DOCTORAL THESIS IN ATOMIC AND MOLECULAR PHOTONICS

Magnetic responsive materials for untethered robotic function

PhD open position within the doctoral network "Soft Active Matter Microrobots for Medicine (SAM3)", funded by EU HORIZON-MSCA-2025-DN-01-01 # 101312674

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Research project on Magnetic responsive materials for untethered robotic function (SAM3/ESR3 - magnetism)

This project takes place within the Marie Curie Doctoral Network on Soft Active Matter Microrobots for Medicine (SAM3). This doctoral network of 12 PhD candidates aims at exploring the ear-nose-throat area from a microrobotics perspective. Thanks to active matter and small scale microrobotics engineering, three specific goals are targeted: (1) access the middle ear through the Eustachian tube; (2) access the olfactory clefts for mucosal biopsy; (3) access the skull cavity through the nose and the cribble plate for cerebrospinal fluid biopsy.

This specific PhD proposal on Magnetic responsive materials for untethered robotic function is part of the third endoscopic area namely the cerebrospinal fluid system. The goal of the PhD is to develop 3D-printable magnetic responsive materials based on thermally responsive shape-changing Liquid Crystalline Networks (LCNs) doped with magnetic nanoparticles (MNPs) allowing the development of unthethered robotic function. Combining 3D patterning by photolithographic techniques with different nanoparticle responsive behaviors to alternate or static magnetic fields, micrometric actuators capable of both navigation and gripping will be realized.

The expected results are further set as follows: **1) Synthesis of magnetic nanoparticles (MNPs)** with high specific loss power and surface functionalization for stable dispersion in liquid crystalline matrices; **2) Development and characterization of thermo-responsive liquid crystal networks** (LCNs) capable of deformation under physiological conditions; **3) Fabrication of magnetic field-responsive materials** by incorporating MNPs into thermo-responsive LCNs; **4) Creation of 3D microstructures** using photolithographic techniques; **5) Demonstration of microrobot locomotion** in liquid environments, controlled by gradient (static) magnetic fields, including tests within anatomical phantoms; **6) Validation of microrobot deformation and gripping** capabilities under alternating magnetic fields, leveraging thermal deformation induced by magnetic hyperthermia.

The candidate will be enrolled as PhD student at UNIFI (Firenze, Italy), in the International Doctorate of Atomic and Molecular Photonics. A co-supervision is planned with Prof Camilla PARMEGGIANI at LENS also.

An industrial stay of 6 months is planned at Heteromerge (Dr Robert KIRCHNER, Dresde, Germany) for the multimaterials 3D structure printing for untethered micro-actuators and an academic stay of 3 months is planned at UT (Prof Sarthak MISRA, Twente, Netherlands) for the tests of navigation with magnetic fields.

Research environment

The main research lab will be the Laboratorio Europeo Di Spettroscopie Non Lineari (lens.unifi.it), in the Scientific Campus of the University of Florence (LENS, Sesto Fiorentino Campus, Firenze, Italy).

The PhD student will be supervised by Dr Daniele MARTELLA (LENS, Firenze, Italy) and co-supervised by Prof. Camilla PARMEGGIANI (LENS, Firenze, Italy).

Both supervisors of this project have complementary expertise towards the goals of this PhD: magnetic nanoparticles and polymer design and synthesis, microfabrication and actuation test under magnetic field activation.

More information on the supervisors:

- Dr Daniele MARTELLA, assistant professor of industrial chemistry at the Department of Chemistry "Ugo Schiff" of UNIFI and associate researcher of LENS, leading research in the fields of photo-responsive materials and liquid crystal applications. Recently, he has coordinated different projects related to Liquid Crystalline Networks for environmental remediation, sensing and actuation.
- Prof. Camilla PARMEGGIANI, professor of industrial chemistry at the Department of Chemistry "Ugo Schiff" of UNIFI and associate researcher of LENS, leading research in the fields of smart materials for soft robotics and biological application. Recently, she has coordinated different projects related to the development of light responsive artificial muscle based on liquid crystal (e.g. FET-PROACTIVE – REPAIR)

LENS and University of Florence are equipped with all necessary facilities for polymer synthesis, manufacturing and characterization at the small scale.

For the implementation of the project, the candidate would move for 6 months to Heteromerge (Germany) and 3 months to UT (Netherlands).

Job description and profile for SAM3/ESR3

We will appoint 1 PhD student on this project, related to 11 other positions open in the SAM3 EU network.

He/she will be registered within the International Doctoral School coordinated by Laboratorio Europeo di Spettroscopie Non Lineari at UNIFI with Dr Daniele MARTELLA as supervisor.

The candidate should have a master degree or diploma in chemistry, material science, material engineering, or related topics, less than 5 years of career at the recruitment date and not having a doctoral degree.

We are seeking talented and enthusiastic students to perform a PhD, with a solid background in polymer chemistry and technology, magnetic nanoparticle synthesis or 3D printing of smart materials. Regarding skills, we look at ability for research management, dissemination, communication with colleagues and supervisors, strong teamwork spirit, creativity, problem solving and attention to safety.

The candidate should have good command of spoken and written English, and Italian, German or Dutch skills are of course an asset.

For more information regarding the PhD studies at the UNIFI please check the website (https://lens.unifi.it/phdschool/).

How to apply

Applications should be sent to the mailbox SAM3@umons.ac.be dedicated only to recruitment. They should include: a) a digital copy with all academic certificates and the respective official transcription in English; b) a detailed CV and a motivation letter in English; c) 2 letters of recommendation.

Duration: 3 years full time.
Starting date: Autumn 2026
Deadline for the submission of applications: 15/7/26 with position open until filled