



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

MASTER THESIS PROPOSAL

Dates: April - September 2019

Laboratory : Mitchell group (Quantum optics, ultracold atoms, quantum sensors)

Institution: ICFO

City, Country : Barcelona, SPAIN

Title of the master thesis: Quantum Control of a Spinor Bose-Einstein Condensate.

Name of the master thesis supervisor: Morgan W. Mitchell

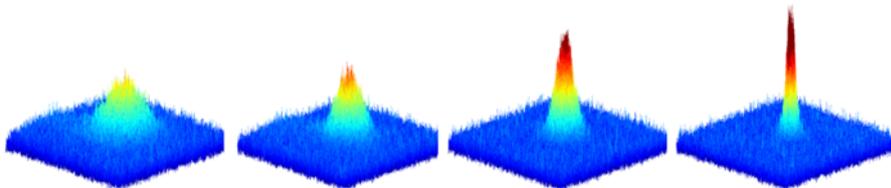
Email address : morgan.mitchell@icfo.eu

Phone number : +34 93 553 4107

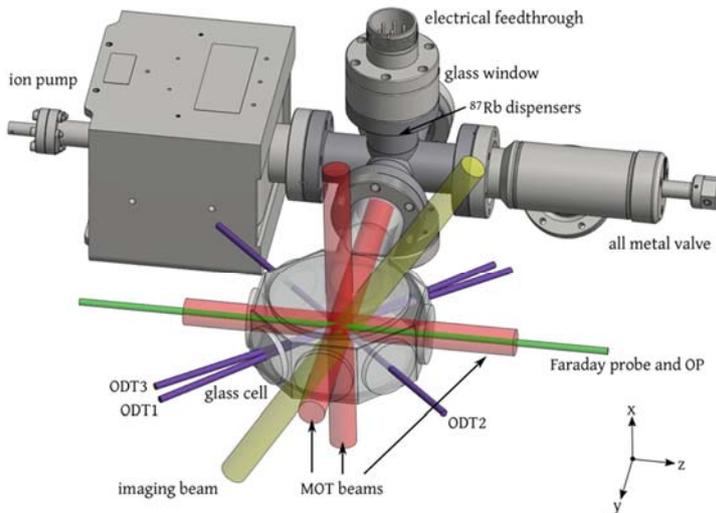
Mail address : ICFO / Av. Carl Friedrich Gauss, 3 / Mediterranean Technology Park / Castelldefels (Barcelona) / 08860 SPAIN

Keywords : Quantum optics, atomic physics

Summary of the subject (maximum 1 page) :



A spinor Bose-Einstein condensate (SBEC) is an ultra-cold gas of atoms with a spin degree of freedom, leading to simultaneous magnetic and superfluid behaviour. In our SBEC, which is ^{87}Rb in the $F=1$ ground state, the magnetic interaction is ferromagnetic, giving a ferromagnetic superfluid. Such a material is extremely sensitive to magnetic fields, and displays a range of unusual behaviours.



One of the extraordinary opportunities of BEC physics is the potential to create “squeezed states” with uncertainty below the shot noise level. These are both valuable to sensing applications, and are an important method to measure entanglement in the BEC. Strong squeezing of the magnetic degrees of freedom is predicted for our system, but until now has not been observed, because of variations in the laboratory magnetic field. We propose a way to observe this squeezing using non-destructive measurement and feedback.

The master project will implement real-time control of the SBEC using non-destructive Faraday probing and control of the global spin via RF manipulation. The main technical work will be to understand the existing capabilities for Faraday rotation measurements, and for RF manipulation, and to “close the loop” using real-time electronics in the form of a microcontroller. If successful, the project will enable us to observe squeezed states in our spinor BEC machine, and also provide interesting insights into quantum control and real-time programming.

Additional information: contact us with any questions.

* Required skills: Strong motivation, interest in ultracold quantum systems, and fast digital electronics, coursework in quantum optics and atomic physics. Experience with lasers and analogue or RF electronics is desirable.

* Miscellaneous