Spécialité de Master « Optique, Matière, Plasmas »

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

Proposition de stage

Date de la proposition : 28/11/2013

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Code d'identification : UPR 3321 Organisme : CNRS

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Lieu du stage / *internship place*: IDRIS, Université Paris-Sud XI, 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 polar molecules, which are expected to have many interesting 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 in the development of quantum technologies [2].

However, the most versatile cooling methods [3] have only been capable of achieving temperatures around 10-500 mK. The biggest challenge in the field is hence to develop a *second-stage* technique to transfer such "cold" species to the microkelvin regime. We have very recently shown [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. All these species can be *magnetically* trapped and our calculations so far have considered collisions in pure magnetic fields.

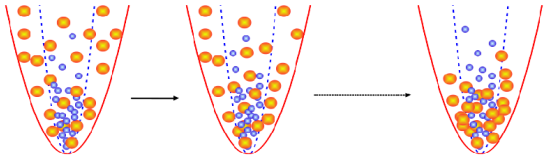

Fig. 1: Schematic representation of the sympathetic cooling of molecules (orange) by H atoms (blue) in a trap.

The goal of this project is to study the prospects of sympathetic cooling for molecular species 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, as well as its role in the development of Stark deceleration [3b] and its current interest [6]. The student will learn how to use the MOLSCAT 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 an important 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 also 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://www.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			