Position Description

1. General Information

Name of the position	**Laser Written optical devices for Astrophotonic and Planetology applications**
Foreseen date of enrolment	1 October 2023
Position is funded by	• COFUND, Marie Skłodowska-Curie Actions (MSCA), Horizon Europe, European Union • Université Grenoble Alpes (UGA) • Macquarie University (MQ)
Research Host	Université Grenoble Alpes
PhD awarding institutions	Université Grenoble Alpes & Macquarie University
Locations	Primary: Grenoble, France Secondary: Sydney, Australia
Supervisors	Guillermo MARTIN (UGA) Simon GROSS (MQ)
Group of discipline	Physics, Optical Engineering, Optics, Lasers & Matter Interaction

2. Research topics (only one of these projects will be funded)

Project 1: *Design and Fabrication of Multi-Telescopes Visible Beam Combiners by Ultrafast Laser Inscription*
Design and Fabrication of a 9T Visible Beam Combiner by ULI, for the FIRST/SUBARU instrument FIRST (Fibered Imager foR a Single Telescope instrument) is an astronomical instrument, installed at the Subaru telescope that enables high contrast imaging and spectroscopy by using a unique combination of sparse aperture masking, spatial filtering by single-mode waveguides and cross-dispersion in the visible. In order to increase the instrument's stability and sensitivity, it is compulsory to increase the number of input waveguides and ideally achieve on-chip phase modulation. The proposed project aims the development of a thermo-optically tuned photonic beam combiner, where the waveguides will be fabricated using Ultrafast Laser Inscription (ULI). The device will enable the interferometric combination of 9 sub-apertures. Three main activities related to fabrication using ULI are identified: a) Input Splitters: Each of the N inputs must be split into N-1 single mode waveguides, with identical flux distribution.

This project has received funding from the European Union's Horizon Europe research and innovation programme under the Marie Skłodowska-Curie grant agreement Nº 101081465

b) Thermo-Optic phase modulation: Thanks to the versatility of ULI, waveguides will be inscribed close to the surface, where micro-heaters will interact with the waveguide, slightly modifying the refractive index, and therefore the phase of the optical beam.
c) Recombination stage: Finally, all the inputs will be combined by pairs using c.1) reversed Y-junctions or c.2) directional couplers.

The student will have to optimize each of the basic functions (Y-junction for splitting, reversed Y-junctions and combiners for beam combination), ideally ensuring achromatic behaviour over the spectral band of interest (600-900nm). Also, an optimization of micro-heaters in order to achieve hundreds of Hz phase modulation will be studied.

During the PhD, the student will acquire the knowledge and skills to locally modify the optical material using ULI, in order to define the waveguiding structures. After a 12 months period of training at Macquarie Univ. the student will move to UGA in order to use the optical bench and characterize the optical chips in terms of interferometric performances. The student will also be formed to simulations tools such as Beamprop, in order to model the fabricated waveguides and study propagation, transmission and interferometric expected behaviour of the beam combiners.

If the optical waveguide chips perform as desired, a secondment at the Subaru Telescope is expected, in order to conduct astronomical observations using the FIRST instrument and test the prototypes in a real environment.

Finally, valorisation will be developed through our collaboration with TeemPhotonics, a French company, based near UGA, that develops laser and photonic chips using classical ion indiffusion fabrication methods. Thanks to ULI, more dense and complex circuits can be obtained, that have an interest for Teemphotonics, in order to develop Visible spectro-interferometers. It is also expected that the student makes shorts secondments at FIRST/SUBARU telescope, in order to test the optical chips in the real instrument, if the targeted performances are reached.

