PROPOSITION DE STAGE DE M1

ORGANISME D'ACCUEIL :

Nom: Laboratoire Aimé Cotton
Adresse: **Bâtiment 505**

RESPONSABLE DU STAGE :

Nom-Prénom : **Nadia Bouloufa, Olivier Dulieu, Charbel Karam**
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DUREE et PERIODE DU STAGE ENVISAGÉES : Avril- Juin 2023

SUJET DU STAGE :

Studying and modeling the Zeeman effect on ultracold polar molecules.

In the last few decades, ultracold physics proved to be a research field at the heart of quantum technologies and has been awarded several Nobel prizes throughout the years: for laser cooling and trapping of atoms in 1997, observation of Bose-Einstein condensation in ultracold gases in 2001, manipulation of individual quantum systems in 2012, and most recently the recognition of the pioneering work in quantum information science made by Alain Aspect. The prerequisite in all the works mentioned above, is the control of quantum systems at the single quantum level.
Molecules are quantum systems with a rich internal structure that opens various opportunities to manipulate them using external fields, such as an electric, magnetic or electromagnetic field, either to act on a very specific internal quantum state, or on the external degree of freedom of the molecules. Polar molecules are appealing in the sense that they are easily manipulated by external fields due to their permanent dipole moment.
However, controlling such systems still remains an important challenge.
During their creation process, the molecules are exposed to an external magnetic field which is used to manipulate the internal state of the system and helps in providing the perfect conditions to reach a target quantum state: the so-called Zeeman effect, which is the effect of a magnetic field on an atom or a molecule, must be perfectly modelled.
The aim of this internship is to understand and model the effect of a magnetic field on a diatomic molecule. The coding language used is FORTRAN (No need to previously know the coding language, the student will be trained during the coding part of the internship). The main points to work on will be:

- Understanding all the internal interactions that take place in a molecule: electronic and nuclear interactions, spin-orbit interaction (going through the various Hund's cases), etc…
- Understanding how a molecule interacts with an external magnetic field.
- Studying the effect of the magnitude of the magnetic field on molecular structure as well as the choice of the appropriate basis set to describe the system.
- **Write a code from scratch to model the Zeeman effect on a polar molecule.**

All the relevant molecular parameters are provided by precise calculations performed in the group.

*Prerequisites: A solid knowledge of the basics of **quantum mechanics**, a good knowledge in **atomic and molecular physics**. Many aspects of molecular physics will be **reintroduced** to the student during the internship.*
***Coding skills** in any language are well appreciated.*