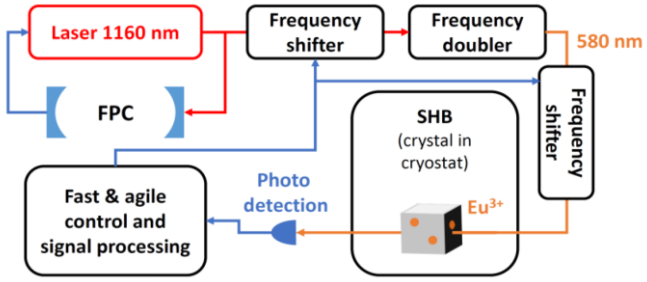
Ph.D. thesis in Paris (LNE-SYRTE/Observatoire de Paris) on

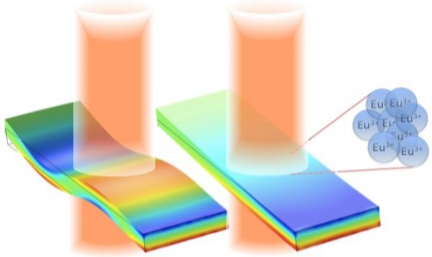
# *Spectral Hole Burning for Ultra-stable Lasers and Atomic-scale Force Sensors*

## Project

Spectral hole burning in rare-earth ion doped crystals is a versatile system in time-frequency metrology and related applications. On one hand, narrow optical transitions of the dopant ions can serve as a frequency reference for laser stabilization. The expected fractional frequency stability can potentially be orders of magnitude better than cavity-locked lasers at the state of the art. On the other hand, mechanical constraints can distort the crystalline structure, thereby shifting the frequency of the transition in the dopant ions. Probing such a transition near resonance allows for opto-mechanical coupling and the realization of novel hybrid quantum systems.




At the SYRTE laboratory, an experimental setup using an $Eu^{3+}:Y_2SiO_5$ crystal has been constructed and the first demonstration of laser stabilization yields a relative frequency stability at a few $10^{-15}$ around 1 s. On-going collaborations with Institut Néel have led to the fabrication of a micro-mechanical resonator made of the same kind of crystal.



The aim of this PhD project is twofold. The successful applicant will improve the techniques of laser frequency stabilization, possibly down to the range of a few $10^{-19}$ at 1 s, and will explore the fundamental limits of such techniques, unknown for the time being. Much work will be devoted to the development of ultra-low-noise detection techniques, and to exploring sub-100 mK temperature regime where ultra-narrow linewidth et unprecedented immunity to thermal noise and fluctuations are expected. In parallel, he/she will perform spectral hole burning experiments in the micro-mechanical resonator in order to study the opto-mechanical coupling. The underlying physics will probably shed light on the possibility of realizing atomic-scale force sensors in our system.

## Scope and funding

The successful applicant will participate in all aspects of the project, including but not limited to working on the experimental setup, data acquisition and analysis, coordination with other experiments in the Optical Frequencies Group (e.g. frequency combs and optical clocks) for more involved measurements, etc. He/she is expected to collaborate with various technical services within the SYRTE laboratory and with our academic and industrial partners on the national and international scale.

The position will be open from November 1st 2018 onwards. A full PhD grant (salary for 3 years) as well as travel expenses (conferences, visits and meetings) is available for the successful applicant.

## The applicant

Must hold a master (M2, MSc or equivalent) in physics, and some experience in experimental physics (in particular in optics, electronics and programming) is considered very useful, but not a strict requirement. Good technical English and capability of communication is a must, given the collaborative nature and international context of the work.

## Contact

CV, a motivation letter and references should be sent both to Dr. Bess FANG (bess.fang@obspm.fr) and to Dr. Yann LE COQ (yann.lecoq@obspm.fr).