Laboratoire ARTEMIS, UMR 7250
UMR CNRS-INSIS, Observatoire de la Côte d'Azur et Université Côte d'Azur

Thesis proposal 2020-2023

Study of photoreceivers under proton irradiation for the LISA space mission

Description of the subject:

This thesis is developed in the framework of the LISA (Laser Interferometer Space Antenna) International Consortium. An interdisciplinary collaboration between ARTEMIS, laboratory of the Observatory of the Côte d'Azur, and the Center of Proton-Therapy Antoine Lacassagne (CAL) in Nice is also part of the project.
The thesis concerns the study of the Photoreceivers dedicated to the LISA space mission: https://www.elisascience.org/articles/lisa-mission/lisa-mission-gravitational-universe

In the LISA instrument, the optical interference signal (λ = 1064 nm) is transformed into an electrical signal by a quadrant photodiode (QPD), connected to a front-end electronics (FEE), the assembly having the name " Photoreceiver" (PR). The performance of PR in terms of detection efficiency, bandwidth, noise, power dissipation, is essential to ensure the accuracy required for the measurement of gravitational waves signals in the LISA instrument.

Throughout the duration of the mission, estimated at 12.5 years, the PR will be subjected to irradiation of solar energetic particles (protons) likely to affect their proper functioning, or even lead to their destruction. The hardening and qualification of PR in space environment represents therefore a major technological challenge for a space mission like LISA, which is based on high precision interferometric optical measurements.

The main objective of the thesis is the validation of the Photoreceivers for the LISA mission. In this context, the thesis proposes the study and understanding of the damage mechanisms of PR in space environment. The effect of PR characteristics degradation in laser interferometric testing facilities similar to the LISA instrument will be also investigated.

Physicist/engineer and experimenter, the PhD student will have to develop electro-optical test benches to characterize QPD specific parameters (dark current, capacitance, detection efficiency and homogeneity of the spatial response), but also to measure the global parameters of PR (noise, power dissipation, bandwidth). Experimental measurements in air and under vacuum, before and after proton irradiation, will have to be carried out.

The PhD student will contribute actively to the building of the experimental system necessary for the irradiation and testing of PR at the proton irradiation facility. Monte Carlo simulations are required for the definition and optimization of the irradiation conditions (geometry, fluence, energy). The PhD student will study the effect of degradation of PR characteristics on the interferometric measurements and contribute to the implementation of these results to the LISA Instrument Performance Model.

Thus, the results will help guide the development of PR devices with the aim of minimizing degradation and improving electro-optical performances.
The proposed study is applied in a first step to the optimization of PR for the LISA mission. However, space applications like LIDAR sensors and inter-satellite optical communications as well as ground applications like high-speed optical digital transmission systems for high energy physics experiments may benefit from the results of the present thesis.

Knowledge and skills required: Physics of semiconductors; Radiation-matter interaction; Instrumentation associated with radiation experiments; Instrumentation associated with the characterization of photo-detectors; Electronics associated with photo-detectors; Photonics / lasers; Homodyne and heterodyne interferometry; Analog and digital signal processing; Interfacing of experience setups; Use of semiconductor simulation tools (SILVACO TCAD); Space engineering.

Recommended profile of the candidate: Graduate of engineering school or master in materials physics, photonics / lasers or aerospace, general knowledge in signal processing and analysis, interest for measurements and precision, a strong attraction for instrumentation and electronics, both autonomous, imaginative, persevering and able of taking a look back on the results. A perfect knowledge of written and oral English is imperative: almost all of the documentation is in English.

Thesis supervisors:
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https://www.aei.mpg.de/179093/Interferometry_in_Space

Interested candidates are requested to send an application including:

- CV
- list of previous grades (Bachelor and Master)
- 2 letters of recommendation
- cover letter

and get in contact with Nicoleta Dinu-Jaeger (Nicoleta.Dinu-Jaeger@oca.eu) as soon as possible for preliminary discussion/selection before the **formal deadline (April 6th)** application for the financial support.