

## **PhD position in Optoelectronics & Bio-Photonics :** **Advanced laser sensor based on III-V nanostructures for the** **angular manipulation and metrology of biologic nanomotors**

IES (Institute of Electronics & Systems, Photonic and waves department – University Montpellier) is a world leader in the field of highly coherent III-V surface emitting semiconductor laser (VCSEL) and optical/RF noise physical study, which find diverse applications in low noise photonic sensors. CBS (Centre de Biochimie Structurale), historically focused on structural biology, is a multidisciplinary institute where state of the art biological, biochemical and biophysical techniques are developed and employed. The department of Single Molecule Biophysics hosts four groups with expertise in advanced fluorescent and near-field microscopy, micro-fluidics, and single molecule manipulation. *The objective of the thesis is to demonstrate for the first time the potential of an innovative laser sensor technology, developed at IES, in advanced biophysical measurements performed at CBS.*

A state of the art design and control of the physical properties of the semiconductor laser cavity during fabrication, based on III-V semiconductor VCSEL and photonic crystals nanotechnologies, recently allowed our group at IES to develop and patent a first version of a compact coherent laser source with a stable and controllable *orbital angular momentum*, termed *Optical Vortex*. The exotic photon state from this laser, via the exchange of *angular momentum*, is able to interact with matter in ways that can be exploited in several new applications. We want to demonstrate in particular the potential of this novel technology in mechanical control (optical tweezers) and measurements (velocimetry Doppler) at the level of single molecules of biological relevance. The exchange of both linear and angular momentum from light can be used to apply and measure both external *force* and *torque* at the scale of the nanometer using Optical Tweezers. This overcomes important limitations in the field of single-molecule manipulation, where particularly the torque applied on molecules cannot generally be controlled or measured. The model system we will study is the protein complex termed *Flagellar Motor*, a powerful rotary molecular motor found in bacteria. Torque is the relevant physical parameter of this motor, therefore our new laser concept and technology is well suited for its angular manipulation and measurement, with the potential to extract novel information about the motor complex and the kinetics of its internal components. The strict requirements imposed on the laser source by the biophysical measurements which we aim to perform at the nanometer scale (e.g. source stability, power, coherence, control of the vortex charge etc.) will guide the further development and improvement of the laser physical properties and technology. Having full control of the bottom-up manufacturing of the laser device, we will be able to tune it to meet the needs of the biophysical measurements. The successful candidate will share his/her effort both on the technological development of the laser source (modeling, III-V nano-fabrication, physical

study), and on the biophysical measurements (optical tweezers). The student will receive full support from both groups at IES and CBS, experts in their respective fields.

This work will be carried out in collaboration with several academic institutes (IOGS Bordeaux, LPN Marcoussis, CBS, Univ.Montpellier, LOMA Univ. Bordeaux, University of Southampton UK, IMEDEA Spain) and one company (INNOPTICS).

**Keywords:** Photonic sensor, Semiconductor Laser, Optics, Bio-photonics, Optical tweezers, nanomotor, velocimetry

Applicants should have a strong interest in semiconductor laser physics and technology, optics and biophotonics, RF signal processing and noise, a promising research record, and good practical skills. Please send a CV including names of two referees by e-mail to [arnaud.garnache@ies.univ-montp2.fr](mailto:arnaud.garnache@ies.univ-montp2.fr). Further information can be obtained from Dr GARNACHE Arnaud. Links: <http://vecsel.ies.univ-montp2.fr/>

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