COLLABORATIVE IBEC INTERNATIONAL PhD PROGRAMME

Position

1. Project Title:
   Hyperpolarized MRI and Magnetometry for Molecular Imaging

2. Research project/ Research Group description

Hyperpolarized Magnetic Resonance Imaging (HP-MRI) is a groundbreaking technique in drug discovery and disease diagnosis, using small-molecule metabolites with nuclear spin polarizations nearing 100%. This vastly surpasses conventional MRI polarization (~0.001%), enabling imaging of metabolite biodistribution and flux, which can track diseases like cancers, liver inflammation, and neurodegenerative disorders. At IBEC's **Molecular Imaging for Precision Medicine (MIPMED)** lab, we develop **^{13}C HP-MRI** for various disease models, from in vivo to organs-on-a-chip.

The MIPMED lab is also innovating methods to reduce the cost and time of hyperpolarizing metabolites while increasing efficiency, aiming to enhance industry and clinical adoption. One promising approach uses **para-enriched H_2** whose quantum mechanical properties (Pauli's principle) provide 100% **^{1}H nuclear spin polarization** in an MRI-invisible spin-0 state. By chemically transferring this polarization to metabolites, we achieve an MRI-visible state, hence the name **ParaHydrogen-Induced Polarization (PHIP)**.

Collaborating with BIST institute ICFO, we have used sensitive magnetometers to monitor the magnetic field produced by the sample during the PHIP reaction, providing passive readout of nuclear spin state: https://phys.org/news/2024-10-atomic-sensors-unveil-hidden-dynamics.html. This could enable **sensor-guided hyperpolarization**, where feedback-controlled magnetic fields optimize polarization. Alternative sensors based on magneto-optical rotation of light by nuclear spins are also under study, for efficient integration with microfluidics. These developments if successful will be widely applied for reliable HP-MRI tracer production.

Collaborating groups:

"Molecular Imaging for Precision Medicine", IBEC, led by Dr. Irene Marco-Rius https://ibecbarcelona.eu/molecular-imaging-for-precision-medicine

"Atomic Quantum Optics", ICFO, led by ICREA Prof. Morgan Mitchell https://www.icfo.eu/research-group/8/q-light-atoms/home/437/

3. Job position description

We seek a motivated PhD candidate with a Master's degree in **Physics, Chemical Physics, Engineering**, or a related field to join a cutting-edge interdisciplinary project at the intersection of **molecular imaging**, **NMR**, and **magnetometry**. This is an exciting opportunity to advance Hyperpolarized MRI technology and contribute to revolutionary applications in drug discovery and clinical diagnostics.

As a successful candidate, you will:

- Work on **microfluidics integration of magnetometers** to enhance precision in metabolic imaging workflows. Experiment design and assembly will be required.
- Develop and implement **parahydrogen-based approaches** for preparing hyperpolarized metabolites, with the goal of faster and more reliable imaging.
- Employ advanced **magnetometry tools** for real-time quality control, plus **sensor-guided hyperpolarization** techniques, including feedback control. A knowledge of programming is useful though not essential.
- Perform computational tasks such as **data analysis, system modeling**, and **integration**, using languages **Python**, **MATLAB**, and **C++**.

This role offers the unique opportunity to work with leading research teams at IBEC and ICFO, combining **physics and engineering principles** to tackle challenges in metabolic imaging. You will gain hands-on experience in **high-TRL device development**, participate in translational research, and contribute to the **commercialization of next-generation imaging technology**

Highly desired:

- A passion for applying scientific principles to real-world problems in biomedicine and technology.
- A demonstrated ability in **programming skills**
- Experience working in a **collaborative, multidisciplinary environment**.

Group Leader at IBEC

1. Title: Junior Group Leader
2. Full name: Irene Marco-Rius
3. Email: imarco@ibecbarcelona.eu
4. Research Group: Molecular Imaging for Precision Medicine (MIPMED)

IBEC
Institut de Bioenginyeria de Catalunya

Collaborators in the other institution

1. Title: ICFO Staff Scientist, Dr
2. Full name: Michael C. D. Tayler
3. Email: michael.tayler@icfo.eu
4. Institute: ICFO
5. Research group: Atomic Quantum Optics

1. Title: ICREA and ICFO Professor, Dr
2. Full name: Morgan W Mitchell
3. Email: morgan.mitchell@icfo.eu
4. Institute: ICFO
5. Research group: Atomic Quantum Optics