AUFRANDE

Aix*Marseille université Socialement engagée

THE UNIVERSITY OF SYDNEY

Position Description

1. General Information

Name of the position	**Near-field effects in electromagnetism**
Position is funded by	• COFUND, Marie Skłodowska-Curie Actions (MSCA), Horizon Europe, European Union • Aix-Marseille Université (AMU) • The University of Sydney (USYD)
Research Host	Aix Marseille Université
PhD awarding institutions	Aix-Marseille Université & The University of Sydney
Locations	Primary: Marseille, France Secondary: Sydney, Australia
Supervisors	Stefan Enoch (CNRS, AMU) Redha Abdeddaim (AMU) Martijn de Sterke (USYD) Boris Kuhlmey (USYD) Alessandro Tuniz (USYD)
Group of discipline	Physics, Electrical Engineering

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

Project 1: *Local density of States in Complex environments*
Spontaneous emission is a random process, somewhat like radioactive decay. Given a set of atoms in an excited state, it is known how long, on average, they stay there before relaxing to the ground state but predicting which atoms relax and which do not is impossible. The spontaneous emission lifetime is a bit like the radioactive half-life, and indeed they differ by only a factor ln(2). For decades it was assumed that the spontaneous emission lifetime was an intrinsic property of the atomic species, a bit like the mass. However, this is not so—the spontaneous emission lifetime depends on the environment in which it is placed. For example, if an atom is placed in a cavity from which light cannot escape then the photons cannot escape and the spontaneously emission is profoundly changed. In fact, the spontaneous emission lifetime is determined by the *Local Density of States*, the number of states available to photons as a function of position; in the node of the electric field, for example, the Local Density of States vanishes. Measuring these changes is very difficult since atoms are small, and their detailed environments are difficult to control. We have recently pioneered a technique carry out equivalent techniques but, in the microwave, and terahertz regions of the

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electromagnetic spectrum. Such experiments are relatively easier and make use of techniques that have been developed for these wavelength ranges.

The aim of this project is to carry out microwave and/or terahertz experiments to characterise the Local Density of States in a number of complex environments, for example in near waveguides and in band gaps of photonic crystals and to understand the results using intensive computer simulations. The results will be applied to practical devices, for example scintillators for medical devices or antennas for MRI systems.

Multiwave Imaging (MW) will provide a non-academic secondment and give concrete and valuable insights regarding impact development and creation. MW and Institut Fresnel are already research partners for more than 5 years and have co-supervised several PhD students in various topics including near field energy transfer and biomedical applications. The secondment will also help the PhD student to develop a network of non-academic contacts, expanding their career opportunities.

Supervisors:

Stefan Enoch (CNRS, AMU); Redha Abdeddaim (AMU)

Martijn de Sterke (USYD); Boris Kuhlmey (USYD); Alessandro Tuniz (USYD)

Marc Dubois (MW)

Research Fields: Photonics, microwave physics, terahertz physics

Project 2: *Förster energy transfer*

Förster Resonant Energy Transfer (FRET) is a fundamental phenomenon that described the exchange of energy between two atoms (the “donor” and the “acceptor”). Initially one of the atoms is in the excited state and the other is in the ground state. In the final state this situation is reversed. FRET is important in many processes, for example in photosynthesis and to track interactions between proteins. In free space, FRET strongly depends on the relative positions of the donor and the acceptor: if they are far apart the FRET rate, the rate at which the energy transfers, is dominated by radiation and decreases as r-2, but in the near field it drops at r-4 or r-6 depending on the orientation of the dipoles. The FRET rate also depends strongly on the environment, particularly if this environment has features that are comparable to the wavelength. Doing systematic experiments on the FRET rate at optical wavelengths is very difficult because it requires submicrometer positioning in well-controlled environments. We have shown that such experiments can be carried out using microwaves and terahertz radiation.

