Spécialité de Master « Optique, Matière, Paris »

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

Proposition de stage

Date de la proposition : 15 octobre 2015

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.ens.fr/-Helium-polarise-et-fluides-

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 L164

Titre du stage / *internship title*: **RF discharges in helium gas: optimisation for optical pumping**

Context - In an helium plasma, a variety of excited states can be populated by electronic impact. The ***RF discharges*** used for He ***optical pumping***, OP, typically promote a small fraction of the atoms to the metastable 2^3S state. Driving OP cycles (selective excitation by circularly polarized light / spontaneous emission) on the 2^3S-2^3P transition at 1083 nm, one can obtain a very high nuclear polarisation in ^{3}He, thanks to metastability exchange, ME (a binary collisional process in which metastable 2^3S atoms and 1^1S ground state atoms exchange electronic-only excitation and retain their nuclear spin orientations). Current applications of laser-polarised ^{3}He 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.

Presently, our main objectives are to optimize the plasma conditions for MEOP in the so-called standard conditions (room temperature, low magnetic field, low gas pressure), to understand the origin of the strong enhancement of nuclear spin relaxation which is due to the 1083 nm excitation and observed both at low and high field or pressure (a few mT – several T, 1 – 400 mbar), and to extend the ongoing study of MEOP in non-standard conditions to the operation at cryogenic temperatures.

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

- Using tunable laser diodes at 1083 and 706 nm, the student will probe the relevant excited species and study the (re)distribution of angular momentum in the 2^3P state during OP.

- The low abundance (a few ppm) of 2^3S atoms is spatially non uniform in the weak RF discharges used for MEOP (< 5 W, < 3 MHz). The student will try and optimise the amount of pump light power absorbed by the gas, which essentially determines the OP rate, without substantial increase of the nuclear spin relaxation rate.

Read more:
http://www.lkb.ens.fr/-Polarisation-de-3He-
http://www.lkb.ens.fr/Sujet-P-O-des-plasmas-d-He

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 efficiently control or neutralise the identified source(s). The work will focus on the search for the underlying physical process(es) and for a quantitative description of its (their) contribution(s) to O.P. dynamics, in order to improve the predictive numerical models developed for MEOP. Experimental investigations with ^{3}He 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 ^{3}He or in isotopic ^{3}He-^{4}He mixtures. Application to high-sensitivity ^{3}He magnetometry for high resolution mass spectrometry in ion traps also provides new challenges and, based on pioneering LKB work on ^{3}He OP at low temperature, the development of improved experimental and theoretical tools.

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

Si oui, financement de thèse envisagé/ *financial support for the PhD***: via l'ED ou contrat (demandé)**

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