Lattice complexity and Fano resonances near a Lifshitz Transition in strongly correlated systems

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While new functional doped magnetic materials are developed and used in modern nanotechnology the physics of these complex systems is object of active discussions. The multi-scale lattice and electronic complexity from nanoscale to mesoscale in these systems [1,2] pushes the fundamental physics of these systems beyond the solid state physics of XX century using simple models based on single band and rigid band approximations.

Here we show that the physics of all known doped magnetic systems showing high temperature superconductivity is characterized by a dome of Tc controlled by tuning the chemical potential near Lifshitz transitions in strongly correlated multi orbitals systems by adding dopants, pressure, strain, and charge density [3-6]. A major step in the field has been the development of the theory of superconductivity of two components scenarios [7] and in particular of the scenario with coexisting a narrow band and a wide band near a Lifshitz transition [8,9]. The physics is getting very complex because of frustrated phase separation occurring at the Lifshitz transitions in strongly correlated magnetic systems [10]. This very complex lattice scenario has been observed by using scanning micro x-ray diffraction [2] and using the EXAFS method [11] in cuprates single crystals [12], and iron chacogenides [13]. Finally we discuss the emerging role of Fano resonances in p-terphenyl [9] and the complex hyperbolic space for the percolation pathways promoting the emergence of quantum coherence at high temperature [2].

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