

INTERNSHIP PROPOSAL

Laboratory name: LTE (Laboratoire Temps-Espace)

CNRS identification code: UMR 8255

Internship director's surname: Rodolphe Le Targat

e-mail: rodolphe.letargat@obspm.fr

Phone number: 01 4051 2344

Web page: <https://roymageanr.obspm.fr/>

Internship location: LTE, Observatoire de Paris, 77, Avenue Denfert-Rochereau, 75014 Paris

Thesis possibility after internship: YES

Funding: YES

Type of funding: Ressources propres

A new source at 578 nm for clock interrogation and shelving of Yb atoms

The frequency of optical lattice clocks - based on the probing of the ultranarrow transition $^1S_0 \rightarrow ^3P_0$ of $\sim 10^4$ neutral atoms trapped in a "magic" optical lattice - can now be controlled at the 18 digits level. This makes them the most accurate instruments ever built, which opens the possibility of applying this capacity to new fields of science: tests of General Relativity (Lorentz invariance, possible drift of fundamental constants), quest for dark matter, or sensing of the geopotential (chronometric geodesy). In this perspective, LTE (Observatoire de Paris) is developing the **transportable optical lattice clock ROYMAGE**, based on neutral Ytterbium, with the prospect of improving the cartography of the Earth gravitational potential, which is probed by the atoms through gravitational time dilation.

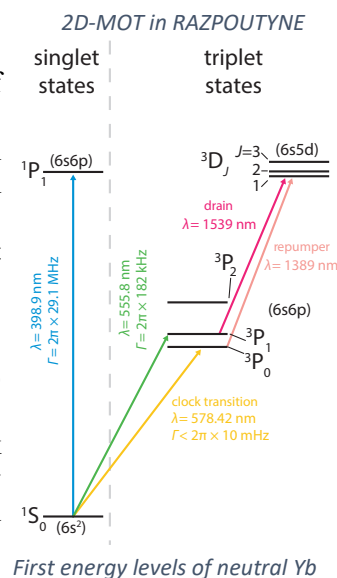
Our team has designed and assembled two apparatus aiming at ultrasfast atom loading to increase the stability of the clock. Yb-1 (ROYMAGE) is based on an optical molasses (adapted to transverse speeds up to 18 m/s), a permanent magnets-based Zeeman slower (able to slow atoms down to < 20 m/s), an ongoing 2D-MOT (Magneto-Optical Trap) project and a Science chamber featuring two 3D-MOT (399 and 556 nm) and magic-wavelength trapping at 759 nm. Yb-2 (RAZPOUTYNE) is based on a very promising approach that lead to obtaining a high flux 2D-MOT recently.



The **M2 applicant** will work on two different aspects of the project:

- **Atomic Physics:** He/She will work on the simulation and the design of an atomic drain, a technique developed at LTE to shelve atoms in the metastable states in order to decouple the dynamics of the 3D-MOT from the loading of the optical lattice. The first step is a Monte Carlo simulation to evaluate the dynamics of the draining process. The second step aims at locking the two necessary lasers (556 and 1539 nm) to the correct frequencies, and at demonstrating the transfer towards the metastable states, either in a 399 nm MOT, or in a 759 nm lattice.

- **Laser Physics:** He/She will build an enhancement cavity to frequency-double 1156 nm light into 578 nm light, in order to equip the clock with a compact, reliable source of yellow photons to probe the clock transition. The first step will be the calculation of the geometry necessary to form a butterfly cavity around a PPLN non-linear crystal. The second step will be the mounting of the cavity, aiming at continuous operation.



Techniques: atomic spectroscopy, optics (@ 399 nm/556 nm/578 nm/759 nm/1539 nm), theoretical description of light-matter interactions, data analysis, numerical simulations, electronics, vacuum

Size of the team: 5 people (2 staff researchers, 1 guest researcher and 2 Phd Students)

Complete proposal description on the home page: <https://roymageanr.obspm.fr/>

Please, indicate which speciality(ies) seem(s) to be more adapted to the subject:

Condensed Matter Physics: NO

Quantum Physics: YES

Soft Matter and Biological Physics: NO

Theoretical Physics: NO