



## MASTER IN PHOTONICS – “PHOTONICS BCN” ERASMUS+ “EUROPHOTONICS-POESII”

### MASTER THESIS PROPOSAL

**Dates: April - September 2018**

**Laboratory : Departament de Física Quàntica i Astrofísica**  
**Institution: Universitat de Barcelona**  
**City, Country : Barcelona, Spain**

**Title of the master thesis: Transfer of vortex states between two coupled atomtronic circuits**

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**Keywords :** Bose-Einstein condensates, ultracold atoms, atomtronics

### **Summary of the subject (maximum 1 page) :**

Atomtronics is an emergent field of research which aims to produce quantum circuits using ultracold atoms [1] as analogues of electronic circuits and devices. Recent experimental advances in the field of ultracold atoms have shown the large control and tunability of these quantum systems trapped in few sites of an optical lattice [2]. An interesting confinement for our purposes are closed periodic geometries that can exhibit persistent currents or vortex states with quantized circulation [3,4].

In this work, we aim to study the transfer of ultracold bosons between two coupled Bose-Hubbard rings connected by only one link [5] to get insight the coupling of minimal atomtronic circuits. We will characterize the system by solving the corresponding Bose-Hubbard Hamiltonian. We will study the single-particle as well as the many-body ground state in presence of repulsive interactions. In particular, we will investigate the static properties of the ground state by means of coherence, correlations and entanglement. Finally, we will investigate the transfer of vortex states between the two coupled rings as a function of the inter-ring coupling.

- [1] L. Amico et al., New J. Phys. **19**, 020201 (2017).  
[2] C. Gross et al, Nature **464**, 1165 (2010); A. N. Wenz et al., Science **342**, 457 (2013); R. Islam et al, Nature **528**, 77-83 (2015); S. Murmann et al, Phys. Rev. Lett. **114**, 080402 (2015).  
[3] D. Aghamalyan et al, New J. Phys. **17**, 045023 (2015).  
[4] A. Gallemí, M. Guilleumas, J. Martorell, R. Mayol, A. Polls, and B. Juliá-Díaz, New J. Phys. **17**, 073014 (2015).  
[5] M. R. Sturm, M. Schlosse, R. Walse, and G. Birkl, Phys. Rev. A **95**, 063625 (2017).

**Additional information :**

\* Required skills : Basics of quantum mechanics, many-body quantum mechanics and programming skills.

\* Miscellaneous :