Position Description

1. General Information

Name of the position	**Experimental study of laser-driven nuclear interactions**
Foreseen enrolment date	1 July 2024
Position is funded by	• COFUND, Marie Skłodowska-Curie Actions (MSCA), Horizon Europe, European Union • Centre National de la Recherche Scientifique (CNRS) • The University of New South Wales (UNSW)
Research Host	Centre National de la Recherche Scientifique - CELIA - Centre Lasers Intenses et Applications - UMR5107
PhD awarding institutions	Université de Bordeaux & The University of New South Wales
Locations	Primary: Bordeaux, France Secondary: Sydney, Australia
Supervisors	Didier Raffestin (UB), Dimitri Batani (UB) François Ladouceur (UNSW)
Group of discipline	Nuclear engineering, plasma physics, photonics

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

Project 1: *Experimental study of laser-driven nuclear interactions: focus on energy production*
Almost all efforts to realize fusion-based energy generation involve thermally fusing two isotopes of hydrogen – deuterium with tritium (DT fusion). Due to recent advances in laser technology – and in particular chirped pulsed amplification (CPA) – it is now believed that a viable, although difficult, path to fusion can rest on the fusion of hydrogen (H) with boron (B). The HB fusion reaction possesses the key advantage that it is aneutronic i.e. that it does not release energetic neutrons. This would virtually eliminate the deleterious environmental impact associated with neutron radiation (activation of material) and overall greatly enhance operational safety and drastically reduce production of radioactive waste. The key to unlock the potential of HB fusion is to move away from thermal equilibrium by providing to the reactants the kinetic energy necessary for fusion not through thermal motion but through electromagnetic field acceleration. While petawatt laser systems have already been used for fusion experiments providing interesting results, a strong need exists to explore the wide parameter space (in terms of pulse duration, peak power, focussing geometry) that is needed for optimising the process of particle generation in order to enabling HB fusion in a controlled environment. This project is in collaboration with the Centro de Laseres PUlsados (CLPU), Salamanca, Spain and HB11 Energy Pty Ltd, Sydney, Australia.
Supervisors: Didier Raffestin (UB), Dimitri Batani (UB), François Ladouceur (UNSW)

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Research Fields: Nuclear engineering, plasma physics, photonics

Project 2: *Experimental study of laser-driven nuclear interactions: focus on radio-isotopes production*
Almost all efforts to realize fusion-based energy generation involve thermally fusing two isotopes of hydrogen – deuterium with tritium (DT fusion). Due to recent advances in laser technology – and in particular chirped pulsed amplification (CPA) – it is now believed that a viable, although difficult, path to fusion can rest on the fusion of hydrogen (H) with boron (B). The HB fusion reaction possesses the key advantage that it is aneutronic i.e. that it does not release energetic neutrons but rather high-energy alpha particles. In addition to nuclear fusion for energy, and on a shorter time scale, such alpha particles could be used for the generation of radioisotopes of medical interest. While petawatt laser systems have already been used for fusion experiments providing interesting results, a strong need exists to explore the wide parameter space (in terms of pulse duration, peak power, focussing geometry) that is needed for optimising the process of particle generation and for allowing the development of a future generation of particle sources and more specifically of alpha particle sources. This opens the possibility of triggering reactions requiring high-energy particles, useful, for instance, for producing radioisotopes of medical interest. This project is in collaboration with the Centro de Laseres PUlsados (CLPU), Salamanca, Spain and HB11 Energy Pty Ltd, Sydney, Australia.
Supervisors: Philippe Nicolai (UB), Dimitri Batani (UB), François Ladouceur (UNSW)
Research Fields: Nuclear engineering, plasma physics, photonics

Project 3: *Experimental study of laser-driven nuclear interactions: focus on new, optimised fuel compounds*
Due to recent advances in laser technology – and in particular chirped pulsed amplification (CPA) – it is now believed that a viable path to fusion can rest on the fusion of hydrogen (H) with boron (B). In all demonstrations of laser-driven HB fusion reactions, almost no effort has been made to optimise the fuels to achieve the maximum reaction gains. For example, neither simple hydrogen loading (as often used by the fibre optics industry) nor tailor-made boron nitride materials have been investigated so far. We intend to use newly developed fuels provided by our partner organisation HB11 Energy to conduct the experiments using a fuel that is optimised for the generation and observation of HB fusion reactions where unwanted nuclear reactions (e.g. with nitrogen) could possibly be eliminated. Furthermore, samples including nano-structured boron nitride engineered to contain high quantities of hydrogen, or new materials containing only isotopically pure boron-11 and hydrogen will be investigated. These materials will allow the laser parameters to be modelled and specifically optimised for these targets and provide the best possibility of quantifying the primary HB fusion reactions. This project is in collaboration with the Centro de Laseres PUlsados (CLPU), Salamanca, Spain and HB11 Energy Pty Ltd, Sydney, Australia.
Supervisors: Didier Raffestin (UB), Dimitri Batani (UB), François Ladouceur (UNSW)
Research Fields: Nuclear engineering, plasma physics, photonics

3. Employment Benefits and Conditions

CNRS offers a 36-months full-time work contract (with the option to extend up to a maximum of 42 months). The total working hours per week is 38.5h.

The remuneration, in line with the European Commission rules for Marie Skłodowska-Curie grant holders, will consist of a gross annual salary EUR 27,000. Of this amount, the estimated net salary to be perceived by the

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Researcher is EUR 1,850 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 all the necessary facilities and laboratories at the University of Bordeaux (namely CELIA - Centre Lasers Intenses et Applications - UMR5107) and UNSW.
- 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 up to 12 months in Australia.
- 45 days paid holiday leave.
- French Social security coverage.
- 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.

Applicants must hold a Master degree in physics, nuclear engineering or a related field recognised in France or an equivalent qualification awarded following a training course with a substantial research component and demonstrated capacity for timely completion of a high-quality research thesis.

Applicants must demonstrate an English language proficiency equivalent to an overall IELTS score above 6.5 and no band below 6. Note that the test needs to be completed no more than two years before enrolment. For more information about the tests accepted and scores required, visit: https://www.unsw.edu.au/study/how-to-apply/english-language-requirements

More information on the Université de Bordeaux' requirements

Visit the website: https://ed-spi.u-bordeaux.fr/

More information on UNSW' requirements

Visit the website: https://research.unsw.edu.au/higher-degree-research-programs

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