Stage de master de physique / Physics Master Internship

Proposition de stage/ Internship proposal

Date de la proposition : 04/11/2024

Responsable du stage / *internship supervisor*:

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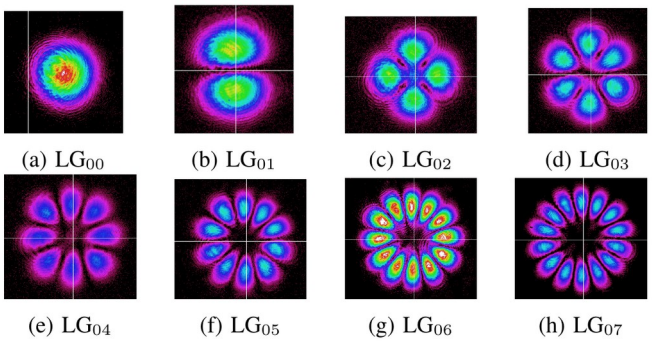
Nom du Laboratoire / *laboratory name*:

Code d'identification : UMR8630 Organisme : SYRTE, Observatoire de Paris
Site Internet / *web site*: https://syrte.obspm.fr/
Adresse / *address:* 77 avenue Denfert-Rochereau, 75014 Paris
Lieu du stage / *internship place*: SYRTE, Observatoire de Paris

Titre du stage / *internship title*: **Optical lattice clock with Laguerre-Gauß profiles**

Résumé / *summary*

Optical lattice clocks, which consist in probing an ultra-narrow optical transition of a set of ultra-cold atoms trapped in a dipolar optical lattice are now the best frequency standards, with uncertainties in the 10^{-18} range, and are well positioned to replace the Cs atom for the next definition of the SI second. LNE-SYRTE, the French National Metrology Institute for time and frequency has developed a new generation optical lattice clock with strontium atoms, aiming at further improving the accuracy of the clock. In this clock, the dipole optical lattice in which the the Sr atoms are trapped is formed by a strong standing laser beam formed by a high order transverse mode inside an optical cavity. The transverse profile (captured at the cavity output in the right picture for different modes) has several lobes, multiplying the trapping sites for the atoms. It offer a controllable way to characterize the cold collisions between atoms, as well as the perturbation induced by the trapping potential, which are two prominent features of optical lattice clocks. The team at LNE-SYRTE has recently achieved the trapping of Sr atoms in such a lattice, up to the LG_{02} profile.



Transverse profile of the optical lattice in the clock.

The aim of this internship is to perform the first spectroscopy of the Sr clock transition in the Laguerre-Gauß profile. By saturating the transition, we will observe the motional sidebands witnessing the quantization of the motion in the trapping potential, and use them to assess the properties of the optical lattice.

The internship is meant be followed by a PhD thesis, whose aim is to establish the first accuracy budget of the Laguerre-Gauß clock, including :

- Assessing the frequency shift resulting from cold-cold collisions by varying the density and the LG mode order
- Modelling the frequency shift induced by the lattice, taking into account the temperature of the atoms
- Validating the accuracy budget through international clock comparisons by optical fibre links
- Contributing the calibration of the International Atomic Time (TAI) with this new clock
- Improving the loading rate of atoms in the LG modes by adding a 2D magneto-optical trap

The PhD thesis work is part of the CoCoRICO (https://cocorico.obspm.fr) European project, involving European Metrology Institutes and academic partners.

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***: CoCoRICO EURAMET Project**