

## PROPOSITION DE STAGE EN COURS D'ETUDES

Référence : **DOTA-2026-26**  
(à rappeler dans toute correspondance)

Lieu : Laboratoire d'Astrophysique de  
Marseille & centre ONERA de Salon  
de Provence

Département/Dir./Serv. : PHY/DOTA/HRA

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### DESCRIPTION DU STAGE

Thématique(s) : Optics, Physics, Adaptive Optics, Wave-Front Sensing

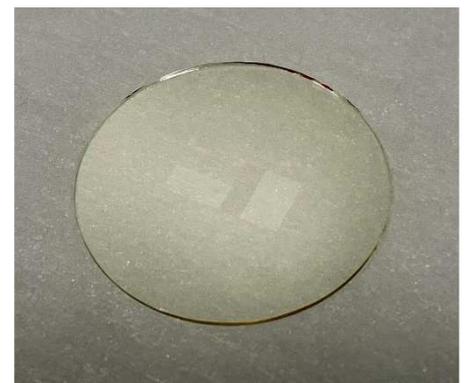
Type de stage :  Fin d'études bac+5  Master 2  Bac+2 à bac+4  Autres

**Intitulé: Paving the way to the first on-sky demonstration of the Bi-O Edge, a new wave-front concept dedicated to exoplanetary science**

In a few years from now, the Extremely Large Telescope (ELT - <https://elt.eso.org/>) will provide the astronomy community with a revolutionary observing facility achieving unprecedented angular resolution thanks to its 40-m diameter primary mirror. Adaptive Optics (AO) systems will have a crucial role to counter-act optically and in real time on the optical aberrations induced by the atmospheric turbulence and the telescope itself.

In the context of exoplanetary science, the performance of classical AO systems will however not meet the quality of wave-front control and high contrast level required to separate earth-like exoplanet from their host star using coronagraphic capabilities [Kasper et al 2021 - <https://arxiv.org/abs/2103.11196>]. This very ambitious goal requires indeed the development of **eXtreme AO (XAO)** to minimize any source of error that could jeopardize the observation. As part of this R&D activity, innovative AO concepts and components such as high actuator count deformable mirrors (DM) and ultra-sensitive Wave-Front Sensors (WFS) are currently investigated by the AO community.

In this context, the joint team ONERA & LAM is focusing on the development of a new WFS concept, the Bi-O Edge [Vérinaud et al 2021 - <https://arxiv.org/abs/2309.07485>], that promises a significant gain in sensitivity with respect to the current state of the art. This WFS, inspired from the Foucault Knife Edge Test, was designed to take into account the needs and specificity of future XAO instruments to maximize the AO performance at high speed. The concept has already been validated in simulation and a first prototype is currently being studied experimentally on a test bench at LAM making use of polarizing elements to perform the beam separation. **The next milestone of the project is to make the first On-Sky validation of concept in real conditions.** To achieve this goal, the WFS will be integrated in the EKARUS AO system on the Copernico Telescope at the Asiago Observatory (<https://sites.google.com/inaf.it/adoni-coude/ekarus>).



*Bi-O Edge mask prototype based on liquid crystal to perform the spatial filtering*

As part of the EKARUS project, this internship will focus on developing the experimental branch dedicated to testing the Bi-O-Edge concept. The work will take place within the R&D group of the ONERA/LAM joint team (<https://www.lam.fr/recherche/equipe/groupe-rd-optique-instrumentation/presentation/>), in close collaboration with the EKARUS team in Italy.

The internship will combine experimental and numerical work, **with the main objective of designing and validating the Bi-O-Edge optical branch** in preparation for its integration into the EKARUS adaptive optics system. Depending on the progress of the project, the student may contribute to other development phases of the instrument.

Envisioned activities include:

- Defining key experimental parameters (e.g. pupil magnification, prototype geometry, detector sampling).
- Running end-to-end simulations to predict on-sky performance and evaluate the design's impact on AO performance.
- Performing a photometric budget of the full optical chain (Telescope + EKARUS bench + Bi-O-Edge branch).
- Selecting off-the-shelf optical and optomechanical components.
- Validating the final optical design and carrying out a tolerancing analysis.
- Procuring, assembling, and characterizing the chosen hardware in the lab.
- Measuring and characterizing the Bi-O-Edge mask (e.g. transmittance, geometry).
- Contributing to EKARUS project activities, including technical meetings and presentations.

This internship is an opportunity to gain experience on various aspects of wave-front sensing that will be very valuable for candidates that would like to apply to PhD positions in the field of Adaptive Optics. A PhD on the topic is not envisioned but other PhD positions in the frame of the EKARUS project are expected to be out in 2026 if the fundings are secured.

**Supervising Team :**

- F. Leroux is a 2<sup>nd</sup> year PhD student working on the Bi-O-Edge WFS concept.
- C.T Héritier is a researcher in Adaptive Optics, co-proposant of Bi-O Edge concept, co P-I of the EKARUS project and main PhD supervisor of F. Leroux.

**External collaboration :**

- C. Vérinaud (ESO), AO scientist, proposant of the Bi-O Edge concept, co-supervisor of F. Leroux.
- D. Greggio (INAF-Padova), AO Scientist, Co-PI of the EKARUS project.

Est-il possible d'envisager un travail en binôme ?    Non

**Méthodes à mettre en oeuvre :**

- |   |   |
|---|---|
| <input type="checkbox"/> Recherche théorique                | <input checked="" type="checkbox"/> Travail de synthèse             |
| <input checked="" type="checkbox"/> Recherche appliquée     | <input checked="" type="checkbox"/> Travail de documentation        |
| <input checked="" type="checkbox"/> Recherche expérimentale | <input checked="" type="checkbox"/> Participation à une réalisation |

Possibilité de prolongation en thèse : Non

**Durée du stage :**                      Minimum : 4 months                      Maximum : 5 months (6 months on exemption only)

Période souhaitée : spring semester/summer 2026

**PROFIL DU STAGIAIRE**

**Connaissances et niveau requis :**

- Geometrical and Fourier Optics
- Laboratory Experience in Optics
- Data Analysis,
- Programming skills (Python preferred, Experience with Zemax appreciated)
- English language required

**Ecoles ou établissements souhaités :**

Engineering school of Optics, Master in Astronomy, Master in Instrumentation, Optics, Physics