

Student research project (Master level)

Proposition de stage Master - Novembre 2016

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Lieu du stage / location: ENS Lhomond building, 1st floor, room L166

Titre / title: Metastable He dimers: spectroscopy at 465 nm

Context – Metastability exchange optical pumping, MEOP, of ^3He is generally performed at room temperature, low pressure, low magnetic field, under weak excitation by a RF discharge. It yields very high nuclear spin polarisations (80 – 90%) with a high efficiency (1 polarised nucleus per absorbed optical photon, typically), thanks to the combination of OP cycles performed on the closed 2^3S - 2^3P transition at 1083 nm (selective excitation by circularly polarized light / de-excitation by spontaneous emission) and of polarisation transfer by metastability exchange collisions (a binary process in which metastable 2^3S atoms and ground state He atoms exchange electronic-only excitation and retain their nuclear spin orientations). Applications of laser-polarised ^3He include pre-clinical [lung MRI](#), spin filters for neutron beams, targets for high energy physics, high resolution magnetometry, etc.

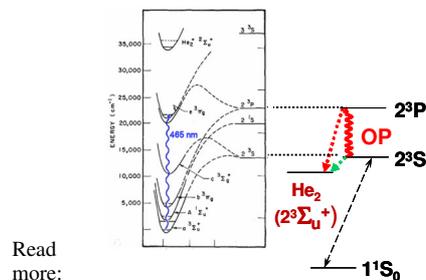
Our recent investigations have focused on the fundamental limits of MEOP and on some of the new challenges introduced by operation in non-standard conditions (high pressure, high field, and/or low temperature). The systematic observation of unexpected, laser-enhanced, polarisation losses during OP has triggered a search for potential source(s) of deleterious contribution(s) to OP dynamics. In particular, a tunable blue laser has been developed for absorption-based monitoring of the abundance of metastable He dimers, He_2^* , in the RF discharge (with and without atomic 2^3S - 2^3P excitation). For absolute number density measurements, detailed knowledge of the rotational structure and of the absorption line shape is needed for the molecular transition probed at 465 nm, $a^3\Sigma_u^+(0)-e^3\Pi_g(0)$.

Internship work – A first series of measurements have been performed in ^3He , ^4He , and isotopic mixtures. The recorded (Doppler- and pressure broadened) spectra provide a clear evidence of underlying (hyper)fine structures for a majority of rotational components.

The objective is to resolve and quantitatively analyse the absorption spectrum of $^3\text{He}_2^*$ and its isotopologues. Experimentally, the linear Zeeman effect may be used to separate and identify out the various lines.

The student will use the available pieces of equipment to build a dedicated set up, perform the measurements, and analyse the compiled data.

The MEOP topic is open for PhD - The primary objective will be to explain the increase of angular momentum loss which has been systematically observed, so far, during OP with strong 2^3S - 2^3P excitation. Ultimately, it is highly desirable to find a way to efficiently control or neutralise the identified source(s) of relaxation in standard and non-standard MEOP conditions. The work will focus on the search for the underlying physical process(es) and for a quantitative description of the corresponding contribution(s) to O.P. dynamics, in order to improve the predictive numerical models developed for MEOP. This may require new and complementary experimental tools and further investigations of ^3He MEOP in standard conditions. The work may also involve comparative studies for various gas pressures, magnetic field strengths, for pure ^3He or isotopic ^3He - ^4He gas mixtures. Application to high-sensitivity ^3He magnetometry for high resolution mass spectrometry in ion traps provides new challenges and the pioneering work performed at LKB on ^3He MEOP at low temperature may deserve to be revisited, with improved experimental and theoretical tools (WideNMR project, 2016-2019).



Read more:

<http://www.lkb.science/polarisedhelium/openings-op/>

Le stage pourra être suivi d'une thèse sur le MEOP – *The MEOP topic is open for PhD.*

Financement de thèse envisagé/ Financial support : **via l'ED ou par contrat (demandé) / To be found.**