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Halide perovskite artificial solids as a new platform to simulate collective phenomena in doped Mott insulators

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Finding novel artificial platforms where to test in a controllable and tunable way the complex manifestation of many-body physics in Correlated Quantum Materials is one of the great challenges of condensed matter physics. The strong electronic interactions give rise to many exotic phenomena, such as high-temperature superconductivity, insulator-to-metal transitions (IMT), multiferroicity. The richness and technological potential of this class of materials is however counterbalanced by an inherent complexity originating from the strong intertwining of electron, lattice and spin degrees of freedom. Consequently, in the last years condensed matter physics focused on the development of simpler artificial platforms, referred to as Quantum Simulators, that contain the same physical ingredients as the relevant ones of real materials, but in a controlled and tunable framework. The paradigm of quantum simulations has been pioneered by the development of ultracold-atoms systems and extended to solid state systems through twisted bidimensional materials.

Here we present lead halide perovskite quantum dots superlattices as a novel platform for simulating strongly correlated materials. These nanostructures host quantum confined excitons and can self-organize into highly ordered three-dimensional superlattices, resulting in the possibility of creating large-scale artificial solids, whose properties, such as lattice parameters, hopping, excitonic energies and symmetry of the unit cell, can be tuned by chemical means. The emergence of cooperative phenomena and excitonic Mott transition makes these systems suitable to mimic the physics of quantum correlated materials. By employing resonant-pumping ultrafast optical spectroscopy, we show that ultrashort laser pulses can be used to access on demand phases of matter ranging from superradiant states to Mott insulating and metallic phases. The emergence of cooperative phenomena close to the transition to a metallic-like phase suggests that perovskite superlattices can be employed to map phenomena such as superconductivity and charge ordering in doped Mott insulators.

PhD Seminar

8th February 2023
Sala Riunioni S5, 16.40
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