## PHD Position

# Numerical Optimization of Electromagnetic Metasurfaces for Opto-Mechanical Microrobots Actuation

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**Location:** Institut FEMTO-ST, Université de Franche-Comté, CNRS, ENSMM

**Founding source**: 3 years and full time: https://anr.fr/Projet-ANR-21-CE33-0003

**Application:** Please send your Full application in a single PDF (CV, Cover Letter, Master Grades and 2 Reference Letters) to aude.bolopion@femto-st.fr and Muamer.kadic@femto-st.fr

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Over the last decade, there has been a growing interest in microrobotic solutions, especially for in-vitro experiments. Two main approaches are currently pursued: manipulation by contact and without contact. The first robotic approach consists of spikes, microtongs or multi-finger manipulators capable of interacting with micrometer-sized objects. It benefits from significant blocking forces, great dexterity and the possibility of measuring the force applied to the object, but it currently requires a physical connection between the tool and a macroscopic structure allowing its movement and actuation. Therefore, it needs to work in an open environment to let the tool connect, and it is not suitable for closed environments to maintain sample sterility. The second approach is to use remotely induced force fields to act wirelessly on microscopic objects. Autonomous approaches are mainly based on remote electromagnetic actuation, and most current work is moving towards the use of magnetic fields. The OptoBots project combines the two approaches to develop mobile microrobots with integrated degrees of freedom and sensing capabilities, introduced directly into the sample chamber.

In this thesis, the work will focus only on optical trapping. To extend these possibilities, the project will invest in the use of optical and elastical metamaterials: these are artificially structured materials with novel electromagnetic properties combined with controlled swimming properties [1]. This approach aims at engineering the light/matter interaction, and has an obvious impact on optical tweezers, for example to increase the force generated. Metasurfaces and special metallic structures were used to increase the light-matter interaction. Beyond what can be achieved by a classical continuum approach, only a few works have explored beyond this limit with materials with optical gain [2,3].
The work will be theoretical and will be performed using finite elements.

[1] Quispe, J. E., Bolopion, A., Renaud, P., & Regnier, S. (2021). Enhancing swimming and pumping performance of helical swimmers at low Reynolds numbers. *IEEE Robotics and Automation Letters*, *6*(4), 6860-6867.
[2] Alaee, R., Gurlek, B., Christensen, J., & Kadic, M. (2018). Optical force rectifiers based on PT-symmetric metasurfaces. *Physical Review B*, *97*(19), 195420.
[3] Alaee, R., Christensen, J., & Kadic, M. (2018). Optical Pulling and Pushing Forces in Bilayer P T-Symmetric Structures. *Physical Review Applied*, *9*(1), 014007.