

3rd Year Report

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This is a short report on my PhD work of under the joint MAP-fis Doctoral Program in Computer Science of the universities of Minho, Aveiro, and Porto. My PhD is under the supervision of Prof. Ernesto Galvão (International Iberian Nanotechnology Laboratory - INL) and Prof. Nuno Cavaco Reis Peres (Departamento de Física, Universidade do Minho). I have successfully completed the following courses in the MAP-fis graduate programme:

- Tópicos de Física Teórica
- Empreendedorismo
- Comunicação.

In my first year I worked on excitonic effects on optical response of two-dimensional materials. As a result of this investigation, together with several other authors, I was able to publish an article on the IOP Journal of Physics: Condensed Matter <https://doi.org/10.1088/1361-648X/ab47b3>.

In the second year, due to financial reasons related to the availability of research scholarships, I changed the subject of my research to quantum information and started a project called “Understanding and overcoming limitations of linear-optical quantum computation”.

Concerning the research goals, I have learned the basic concepts of my research topic, studying the description of linear-optical circuits, and implementing high-performance software code in Julia for simulation of Fock states evolving in linear interferometers. This permitted us to start investigating some of the questions associated with the research project. In particular, we have described various figures of merit for bosonic bunching in these interferometers, describing families of interferometers that have extreme behavior (either the most bunching, or the smallest bunching effect with respect to the classical particle behavior). I have also been numerically investigating post-selected linear-optical simulations of non-linear photon-photon interaction Hamiltonians, in particular the single-mode non-linear phase gate. These simulations have a curious behavior, with non-monotonic behavior of the probability of success, as a function of the parameters describing the non-linear gate. We hope this research will develop into more comprehensive and mature results, which may be suitable for publication. Lately, I have been studying the application of post selection to the generation of Bell states.

I have also presented the progress of my PhD work in the MAP-FIS annual conference in 9th of July 2021. I have been an active participant in the

Quantum and Linear-Optical Computation (QLOC) group meetings and seminars over this last year. My training has been supplemented by attendance of the following conferences: 24th Annual Conference on Quantum Information Processing, Technical University of Munich 1st - 5th of February 2021. Quantum Colloquium, University of California Berkeley, Ongoing