



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

MASTER THESIS PROPOSAL

Full time from April 2026 (or part time from February 2026)
Presentation date to be chosen: end of July or beginning of September 2026

Laboratory: Atomic Quantum Science Lab (UB)
Institution: Physics Faculty, Universitat de Barcelona
City, Country: Barcelona, Spain

Title of the master thesis: Quantum Optics with an Atomic Vapor

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Keywords: Atomic physics, quantum optics, laser spectroscopy

1. Summary of the subject:

The **interactions between light and matter** are key for understanding many fundamental phenomena as well as to harness them for practical applications. Quantum mechanics can introduce unintuitive effects that emerge when one considers few quantum states interacting with driving fields. A very neat example in quantum optics is *Electromagnetically Induced Transparency*¹ (EIT), a phenomenon that has been studied extensively in many different platforms.

In EIT, an opaque atomic medium can become transparent to a probe laser when a second control laser couples another transition in a three-level atomic system. This transparency effect arises from quantum interference between excitation pathways, which effectively cancel the absorption at a particular frequency. Besides its fundamental interest, EIT has also found vast applications, such as in laser cooling, quantum metrology or quantum memories.

In this master project, you will be able to explore the physics of EIT by **driving a gas of rubidium atoms with resonant laser light** at 795 nm. The setup, which is part of the *Advanced Quantum Physics Lab* at UB, can be used to isolate an atomic lambda-like level system and realize EIT by driving two laser frequencies simultaneously. In addition, this same setup could be extended to

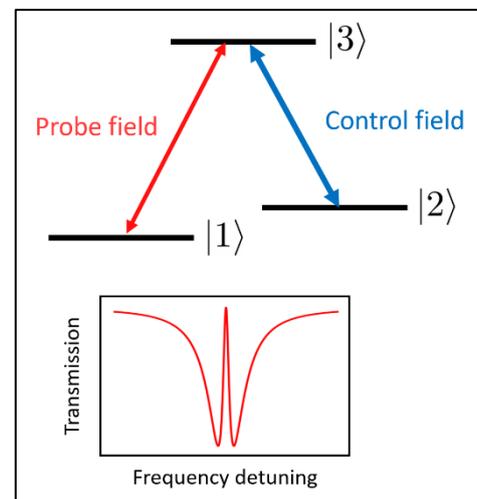


Figure 1 Schematic concept of EIT in a lambda-type system.

realize "slow light", in which the speed of light can be significantly reduced while propagating through the EIT medium. The experimental setup as a whole offers a unique combination of atomic and photonics tools (narrow-linewidth lasers, acousto-optic modulators, vapor cells...), which makes for a great introduction to the field of cold atoms.

You can get more insight into the project by watching the following "Quantum Spain" videos that we recorded at the Universitat de Barcelona:

<https://www.youtube.com/watch?v=ZRnoK2m-a04>
<https://www.youtube.com/watch?v=OVIwu10N5IM>

[1] R. Finkelstein et al. 2023 New J. Physics 25 035001 (2023)

2. Objectives:

The exact goals of the project will be determined according to the interests and skills of the applicant, but a suggestive list includes:

- Characterize, understand and optimize a rubidium-based EIT setup.
- Obtain numerical results for a 3-level quantum system and compare them to the experimental results.
- Explore the feasibility (and potential realization) of detecting slow light by upgrading the existing setup.

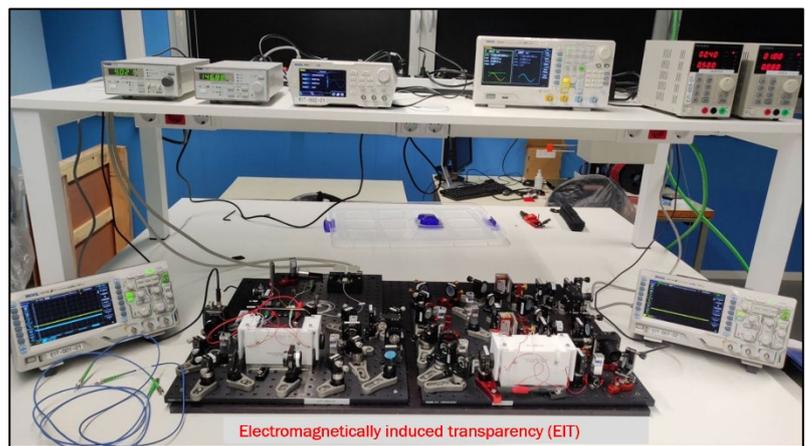


Figure 2 EIT setup at the Universitat de Barcelona. The module includes one laser source at 795 nm and two vapor cells of rubidium for spectroscopy.

Additional information:

* Advised skills (not mandatory):

- Undergrad knowledge of atomic and quantum physics.
- Experience in experimental physics, ideally in photonics.
- Experience with electronics or mechanical design.

* Miscellaneous:

The Master project, which will take place at UB, will be aligned with the activities ManboQu team (<https://manboqu.fqa.ub.edu>) and the QComms Lab (<https://quantumcomms.fqa.ub.edu/>).

Opportunities for fellowships might be available through the Màster+UB program.