb orbital order near the charged defect and a doped hole [7]. As a result, the collapse of G-type orbital order occurs but C-AF spin order stays robust under increasing doping.

References:

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