Single Graphene Quantum dots for Quantum Technologies

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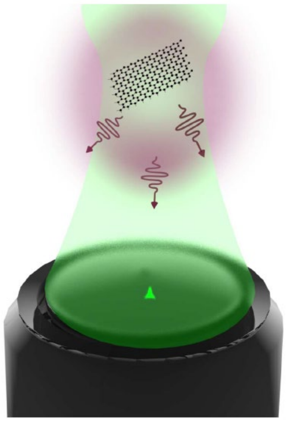

Over the last few years, the development of new single quantum emitters has been a fast-growing field of research since they are key building blocks for a wealth of applications in quantum technologies. In particular, single organic molecules represent a whole section of the development of new technological area [1]. In this context, graphene quantum dots (GQDs) have many assets. The perfect control of their size, symmetry and edge shape, provided by bottom-up synthesis, offers a wide range of tunable properties. The understanding and mastering of these properties will open the way toward Swiss-knife emitters with well-defined functionalities.

Our recent efforts to address the photophysics of GQDs at the single-molecule level [2, 3, 4] were the first essential steps toward this goal. Indeed, we showed first that GQDs are photostable and can be addressed at the single object level. Then, that they are very bright quantum emitters with excellent single-photon purity at room temperature. We recently investigate the interplay of structure (symmetry, size…) and photophysics of large GQDs with high dipole amplitude [5].

The next step forward is to control the GQD's local environment to achieve lifetime limited linewidth at low temperature reaching the emission of indistinguishable photons. In that context, the goal of the internship/PhD is to reach lifetime limited linewidth for single GQDs by embedded them in a proper matrix. Our group has recently developed original molecular crystals and has shown the emission of single GQD embedded in it. The candidate will optimize the fabrication of the crystals and perform single molecule spectroscopy at low temperature. The outcome will be the obtention of an on-demand source of indistinguishable photons at high rate, thus outperforming current molecular systems of quantum optics.

The basis of the second quantum revolution is quantum entanglement. In this context, there are currently efforts to build arrays of coherently coupled solid-state emitters [6, 7]. One key parameter is the strength of the dipole-dipole coupling that depends on the square of the dipole amplitude. In this context, GQDs are promising candidates thanks to their high dipole amplitude. Moreover, in order to be useful, entanglement of electronic states have to survive to decoherence processes. A second part of the internship/thesis will be to use GQDs to build arrays of entangled dipoles.

The candidate will work closely with other PhD students and a post-doc of the group. He/She will be involved in the discussions with collaborators from theory and chemistry syntheses.

References :

[1] C. Toninelli et al, Nature Materials 20, 1615 (2021)
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[5] D. Medina-Lopez et al Nature Com 14, 4728 (2023)
[6] J.-B. Trebbia et al, Nature Communication 13, 2962 (2022)
[7] C. M. Lange et al, Nature Phys. 20, 836–842 (2024)