Abstract

Studio sperimentale di nanocristalli di perovskite $CsPbBr_3$ come emettitori di fotoni unici

Experimental study of $CsPbBr_3$ perovskite nanocrystals as single photon emitters

Single photon sources are essential building blocks of quantum information science, including quantum cryptography, quantum communications, quantum computing and quantum metrology. Indeed photons, for their quantum-mechanical properties, have been early identified as natural carriers of quantum information and good candidates for these quantum technologies applications. There are a variety of system that have been investigated for use as on-demand sources of single photons, such as single atoms and ions, single molecules, color centers in diamonds and semiconductor quantum dots. In the last few years, the interest in perovskites - originally studied for solar-cell applications - has rapidly increased in the quantum optics community for their attractive optical and quantum properties. Indeed lead halide perovskite nanocrystals appear to be promising versatile nano-objects for quantum applications: they enable to obtain efficient single photon emission at low and room temperature with the possibility to tune their emission wavelength playing on their size and composition. Moreover, they are easily synthesized by low-cost, well mastered wet-chemistry techniques. Despite these interesting properties, photo-stability remains a significant challenge for their practical applications.

In this thesis I present a full study of the optical and quantum properties of highly efficient and photostable $CsPbBr_3$ perovskite nanocubes, synthesized with an established method - used for the first time to produce quantum emitters - which ensures an increased photo-stability. Properties like photo-luminescence spectra, photo-stability, lifetime and polarization are systematically assessed for each emitter of a large sample. Moreover, I investigate the role of the dilution on the stability and I present a deep analysis of the photoluminescence fluctuations (blinking) and of the emission of non classical states of light. These phenomena are carefully discussed, as well as the experimental tools and methods used for their characterization, showing that our emitters exhibit reduced blinking together with a strong photon antibunching. In particular I highlight the crucial role of the charge confinement on the quantum properties. Finally, for the first time with such kind of emitters, we achieve the coupling of a single perovskite nanocrystal with a tapered optical nanofiber, fabricated by heating and pulling a standard single mode fiber in order to reduce its diameter up to some hundreds of nanometers. This results in a strong evanescent field around the nanofiber, which enables the light emitted by the nanocrystal placed on the nanofiber to be coupled to the guided mode. This achievement is a promising step towards the realization of a compact integrated single photon device at room temperature with perovskite nanoemitters.

Candidato: Marianna D'Amato
Relatore: Prof. Alberto Bramati
Correlatore: Prof. Francesco Marin