PhD Opportunity: Exploring the limits of light–matter interaction with infrared phonon-polaritonic nanoresonators

Centro de Física de Materiales (CFM) and NanoGune, San Sebastián, Spain
Fully Funded | **Start Date**: Late 2026-Early 2027
Applications accepted until the position is filled.

The **Theory of Nanophotonics Group** at the Material Physics Center (CFM) and the experimental NanoOptics Group at Nanogune, both in **San Sebastián (Spain),** offer a **fully funded PhD position** to explore theoretically how light-matter interactions between infrared nanoresonator modes and vibrational excitations opens new possibilities for nanoscale sensing, light emission, and single-molecule control. This position offers an opportunity to work in a **world-class research environment, developing advanced theoretical models alongside frontier experiments in nanophotonics and nanoscale microscopy**, to explore the ultimate limits of infrared light-matter interactions.

Project Overview

The PhD will focus on the coupling of phonon-polaritonic infrared nanoresonators with molecular vibrations and phonons in 2-dimensional materials. Although the work will be theoretical, it focuses on guiding the cutting-edge experiments of the NanoOptics Group and on analyzing the experimentally observed novel effects that are regularly discovered in this group and that offer new opportunities for **sensing and light emission**. The theoretical work will depart from **multiscale electromagnetic simulations** of complex nanophotonic systems, complemented by the development of **analytical models** based, for example, on coupled harmonic oscillators. Depending on the progress of the thesis and the interests of the PhD candidate, these methods can be enriched by:

- **Quantum electrodynamics (c-QED)** models, to explore effects arising from the quantization of the system's excitations, for example in the rapidly evolving field of molecular quantum optomechanics.
- **First-principles calculations** of the properties of molecules and 2-dimensional materials.

As an example, the candidate will develop theoretical descriptions of near-field optical microscopy techniques pioneered by the NanoOptics Group to explore the interaction between infrared phonon-polaritonic nanoresonator modes and molecular vibrations of one or few molecules. The ultimate goal is to build **increasingly realistic and predictive theoretical models of experiments** at the forefront of molecular spectroscopy, nanometrically-resolved microscopy and nanophotonics.

The group

The thesis will be supervised by **Rubén Esteban** in the **Theory of Nanophotonics Group** and by **Rainer Hillenbrand** in the experimental **NanoOptics Group**, at the Centro de Física de Materiales (CFM) and Nanogune, respectively, **in San Sebastián**. These groups bring together complementary theoretical and experimental expertise in nanophotonics, with pioneering work in field-enhanced spectroscopy, microscopy and quantum technologies.

Google Scholar and Group page Rainer Hillenbrand

Google Scholar and Group Page Rubén Esteban

Why This PhD?

- Explore new physics at the **interface of nanophotonics and infrared spectroscopy**
- Direct application of the theoretical developments to state-of-the-art measurements
- Close interaction with leading international collaborators
- Live and work in San Sebastián, one of Europe's most beautiful and livable cities

What We're Looking For

We're seeking a motivated and curious candidate with:

- A **Master's degree** (or equivalent) in Physics, Materials Science, Electrical Engineering, or a related field
- Background in **nanophotonics, computational modelling, molecular spectroscopy or c-QED** (highly valued)
- Initiative and interest in developing theoretical models in direct contact with experimentalists.

To Apply

Please send to ruben.esteban@ehu.eus with subject line: "PhD infrared nanophotonics":

- **Cover letter** (max. 1 page) explaining your interests and motivation
- **Curriculum Vitae**, including academic transcript
- **Reference letter(s)**