Supervisors:

Guillermo Martin (UGA - IPAG), Simon Gross (MQ), Olivier Guyon (SUBARU Telescope) & Cédric Cassagnettes (TeemPhotonics)

Research Fields: Physics, Optical Engineering, Optics & Photonics, Lasers&Matter Interaction

Project 2: *Design and Fabrication of near IR mode selective Photonic Lanterns for high efficiency flux collection, coupled to SWIFTS spectrometers*

Design and Fabrication of near IR mode selective Photonic Lanterns for high efficiency flux collection, coupled to SWIFTS spectrometers

Astrophotonic applications (interferometry, spectrometry) are linked to the development of single-mode waveguides that, by definition, have low numerical apertures and therefore collect a reduced amount of light, which translates into a reduced sensitivity. In order to improve the collection efficiency, an interesting approach is the use of photonic lanterns.

These systems allow for high efficiency flux collection due to their multimode input, which then is split in a loss-less manner into a number of single-mode waveguides. A lantern can be made mode-selective by introducing asymmetry. As a result, phase information is preserved which extends its application to interferometry.

The main objectives of this project are:

a) To develop and optimise near IR mode selective photonic lanterns using Ultrafast Laser Inscription
b) To couple the lantern to an integrated optics spectrometer

In order to achieve the complete prototype, the student will have to optimize the photonic lantern for maximum flux collection efficiency. Also, a detailed study on the phase distribution among the different outputs will be done.

This project has received funding from the European Union's Horizon Europe research and innovation programme under the Marie Skłodowska-Curie grant agreement Nº 101081465

During the PhD, the student will acquire the knowledge and skills to locally modify the optical material using ULI, in order to define the waveguiding structures and lanterns for the near IR. After a 12 months period of training at Macquarie Univ. the student will move to UGA in order to use the optical bench and characterize the optical chips in terms of transmission and temporal stability. The student will also be formed to simulations tools such as Beamprop, in order to model the fabricated waveguides and study propagation, transmission and interferometric expected behaviour of the lanterns.

Finally, valorisation will be developed through our collaboration with TeemPhotonics, a French company, based near UGA, that develops laser and photonic chips using classical ion indiffusion fabrication methods. Thanks to photonic lanterns developed by ULI, more complex circuits can be obtained, that have an interest for Teemphotonics, in order to develop near IR spectrometers. The idea will be to couple the photonic lantern to the optical waveguides developed by Teem. These waveguides contain near IR spectrometers, which sensitivity could be increased by the use of photonic lanterns to improve flux collection.

Supervisors:

Guillermo Martin (UGA - IPAG), Simon Gross (MQ), Olivier Guyon (SUBARU Telescope) & Cédric Cassagnettes (TeemPhotonics)

Research Fields: Physics, Optical Engineering, Optics & Photonics, Lasers&Matter Interaction

Project 3: *Mid IR beam combiners for Nulling Interferometry in novel optical materials*

The ASGARD-NOTT instrument is a nulling beam combining instrument that is proposed for the VLTI. Its heart is currently based on a photonic circuit capable of interfering the light coming from the four telescopes operating in the 3-4 microns regime. The aim of the project is to develop low-loss, laser written waveguides and components in novel mid IR materials, passive but also active electro-optic materials such as lithium niobate.

The goals of the project are:

a) Develop and characterise low loss mid-infrared waveguides in novel materials
b) Investigate bend losses experimentally and via simulations
c) Develop basics components such as Y-junctions and directional couplers
d) Develop electro-optic or thermo-optical phase shifters
e) Develop and characterise a fully integrated 4 telescope beam combiner

During the PhD, the student will acquire the knowledge and skills to locally modify the optical material using ULI, in order to define the waveguiding structures and couplers for the mid infrared. After a 12 months period of training at Macquarie Univ. the student will move to UGA in order to use the optical bench and characterize the optical chips in terms of transmission and temporal stability. The student will also be formed to simulations tools such as Beamprop, in order to model the fabricated waveguides and study propagation, transmission and interferometric expected behaviour of the mid IR beam combiners.

If the optical chips are performant, they will be tested at KU Leuven (D. Defrère) who is PI of the ASGARD-NOTT instrument in order to see if they are suitable for the key scientific objectives of the instrument.

