

## Ph.D. Course in Materials Science and Nanotechnology

University of Milano-Bicocca, Department of Materials Science, via Cozzi 55, 20125 Milano

**May 21, 2018 – 11.30 a.m.**

**Seminar room - Department of Materials Science U5**

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## Tuning optical and magnetic properties of PbS colloidal quantum dots by doping with Mn<sup>2+</sup> transition metal ions

The controlled incorporation of magnetic dopants in quantum dots (QDs) is a challenging research field with potential for numerous applications in Nanotechnology, including quantum information processing and energy conversion. Of particular interest is the incorporation of 3d transition metal ions (Mn, Co, etc...) whose *d*-shell electronic configurations imprint the nanocrystal with functional magnetic and optical properties.

We report on the optical and magnetic properties of Mn ions doped into colloidal PbS QDs. We observe a blue-shift of the photoluminescence (PL) and a decrease of the exciton *g*-factor upon increasing the Mn content, thus suggesting tunability of the dopant-carrier *s,p-d* exchange interaction.

For singly doped QDs, electron spin resonance (ESR) studies reveal the six hyperfine lines of isolated <sup>55</sup>Mn<sup>2+</sup> ions. Long phase memory times ( $T_M \sim 10 \mu s$  at 5 K) up to near room temperature ( $T_M \sim 1 \mu s$  at 260K) were detected by pulsed-ESR methods after minimization of the major sources of decoherence. Finally, we use electron double resonance methods to detect the full Mn<sup>2+</sup> NMR spectrum and to drive Rabi oscillations implementing NOT and SWAP universal quantum gates.

In conclusion, Mn<sup>2+</sup> ions provide a means for tuning the optical and magnetic properties of QDs and represent a multi-level quantum bit system, *i.e.* a *qudit*, beyond traditional spin-*qubits* in QDs, for quantum computing application, whose states can be detected, coherently manipulated and potentially optically read-out via the *sp-d* interaction.

PhD students and all interested in the seminar are kindly invited to participate.

The PhD Coordinator  
Prof. Marco Bernasconi