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Project 3: *Investigation of terahertz waveguides by near-field probing*
Waveguides, as the name suggests, are devices that guide light. Though the best-known example of these are optical fibres, most waveguide are chip-based and quite short. We recently discovered a method to characterise waveguides using a near-field emitter and receiver. The near-field effects allow for the full control over the excitation of the waveguide modes, which can then be picked up by the receiver. Scanning the receiver and taking the spatial Fourier transform then gives the allowed wavenumbers of the modes as a function of frequency. Although this is conceptually straightforward for simple planar waveguides which, the investigation of much more complicated, and interesting, for waveguides with structure such as photonic crystal waveguides. It will also be possible to investigate more exotic structures in this way, for example those with Weyl points or Dirac points which can occur in topological materials, materials in which the light flow is confined to the edges of a material, rather than to the bulk. In this project you will carry out experiments to characterise the modes of waveguides and compare with numerical simulations. Multiwave Imaging (MW) will provide a non-academic secondment and give concrete and valuable insights regarding impact development and creation. MW and Institut Fresnel are already research partners for more than 5 years and have co-supervised several PhD students in various topics including near field energy transfer and biomedical applications. The secondment will also help the PhD student to develop a network of non-academic contacts, expanding their career opportunities.
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Research Fields: Applied Physics, Photonics, Electromagnetic waves

3. Employment Benefits and Conditions

Aix-Marseille Université offers a 36-months full-time work contract (with the option to extend up to a maximum of 42 months).

The remuneration, in line with the European Commission rules for Marie Skłodowska-Curie grant holders, will consist of a gross annual salary of 28,764 EUR. Of this amount, the estimated net salary to be perceived by the Researcher is 1,926 EUR per month (before the deduction of tax at source). 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 Institut Fresnel (Aix-Marseille Université) and The University of Sydney.
- Tuition fee waiver 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.

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- Contractual doctoral students are subject to the same sick leave rights as other contractual employees of the State Civil Service, namely: the contractual agent in activity benefits, on presentation of a medical certificate, during twelve consecutive months if its use is continuous or during a period including three hundred days of effective services if its use is discontinuous, of sick leave within the following limits
    - After 4 months of service: 1 month on full pay and 1 month on half pay;
  - After 2 years of service:
    - 2 months on full pay and 2 months on half pay;
  - After 3 years of service:
    - 3 months on full pay and 3 months on half pay.
- Parental leave: if the employee has at least 1 year's seniority at the date of the child's birth, he/she is entitled to parental leave at his/her request (after maternity leave for the mother or paternity leave for the father). This leave ends at the latest when the child is 3 years old. The leave is granted for renewable periods of 2 to 6 months. He/She must apply for it at least 2 months before the start of the 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.

Aix-Marseille Université

To enrol in a Doctorate program you must hold a Master's or equivalent degree. Doctoral candidates holding a Master's degree outside the Bologna process or a degree equivalent to a Master's degree must submit an application for a Master's Degree for validation to the doctoral school secretariat prior to their enrolment.

More information: https://college-doctoral.univ-amu.fr/en

Important: as Institut Fresnel (Aix-Marseille Université) is subjected to ZRR (Zone à Régime Restrictif) regulation, hiring choices must be approved by the Haut Fonctionnaire Securité Défense (HFSD).

The University of Sydney

To apply for a PhD, you need to demonstrate sufficient prior research experience and capability and prove English language proficiency (see: https://www.sydney.edu.au/study/how-to-apply/international-students/english-language-requirements.html). In most cases, you will have either:

- a Bachelor's degree with first or upper second class Honours; or
- a Master's degree performed at a high academic standard, and which includes a substantial component of original research; or
- an equivalent qualification that demonstrates research experience, excellence and capability.

These are the minimum requirements for eligibility, but they do not guarantee admission. Admission remains at the discretion of the Associate Dean (Higher Degree by Research) for each faculty.

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For more information on admission requirements, please visit the University of Sydney's Apply for postgraduate research page: https://www.sydney.edu.au/study/how-to-apply/postgraduate-research.html

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