Finally, valorisation will be developed through our collaboration with TeemPhotonics, a French company, based near UGA, that develops laser and photonic chips using classical ion indiffusion fabrication methods. Thanks to 3D waveguides developed by ULI, more complex circuits can be obtained, that have an interest for Teemphotonics, in order to develop mid IR photonic devices.

Supervisors:

This project has received funding from the European Union's Horizon Europe research and innovation programme under the Marie Skłodowska-Curie grant agreement Nº 101081465

Guillermo Martin (UGA - IPAG), Simon Gross (MQ), Cédric Cassagnettes (TeemPhotonics) & Denis Defrère (KU Leuven)]
Research Fields: Physics, Optical Engineering, Optics & Photonics, Lasers&Matter Interaction

3. Employment Benefits and Conditions

The Université Grenoble Alpes offers a 36-months full-time work contract (with the option to extend up to a maximum of 42 months). There is a probation period of 2 months and the total working hours per week is 36h40.

The remuneration, in line with the European Commission rules for Marie Skłodowska-Curie grant holders, will consist of a gross annual salary of 27,907 EUR. Of this amount, the estimated net salary to be perceived by the Researcher is 1,870 EUR per month. However, the definite amount to be received by the Researcher is subject to national tax legislation.

Benefits include

- Access to all the necessary facilities and laboratories at Université Grenoble Alpes and Macquarie University, including GRICAD computational facilities.
- Tuition fees exemption at both PhD awarding institutions.
- Yearly travel allowance to cover flights and accommodation for participating in AUFRANDE events.
- 10,000 EUR allowance to cover flights and living expenses for 12 months in Australia.
- 45 days paid holiday leave.
- Sick leave.
- Parental leave.

4. PhD enrolment

Successful candidates for this position will be enrolled by the following institutions and must comply with their specific entry requirements, in addition to AUFRANDE's conditions.

Université Grenoble Alpes

To enrol in a Doctorate program you must meet the general conditions, namely:

- to hold a French diploma conferring the degree of master at the end of a training programme establishing the aptitude for research;
- to hold a foreign diploma of equivalent level (obtained at the end of a training programme establishing the aptitude for research). In this case, you should request an exemption from the Master's degree when you apply;
- benefit from the validation of prior learning as provided for by the Education Code.

This project has received funding from the European Union's Horizon Europe research and innovation programme under the Marie Skłodowska-Curie grant agreement Nº 101081465

More information: https://doctorat.univ-grenoble-alpes.fr/preparing-a-phd/doctorate-enrolment/apply-and-register-in-doctoral-school-890537.kjsp?RH=1611137559271

Macquarie University

The minimum requirement for admission to a PhD degree is:

- Completion of a Master of Research (MRes) with a grade of at least a Distinction level (75% or greater in second year; or
- A Master of Philosophy; or
- A two-year Master's degree with a major research component at Distinction level (75% or greater).

Short-listed applicants will need to demonstrate their suitability for entry to the program by:

- Providing a detailed research proposal; and
- Providing evidence of the required level of English language proficiency.

Furthermore, applicants must qualify for a Cotutelle scholarship. Macquarie University assesses applicants for the scholarship based primarily on academic merit and research experience, emphasising previous thesis outcomes. Additional information such as peer-reviewed publications, conference and poster presentations and relevant work or professional experience may also be taken into account. Applicants are rated according to the principle and process outlined in the Higher Degree Research Scholarship Rating Sheet.

Short-listed applicants will be required to submit an application to the PhD program and the Cotutelle scholarship via Macquarie University's online application system.

Successful applicants (if non-Australian citizen) will be required to:

- Meet Australian visa requirements; and
- Obtain Overseas Student Health Cover (OSHC) for the entire duration of their study in Australia.

More information: https://policies.mq.edu.au/document/view.php?id=268

This project has received funding from the European Union's Horizon Europe research and innovation programme under the Marie Skłodowska-Curie grant agreement № 101081465