Spécialité de Master « Optique, Matière, Plasmas »

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

Proposition de stage

Date de la proposition : 31/10/2014

Responsable du stage / *internship supervisor*: **Maykel Leonardo GONZÁLEZ MARTÍNEZ**

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Lieu du stage / *internship place*: IDRIS, Université Paris-Sud, Bât. 506, Campus d'Orsay, 91405 Orsay

Titre du stage / *internship title*: **Sympathetic cooling of ammonia molecules with ultracold atomic hydrogen**

Résumé / *summary*

There is currently great interest for high-density samples of ultracold molecules, at temperatures of 1 mK and below, which are expected to have many exciting applications [1]. In particular, they can be used as Feynman's "quantum simulators", which will be a significant step towards the solution of long-standing problems in condensed-matter physics and the development of quantum technologies [2].

The most versatile cooling methods to date [3], however, have only been capable of achieving temperatures around 10-500 mK. One of the biggest challenges in the field is thus to develop a *second-stage* cooling technique to transfer these "cold" species into the ultracold regime. We recently showed [4] that thermalization (*i.e.*, *sympathetic cooling*, see Fig. 1) with ultracold H atoms is a *very promising* technique, capable of producing ultracold NH and OH molecules, and F atoms. These species may be *magnetically* trapped and our calculations considered collisions in static magnetic fields.

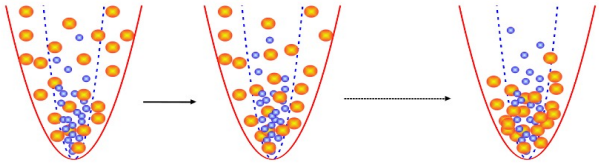

Fig. 1: Schematic representation of the sympathetic cooling of molecules (orange) by H atoms (blue) in a trap.

The goal of this project is to study the prospects of sympathetic cooling of molecules that can only be *electrically* trapped, about which very little is known. We will use ammonia (ND_3) as a prototype, given its importance in both planetary atmospheres and the interstellar medium, and also its role in the development of Stark deceleration [3b] and current interest [6]. The student will learn how to use the MOLSCAT package program [7] to study the scattering properties of $H+ND_3$, and assess the prospects of sympathetic cooling of ammonia molecules. A very important question is whether electric fields will promote inelasticity in collisions with H atoms, thus studying this will be a key objective. The effects of combined electric and magnetic fields will also be investigated. Successful achievement of these goals will lead to publication of the results in a high-impact international journal.

Good knowledge of *Quantum Mechanics,* particularly of *Quantum Scattering Theory,* and of *Atomic and Molecular Physics* is required. Good programming skills (*e.g.*, Fortran, C/C++, Python) are desirable.

[1] LD Carr *et al. New J. Phys.* **11**, 055049 (2009); O Dulieu and C. Gabbanini *Rep. Prog. Phys.* **72**, 086401 (2009)

[2] I Bloch *et al. Nature Phys.* **8**, 267 (2012)

[3] JD Weinstein *et al. Nature (London)* **395**, 148 (1998); HL Bethlem *et al. Nature* (London) **406**, 491 (2000); E Narevicius *et al. New J. Phys.* **9**, 96 (2007); T Rieger *et al. Phys. Rev. Lett.* **95**, 173002 (2005)

[4] ML González-Martínez and JM Hutson *Phys. Rev. Lett.* **111**, 203004 (2013); *ibid, Phys. Rev. A* **88**, 053420 (2013); see http://community.dur.ac.uk/m.l.gonzalez-martinez/files/downloads/2013_mlgm_Granada_H+stuff_poster.pdf

[6] PS Żuchowski and JM Hutson *Phys. Rev. A* **79**, 062708 (2009); L Parazzoli *et al. Phys. Rev. Lett.* **106**, 193201 (2011)

[7] JM Hutson and S Green, MOLSCAT, version 14, CCP6 (Daresbury, UK, 1994); ML González-Martínez and JM Hutson *Phys. Rev. A* **75**, 022702 (2007)

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

Si oui, financement de thèse envisagé/ *financial support for the PhD***: Bourse EDOM**

Lasers, Optique, Matière	**X**	Lumière, Matière : Mesures Extrêmes	
Plasmas : de l'espace au laboratoire			