Institut de Ciències Fotòniques (ICFO)

1. Descripció del centre de recerca

The Institute of Photonic Sciences (ICFO) is a leading research center in the field of photonics, dedicated to advancing the science and technology of light and its applications. Located in the Mediterranean Technology Park in the metropolitan area of Barcelona, ICFO is at the forefront of groundbreaking research and innovation in areas such as quantum technologies, biophotonics, clean tech, and photonic integrated circuits. ICFO employs 500 people, including researchers, PhD students and staff personnel. In its area of specialization and category, the institute is consistently ranked among the highest-quality research institutions worldwide. Our mission is to contribute to scientific knowledge, foster technology transfer, educate of graduate students and postdoctoral researchers, and promote the responsible engagement of science in society.

- Adreça:

  Parc Mediterrani de la Tecnologia

  Av. Carl Friedrich Gauss, 3

  08860 Castelldefels (Barcelona), Espanya

2. Descripció del projecte

In the case of ICFO, five different projects are offered in the following research groups:

Medical Optics

- **Name of the research group:** Medical Optics
- **Group leader:** Turgut Durduran
- **Mentor (if already identified):** Alejandra-Daniela Lopez Solis & Anika Pretorius
- **Summary of the project:** Understanding muscles and brains with light: how do we use light-based tools to monitor brains of critically ill babies and exercising athletes. Basics and on-hands experiments.
- **Any specific requirements or preferences regarding the student profile:** Knowledge and interest in physics, engineering or medicine as well as experience in numerical programming.

SLN – Team Loza

- **Name of the research group:** SLN – Team Loza
- **Group leader:** : Pablo Loza-Alvarez
- **Mentor (if already identified):** Gustavo Castro and Nicolás Mateos

- **Summary of the project:** The primary goal of this project is to demonstrate light-sheet frequency-encoded illumination and signal reconstruction in its simplest, controlled configuration. Specifically, the student will implement dual-color light-sheet illumination, with each wavelength modulated at a distinct temporal frequency, detect the combined fluorescence signal from a single illuminated plane, and computationally reconstruct the individual image contributions through frequency-domain demodulation. This milestone represents the first experimental validation step toward full multi-plane, multi-color volumetric imaging.
    - **Scientific and technical tasks:** The student will work at the interface of optics, instrumentation, and data analysis. On the experimental side, the project will involve preparing simple fluorescent samples, aligning a light-sheet illumination path, and implementing temporal modulation of excitation light using an acousto-optic tunable filter (AOTF). The student will configure the acquisition pipeline to record high-frame-rate image sequences containing multiplexed fluorescence signals from two spectrally distinct channels. On the computational side, the student will develop or adapt data-processing routines to extract frequency components from the recorded time series and reconstruct the individual images associated with each modulation frequency. This will include basic signal processing in the Fourier domain, validation using controlled test samples, and quantitative assessment of reconstruction fidelity.
    - **Training and outcomes:** By the end of the project, the student will have gained hands-on experience in optical alignment, light-sheet microscopy, AOTF control, and synchronized data acquisition, as well as practical skills in signal processing and image reconstruction. Scientifically, the project will deliver a validated dual-color, frequency-modulated imaging pipeline that forms a critical building block for our novel technology.
- **Any specific requirements or preferences regarding the student profile:** Physics, Engineering (Electronics, Telecommunications, Physics, or similar) and Mathematics with eager to have some hands-on experience.

Macroscopic Quantum Optics Theory

- **Name of the research group:** : Macroscopic Quantum Optics Theory
- **Group leader:** : Oriol Romero-Isart
- **Mentor (if already identified):** Andreu Riera-Campeny
- **Summary of the project:** The student will be guided to derive from first principles the gravitational interaction leading to entanglement between two levitated nanoparticles to address a fundamental question: What is the gravitational field generated by a quantum object? Using a quantum field theory approach, they will develop an effective theory of gravity and compute the effective interaction mediated by gravitons. This work will support ongoing efforts to theoretically understand the interplay between gravity and quantum mechanics in cutting-edge tabletop experiments, an effort that our group pursues in collaboration with one of the leading experimental group in the field, the group of Prof. Markus Aspelmeyer (Vienna).
- **Any specific requirements or preferences regarding the student profile:**
    i. Final-year Physics or Physics+Mathematics student

ii. Excellent grades (>8.5/10)
iii. Good English level
iv. Knowledge of Quantum Physics

Photon Harvesting in Plants and Biomolecules

- **Name of the research group:** Photon Harvesting in Plants and Biomolecules
- **Group leader:** Nicoletta Liguori
- **Mentor (if** already **identified):** Saül Garcia-Orrit
- **Summary of the project:**
  Why plants don't use sun cream?
  If you ever have gone to hike to the mountain you probably realized that after a sunny day you have needed a cap, sunglasses and probably sun cream, as solar light can seriously damage your skin and eyes, but around you the whole day there have been hundreds of plants that were not using any of these gadgets. So, how do they avoid solar photons to damage them? How do they adapt the photosynthesis process to photo-protect themselves at the same time they absorb light for biomass and O2 production?
  To answer these questions scientists have been studying the different biological machineries present in plants, known as photosystems, which are molecular systems with quantum properties that evolution has fine-tuned during billions of years to adapt to different extreme ambient conditions. In this project you will have the opportunity to understand the different photophysical properties of photosynthetic proteins, and contribute developing a novel ultrafast spectroscopic methods that may allow us to discover how different organizations of these proteins allow plants to harness solar energy safely.
- **Any specific requirements or preferences regarding the student profile:** Students of Physics, Chemistry, Biochemistry, Biophysics or related. The experiments will involve multidisciplinary science, studying photophysical processes within biological quantum systems present in photosynthesis in plants.

STM on 2D Quantum Materials

- **Name of the research group:** STM on 2D Quantum Materials
- **Group leader:** Carmen Rubio Verdu
- **Mentor** (if already identified): TBC
- **Summary of the project:** Learn about fabrication of twisted graphene devices and participate in low-temperature (350 mK) Scanning Tunneling Microscopy measurements of such magic-angle graphene devices.
- **Any specific requirements or preferences regarding the student profile:** last year students