MAP-fis Essay Proposal, 2013-2014

(*please write in English*)

Supervisor

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Title

Experimental methods to study energy transfer between quantum nanodots

Area

(*Materials, Optics, Condensed Theory, High Energy Theory,....*);

Optics and materials science

Summary of Proposal

Inspiring work from several groups has explored how the process of resonant energy transfer (FRET) between molecules or artificial nanostructures can be influenced by the particular characteristics of the local environment. While quite a lot is known about energy transfer processes in supramolecular systems, the situation concerning nanoscale analogs is less well explored. One intriguing possibility, which preliminary experiments seem to confirm, is that colloidal quantum dots can be assembled into complex mesoscopic structures which facilitate significant energy transfer over distances much longer than those usually associated with molecular FRET.

In a related theme, recent theoretical work [1,2] has indicated that it should be possible to harness plasmonic resonances in graphene to enhance resonant energy transfer between donor and acceptor molecules placed in close proximity to single layer graphene sheets by several orders of magnitude. Recent experimental advances have demonstrated the selective transfer of patterned graphene onto chosen targets using a bilayer polymer structure and femtosecond laser micro-fabrication techniques [3]. This opens up the possibility of creating tailored hybrid graphene plasmonic structures for targeted applications.

One of the main difficulties in these experiments is the lack of sufficient spatial or spectral resolution to follow the long range transfer of excitation amongst the assembly of quantum dots. Since the dots in these structures are randomly orientated and somewhat heterogeneous, the excitonic fine structure is usually obscured by inhomogeneous line broadening mechanisms. However, ultrafast time resolved nonlinear spectroscopic techniques could potentially provide the means to follow the history of the quantum dot exciton states and to examine the relaxation processes among the lowest exciton levels of quantum dots [4]. The aim of this project is to

critically explore the various experimental techniques that might be used to obtain information about the processes leading to long range energy transfer in assemblies of quantum dots.

References

(*to allow students first look at topic*)

[1] “Large enhancement of Forster resonance energy transfer on graphene platforms”, S.-A. Biehs and G. S. Agarwal, Applied Physics Letters, 103, 243112 (2013).

[2] "Long-range plasmon-assisted energy transfer over doped graphene”, K. A. Velizhanin, T. Shahbazyan, *Phys. Rev. B*, **86**, 245432 (2012)

[3] Xu-Dong Chen et al, “The selective transfer of patterned graphene”, SCIENTIFIC REPORTS, 3 : 3216 (2013).

[4] Gregory D. Scholes, Jeongho Kim, & Cathy Y. Wong, “Exciton spin relaxation in quantum dots measured using ultrafast transient polarization grating spectroscopy” Phys. Rev. B (2006) 73, 195325