Position Description

1. General Information

Name of the position	**Complex spatio-temporal dynamics from multimode optical fiber**
Foreseen date of enrolment	1 October 2024
Position is funded by	• COFUND, Marie Skłodowska-Curie Actions (MSCA), Horizon Europe, European Union • CentraleSupélec • Macquarie University
Research Host	CentraleSupélec
PhD awarding institutions	CentraleSupélec & Macquarie University
Locations	Primary: Metz, France Secondary: Sydney, Australia
Supervisors	Delphine Wolfersberger and Marc Sciamanna (CentraleSupélec) Alexander Fuerbach and Mick Withford (Macquarie)
Group of discipline	Photonics

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

Project 1: *Optical signal processing using complex spatio-temporal dynamics from multimode fiber*

The increasing traffic over optical networks, as well as innovative concepts applied to telecommunications such as spatial division multiplexing, have generated a renewed interest in multimode fiber optics.

Most interestingly, the inherent optical nonlinearity in multimode fiber combined with the random linear and the deterministic nonlinear mode coupling mechanisms is at the origin of newly observed dynamics such as multimode optical solitons and mode-locking of transverse modes. These dynamics offer innovative solutions for optical signal processing including the generation of ultrafast light pulses, optical sensing, neuro-inspired optical computing.

This thesis will benefit from the expertise of both groups, respectively in nonlinear photonics and in fiber optics technology and characterization, to revisit the earlier theories and experiments of nonlinear spatio-temporal dynamics of multimode fibers and to address new issues including the observation of chaotic spatio-temporal dynamics and their

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use for optical signal processing and information security: self-beam cleaning suppressing light speckle, super continuum generation with increasing bandwidth, or even the generation of unconventional light transverse profiles including optical vortices.

The project will benefit from interactions with several companies in the fields of optical materials and telecommunications, and in particular with the founding partners of the Chair in Photonics at CentraleSupélec.

References:

1. Katarzyna Krupa, Alessandro Tonello, Alain Barthélémy, et al., APL Photonics 4, 110901 (2019)
2. Dong Mao, Mingkun Li, Zhiwen He, et al., APL Photonics 4, 060801 (2019)

Supervisors:

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Alexander Fuerbach and Mick Withford (Macquarie)

Research Fields: Photonics, Nonlinear science

Project 2: *Spatio-temporal solitons from multimode fiber*

The increasing traffic over optical networks, as well as innovative concepts applied to telecommunications such as spatial division multiplexing, have generated a renewed interest in multimode fiber optics.

Most interestingly, the inherent optical nonlinearity in multimode fiber combined with the random linear and the deterministic nonlinear mode coupling mechanisms is at the origin of newly observed dynamics such as multimode optical solitons, self-beam cleaning suppressing light speckle, and super continuum generation with increasing bandwidth.

This thesis will benefit from the expertise of both groups, respectively in nonlinear photonics and in fiber optics technology and characterization, to revisit the earlier theories and experiments of nonlinear spatio-temporal dynamics of multimode fibers and to address new issues including the transition from temporal multimode solitons to stable spatio-temporal solitons also called light bullets and the onset of dissipative solitons in multimode fiber cavity. These dynamics will offer alternative approaches and solutions to conventional optical signal processing.

The project will benefit from interactions with several companies in the fields of optical materials and telecommunications, and in particular with the founding partners of the Chair in Photonics at CentraleSupélec.

References:

1. Katarzyna Krupa, Alessandro Tonello, Alain Barthélémy, et al., APL Photonics 4, 110901 (2019)
2. Dong Mao, Mingkun Li, Zhiwen He, et al., APL Photonics 4, 060801 (2019)

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Research Fields: Photonics, Nonlinear science

Project 3: *Spatio-temporal solitons from multimode fiber*

The increasing traffic over optical networks, as well as innovative concepts applied to telecommunications such as spatial division multiplexing, have generated a renewed interest in multimode fiber optics.

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Most interestingly, the inherent optical nonlinearity in multimode fiber combined with the random linear and the deterministic nonlinear mode coupling mechanisms is at the origin of newly observed dynamics such as self-beam cleaning suppressing light speckle, the generation of unconventional light transverse profiles including optical vortices and polarization rotation. These dynamics offer possibilities for all-optical control of beam profiles.

This thesis will benefit from the expertise of both groups, respectively in nonlinear photonics and in fiber optics technology and characterization, to exploit the full potential of the multimode spatio-temporal dynamics in fiber systems for beam control and unconventional beam generation.

The project will benefit from interactions with several companies in the fields of optical materials and telecommunications, and in particular with the founding partners of the Chair in Photonics at CentraleSupélec.

References:

1. Katarzyna Krupa, Alessandro Tonello, Alain Barthélémy, et al., APL Photonics 4, 110901 (2019)
2. Dong Mao, Mingkun Li, Zhiwen He, et al., APL Photonics 4, 060801 (2019)

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Research Fields: photonics, nonlinear science

3. Employment Benefits and Conditions

CentraleSupélec offers a 36-months full-time work contract (with the option to extend up to a maximum of 42 months). There is a two months' probation period and the total working hours per week is 39h/week.

The remuneration, in line with the European Commission rules for Marie Skłodowska-Curie grant holders, will consist of a gross annual salary of 29,388 EUR. Of this amount, the estimated net salary to be perceived by the Researcher is 1,936 EUR per month. However, the definite amount to be received by the Researcher is subject to national tax legislation.

Benefits include

- Becoming a Marie Skłodowska-Curie fellow and be invited to join the Marie Curie Alumni Association.
- Access to CentraleSupélec and Macquarie University facilities and LMOPS laboratory.
- 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.
- 25 days paid holiday leave according to the rules at CentraleSupélec.
- Social security rights.
- Parental leave.

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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.

Applicants must hold a Master's or equivalent degree with a major research component at Distinction level (75% or greater).

Applicants must demonstrate an English language proficiency equivalent to an overall IELTS score above 6.5 and no band below 6.

More information on CentraleSupélec's requirements

Visit the website: https://www.centralesupelec.fr/en/doctoral-studies

More information on Macquarie University's requirements

Short-listed applicants will need to demonstrate their suitability for entry to the program by submitting an application to the PhD program and the Cotutelle scholarship via Macquarie University's online application system. The application must include:

- A detailed research proposal; and
- 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.

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.

Visit the website: https://policies.mq.edu.au/document/view.php?id=268

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