Spécialité de Master « Optique, Matière, Paris »

Stage de recherche (4 mois minimum, à partir de début mars)

Proposition de stage

Date de la proposition : 5 octobre 2016

Responsable du stage / *internship supervisor*:

Nom / *name* : **Pierre-Jean NACHER et Geneviève TASTEVIN**

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Nom du Laboratoire / *laboratory name*:

Code d'identification : UMR 8552 Organisme : ENS, CNRS, UPMC (Paris 6), Collège de France

Site Internet / *web site*: http://www.lkb.science/polarisedhelium/

Adresse / *address:* **Laboratoire Kastler Brossel**, Dep^{t} de Physique de l'ENS, 24 rue Lhomond, 75005 Paris

Lieu du stage / *internship place*: ENS Lhomond, 1er étage, pièce L166

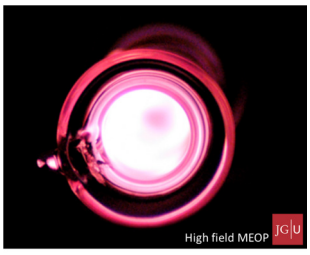
Titre / *title*: **Collision-induced excitation transfer between 2^3P sublevels in ^3He gas**

Context - In a helium plasma, a variety of excited states can be populated by electronic impact. The weak rf discharges used for He optical pumping, OP, typically promote a small fraction of the atoms to the metastable 2^3S state. A cw 1083 nm laser is used to drive fast OP cycles on the electronic 2^3S-2^3P transition (i.e., selective excitation of Zeeman magnetic sublevels by circularly polarized light and random de-excitation by spontaneous emission), which yields a net polarisation in the 2^3S state. When ^3He is involved, OP yields a very high polarisation of the nuclear spin (I=1/2), both for the minority metastable atoms (thanks to strong hyperfine coupling in the 2^3S state) and for the majority ground state atoms (thanks to metastability exchange, ME, a binary collisional process in which 2^3S and 1^1S atoms exchange purely electronic excitation and retain their nuclear spin orientations). Current applications of laser-polarised ^3He include: pre-clinical lung MRI, at arbitrary magnetic field strength; spin filters for neutron beams; targets for high energy physics; high resolution magnetometry; tests of fundamental laws; etc.

MEOP is generally performed in the so-called standard conditions (room temperature, low magnetic field, low gas pressure). Our current objective is to understand the origin of the strong enhancement of nuclear spin relaxation, correlated to the 1083 nm excitation, which has been observed in room-T experiments, both at low and high field (a few mT – several T) or pressure (1 – 400 mbar), and to extend our MEOP investigations to cryogenic temperatures.

Internship project - Using tunable laser diodes at 1083 and 706 nm, the student will study the (re)distribution of angular momentum in the 2^3P state. He/she will monitor the time evolution of atomic populations in relevant Zeeman sublevels, during OP.

The internship will provide an opportunity for hands-on experience with OP in sealed gas cells and optical diagnosis in weak RF discharges (light polarisation analysis, absorption and line shape measurements) with visible and infrared solid state lasers.



Read more: http://www.lkb.science/polarisedhelium/polarised-helium-and-quantum-fluids/

PhD work - The primary challenge is to explain the increase of angular momentum loss which has been systematically observed during OP at strong pump power and, ultimately, to find a way to boost up MEOP efficiency. The work will focus on the search for the dominant underlying physical process(es) and for a quantitative description of its (their) contribution(s) to O.P. dynamics. We have already considered the potential impact of, e.g., radiation trapping or laser-enhanced formation of metastable He_2* dimers, and performed the corresponding experimental tests. We now plan a quantitative investigation of the impact of collisional exchange in the 2^3P state, both experimentally and theoretically. This will certainly help improving the predictive numerical models which have been developed for MEOP and have been extensively used, so far, for comparison with room temperature findings.

The experimental investigations, even restricted to operation in standard OP conditions, may require new and complementary diagnoses. The work may also involve comparative studies for various gas pressures, at high and low magnetic field, in pure ^3He or in isotopic ^3He-^4He mixtures. In addition, application to high-sensitivity ^3He magnetometry for high resolution mass spectrometry in ion traps provides new challenges and, based on pioneering LKB work on ^3He OP at low temperature, calls for the development of improved experimental and theoretical tools.

Ce stage pourra-t-il se prolonger en thèse ? *Possibility of a PhD* **? : OUI** *YES*

Si oui, financement de thèse envisagé / *financial support for the PhD***: via l'ED ou contrat /** *To be found.*

Lumière, Matière, Interactions	**X**	Lasers, Optique, Matière	**X**