PhD Proposal 2024

School - Location: Ecole Centrale Marseille	
Laboratory: Institut Fresnel	Web site: www.jeromewenger.com
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Title: Optically-controlled thermal nanotweezers to manipulate single nano-objects
Scientific field (one among the list- remove other choices): Natural & Life sciences: Physics & Astronomy
Free Key words: microscopy, optics, photonics, nanophotonics, plasmonics, optical nanotweezers

Details for the subject:

The Institut Fresnel is a research state laboratory based in Marseille / France, devoted to research and higher education with affiliation to both CNRS and Aix Marseille University. Institut Fresnel is seeking to recruit talented, enthusiastic young scientists who are highly motivated to boost their research career in the areas of nano-optics and/or biophotonics.

Motivation

Optical tweezers offer a versatile approach to manipulate living cells and other micron-sized objects with minimal invasiveness. However, due to the diffraction limit, objects with sizes below 100 nm are nearly impossible to trap using conventional microscopes. To overcome this limitation, nanophotonics allows to concentrate light well below the diffraction limit. The nano-optical tweezers enable efficient trapping of nanoscale objects that would otherwise be too small or too transparent to be manipulated using conventional optical tweezers. However the plasmonic nanotweezers using optical resonances in metal nanogaps come with their own issues: the fabrication is complex and expensive, the control and reproducibility is often poor for gap sizes below 20 nm, and the range of action is limited, requiring long waiting times of several minutes to trap a particle.

A paradigm change is needed to overcome the limitations in the manipulation of nano-objects. Here we propose to use thermal gradient forces instead of optical gradient forces. Temperature gradients at the micro/nanoscale can induce forces which will be exploited in this PhD project to trap single nano-objects as small as 5 nm with an action range larger than 500 nm.

Research / PhD thesis description

Jerome Wenger's group has acquired a wide expertise in the nanoscale control of light fields in plasmonic nanostructures and its application to enhance fluorescence spectroscopy applications. For our next project we will focus on opto-thermal trapping of single nanoobjects (nanoparticles, quantum dots, proteins with fluorescent tags) to enhance spectroscopy applications on single nano-objects.

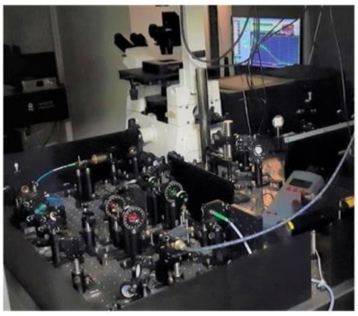
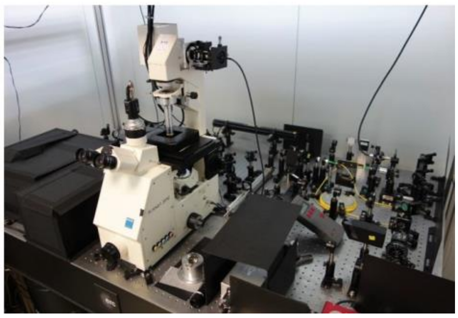
Thanks to the large range of thermal forces, a single nanoparticle can be trapped within a few seconds after the infrared beam is switched on, even at sub-nanomolar concentrations. We target a localization accuracy sufficiently below the spatial resolution of the optical microscopes used for the different applications. As nanometer gaps are not required, the fabrication will remain cost-effective and easily scalable for highly parallel operation.

The manipulation of single nano-objects (nanoparticles, quantum dots, proteins, viruses…) is a key element for various areas of nanosciences, multiplying the potential impact of optically-controlled thermal tweezers. Manipulating single nano-objects is highly cross-disciplinary at the interface between photonics, biophysics and nanotechnology. This innovative approach will enable the exploration of a brand new territory of optical tweezers down to the single molecule level. The outcomes of this PhD project will further advance the fields of nano-optical trapping, nanophotonics and single-molecule biophysics, and will benefit a wide range of sensing applications.

Gains of this PhD project

1. Close supervision by an internationally recognized expert in the field of nanophotonics and single molecule fluorescence techniques, providing unparalleled access to cutting-edge research and knowledge.
2. Direct mentorship and dedicated trainings, tailored to the student's specific interests and goals, to ensure they reach their full potential.
3. Attendance at weekly seminars featuring leading experts in the field, providing opportunities to network and learn from the best in the field.
4. Opportunities to present at major international conferences, giving the student a platform to showcase their research and make valuable connections.
5. Access to state-of-the-art equipment and technology, allowing the student to perform cutting-edge research and stay at the forefront of the field.
6. Personal and professional development training, including opportunities for leadership and communication skills development, to prepare the student for a successful career in academia or industry.
7. The opportunity to work on groundbreaking research projects that have the potential to make a significant impact in the field of nanophotonics and single molecule fluorescence.
8. The chance to be part of a highly skilled and motivated research team, working alongside some of the brightest minds in the field.
9. The opportunity to contribute to the advancement of knowledge in the field and make a meaningful impact on the world through their research.
10. The opportunity to develop a diverse set of transferable skills and gain valuable experience that will be highly sought after by employers in academia and industry.



Supervisor Dr Jerome Wenger

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