INTERNSHIP PROPOSAL

(One page maximum)

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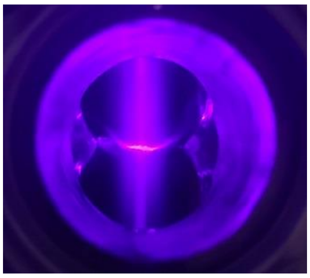
Thesis possibility after internship: YES
Funding: YES If YES, which type of funding: European

399 nm moving molasses of cold Yb for a transportable optical lattice clock

The frequency of optical lattice clocks - based on the probing of the ultranarrow transition $^1S_0 \rightarrow {}^3P_0$ of ~ 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 (Lorenz invariance, possible drift of fundamental constants), quest for dark matter, or sensing of the geopotential (chronometric geodesy). In this perspective, SYRTE (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 sensed by the atoms via gravitational time dilation.

Our team has designed and assembled two apparatus aiming at ultrasfast atom loading so as to increase the stability of the clock. Yb-1 (ROYMAGE) is notably 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 where 3D-MOT (399 nm and 556 nm) and magic trapping (759 nm) will be realized. Yb-2 (RAZPOUTYNE) is based on a very promising approach that lead to obtaining a high flux 2D-MOT in summer 2024.



2D-MOT in RAZPOUTYNE

To this end, the **M2 applicant** will work on the different aspects of the project:

• He/She will work on the simulation and the design of a moving molasses (MM) aiming at pushing a 399 nm 2D-MOT towards a 556 nm 3D-MOT, so as to capture as many cold atoms as possible (target: several 109 atoms/s). The first step is to find a configuration enabling velocities as low as a few cm/s, while preventing the travelling cloud from expanding in the transverse directions. The second step will be the design of the mechanical system to implement this technique in the atomic loader RAZPOUTYNE. Experimental implementation of the MM resulting from this design is expected to take place in summer 2025.

• He/She will build an enhancement cavity to frequency-double 798 nm light into 399 nm light, in order to equip the clock with a compact, reliable source of blue photons. The first step will be the calculation of the geometry necessary to form a butterfly cavity around an LBO non-linear crystal. The second step will be the construction of the cavity itself, aiming at continuous operation.

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

Size of the team: 5 people (2 staff researchers, 3 Phd students)

Complete thesis 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 Soft Matter and Biological Physics: NO
Quantum Physics: YES Theoretical Physics: NO