



UNIVERSITAT POLITÈCNICA
DE CATALUNYA
BARCELONATECH

UAB
Universitat Autònoma
de Barcelona

 UNIVERSITAT DE
BARCELONA

ICFO
The Institute
of Photonic
Sciences



Master in Photonics – “PHOTONICS BCN” Master ERASMUS Mundus “EuroPhotonics”

MASTER THESIS PROPOSAL

Dates: April 2023 – July or September 2023

**Laboratory: Institut de Ciències de l’Espai – Gravitational Astronomy Group
Institution: CSIC
City, Country: Cerdanyola del Vallès, Spain**

Title of the master thesis: Pound-Drever-Hall characterization for ultra-stable temperature measurements.

Name of the master thesis supervisor and co-supervisor:

Miquel Nofrarias

Email address: nofrarias@ice.csic.es

Phone number: +34 93 737 9788

Mail address: Campus UAB, Carrer de Can Magrans, s/n

Keywords: temperature sensing, resonator, gravitational waves

Summary of the subject (maximum 1 page):

The Gravitational Astronomy group at the Institut de Ciències de l’Espai (ICE) is currently leading the Spanish contribution ---the Science Diagnostics Subsystem--- to LISA, the future space-borne gravitational wave detector with expected launch in 2034. The group provided the Data and Diagnostics Subsystems of LISA Pathfinder, a precursor mission launched in December 2015, which successfully measured the residual acceleration of two free-falling test masses in space down to the $5 \times 10^{-15} \text{ m/s}^2/\sqrt{\text{Hz}}$ in the milliHertz band, already probing the required technology for gravitational wave detection from space.

A particular interesting challenge arising in LISA and other fundamental physics space missions is the high stability control of temperature in the very low-frequency range (below the milliHertz). Our group is currently developing the techniques with potential impact in these future missions. For that purpose we are investigating temperature sensing by means of phase locking to optomechanical resonators.

In our lab, a temperature sensor in the nano-Kelvin precision regime is being developed using optical systems, for its applications in Gravitational wave detection. The main element is a Whispering Gallery Mode (WGM) resonator which will serve the purpose of an optical cavity



UNIVERSITAT POLITÈCNICA
DE CATALUNYA
BARCELONATECH

UAB
Universitat Autònoma
de Barcelona

 UNIVERSITAT DE
BARCELONA

ICFO
The Institute
of Photonic
Sciences



that provides time stability in the low frequency domain. The resonator itself can be used as a temperature sensor.

The Pound-Drever-Hall technique (PDH) is used to stabilize the Laser (which is the source of light for the resonator) in frequency, using the direct outputs of the Cavity (WGM resonator). To implement this technique, a frequency modulated beam is locked to a cavity. The output of this beam is measured and down mixed with an oscillator (in phase with the frequency modulation of the beam) to obtain the “off resonance” of the laser with respect to the cavity. This way a feedback loop can be implemented to correct the laser frequency towards resonance with the cavity, in our case, the WGM resonator.

The candidate work will consist of the development, characterization and optimization of the feedback control loop of the PDH technique, and apply it to an existing optical setup working in ultra-stable regime.

Objectives:

Characterization of the PDF lock of a WGR used in setup for ultra-stable temperature measurements.