



Master in Photonics – “PHOTONICS BCN” Master ERASMUS Mundus “EuroPhotonics”

MASTER THESIS PROPOSAL

Starting full time from April 2024

Presentation at the end of July or beginning of September 2024

Laboratory:

Institution: Universitat Autònoma Barcelona

City, Country: Barcelona

Title of the master thesis: Quantum simulators and Hamiltonian complexity

Name of the master thesis supervisor and co-supervisor: Anna Sanpera

(for external proposals a co-supervisor from the Master program and a collaboration agreement is needed)

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Keywords: quantum simulators, quantum dots, graphene

Summary of the subject (maximum 1 page):

The motivation of this master thesis is to exploit the effects produced by nano-mechanical systems, like e.g., suspended nano-carbon tubes, on particle-particle interactions, in particular, mimicking electron-phonon interactions and exploiting polaron (polariton) physics. Such systems have been analyzed for different purposes before, ranging from mimicking a qubit, to analyzing thermodynamics properties. As a case study, we are going to extend previous analysis of quantum dots interacting with graphene nanotubes. Our work is inspired by two previous articles, Phonon induced pairing in quantum dot quantum simulators[1] and its posterior extension Steady-state Peierls transition in nanotube quantum simulator by the same group [4]. Our study, however, incorporates independent nanotubes and opens a new phase diagram that has as a limit the previous ones. The master thesis comprises several aspects:

1. Derivation of the Hamiltonian describing the interactions between different quantum dots (electrons) in carbon



nanotubes

2. - Analytical resolution of the Hamiltonian doing the Lars-Firsov approximation
3. - Interpretation and extension of the results to 2 graphene nanotubes
4. Exact numerical resolution of the Hamiltonian ground state by diagonalization

Objectives:

Learn different physics that can be obtained in quantum simulators and apply concepts developed in the course.

Additional information (if needed):

- * Required skills: analytical and numerical skills
- * Miscellaneous: