International Doctoral Program in Science Position

Study of Cooperative Optical Phenomena in Artificial Solids of Nanocrystalline Metal Halides

Background and motivation

Light-emitting nanocrystals of metal halides provide an opportunity to engineer artificial solids with a cooperative emission. Such solids, known as colloidal nanocrystal superlattices, are a promising platform for applications in quantum photonics and information science. The project will address two important aspects of colloidal nanocrystal superlattices and light emission in them.

First, there is a need to discover single- and multi-component nanocrystal solids made of recent generations of colloidal nanocrystals that include (but are not limited to) lead halide perovskites, lead-free double perovskites, and lead chalcohalides. Despite rapid progress in synthesis and optimization of such nanocrystals, little is known about the diversity of colloidal superlattices that they can form.

Second, there is a need to investigate the cooperative response of such superlattices upon interaction with optical excitation. For example, there are preliminary indications that pulsed laser excitation of cesium lead bromide nanocrystals produces intensity-dependent oscillations and acceleration of radiative decay. Such response could be indicative of cooperative effects, whether that is the case is not well understood.

In the present project we will combine state-of-the-art facilities in the partner institutions. The synthesis and characterization of the colloidal superlattices will be carried out at the Italian Institute of Technology (IIT) in Genova (supervisors: prof. Liberato Manna and Dr. Dmitry Baranov). The investigation of collective and cooperative phenomena in colloidal superlattices will be carried out in collaboration with the group of prof. Claudio Giannetti at Università Cattolica (UCSC) in Brescia and in collaboration with the group of prof. Masaru Kuno at Notre Dame University (ND). A specific multidimensional optical spectroscopy setup will be developed @UCSC to investigate the decoherence dynamics of optical excitons and hunt for evidence of changes in the ultrafast decoherence driven by cooperative phenomena.

The main goals of the project are:

• Synthesis and characterization of novel colloidal superlattices

• Investigation of collective and cooperative phenomena in colloidal superlattices excited by tunable ultrafast light pulses in the weak and strong excitation regimes to manage cooperative absorption and emission on ultrafast timescales

Profile

- Master's degree or comparable qualification in Physics, Materials Science or Chemistry. The title must be obtained before OCTOBER 31ST 2021.
- A strong interest for multidisciplinary research is required.
- Candidates should have a solid background in Chemistry, Materials Science or Physics.
- Good knowledge of the English language, both spoken and written, is essential.
- Strong commitment, ability to work in a team, and eagerness for international mobility is desired.

Opportunities

- Experimental research participating to the international collaboration between IIT, ND, and UCSC, with at least one year spent at ND.
- **Double degree opportunity (European title from UCSC and American title from ND).**
- **The fellowship co-financed by IIT and UCSC amounts to 1500 euros/month net.**

Supervisors

- Prof. Liberato Manna (IIT) Italy, Liberato.Manna@iit.it
- Dr. Dmitry Baranov (IIT) Italy, Dmitry.baranov@iit.it
- Prof. Masaru Kuno (ND) USA, mkuno@nd.edu
- Prof. Claudio Giannetti (UCSC) Italy, claudio.giannetti@unicatt.it

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