Position Description

1. General Information

Name of the position	**Theoretical and experimental study targeting laser-driven nuclear interactions**
Foreseen enrolment date	January 2025
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	Gerard Malka (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: *Theoretical and experimental study targeting 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. At the core of both the theoretical and the simulation models is the Boltzmann Transport Equation (BTE) which describes the statistical behaviour of a thermodynamic system out of equilibrium. As it stands, a large body of more or less disparate work exists but is yet to be integrated into an actual framework that could guide reactor design or optimise fusion yield. This research project seeks to look for additional experimental data, to federate existing theoretical contributions, to implement them in code when appropriate and to validate them experimentally.

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

AUFRANDE cnrs UNSW SYDNEY

This project is in experimental collaboration with the Centro de Laseres PUlsados (CLPU), Salamanca, Spain and HB11 Energy Pty Ltd, Sydney, Australia.
Supervisors: Gerard Malka (UB), Dimitri Batani (UB), François Ladouceur (UNSW)
Research Fields: Nuclear engineering, plasma physics, photonics

Project 2: *Theoretical and experimental study of laser-driven nuclear interactions: focus on radio-isotopes production*

Almost all efforts to realise 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 eb sued 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 develop theoretical and simulation models needed for optimizing the process of particle generation and for allowing the development of a future generation of radioisotope sources of medical interest. As it stands, a large body of more or less disparate work exists but is yet to be integrated into an actual framework that could guide the experimental development. This research project seeks to look for additional experimental data, to federate existing theoretical contributions, to implement them in code when appropriate and to validate them experimentally.

This project is in collaboration with the Centro de Laseres PUlsados (CLPU), Salamanca, Spain and HB11 Energy Pty Ltd, Sydney, Australia.

Supervisors: Gerard Malka (UB), Dimitri Batani (UB), François Ladouceur (UNSW)

Research Fields: Nuclear engineering, plasma physics, photonics

Project 3: *Theoretical and experimental study of laser-driven nuclear interactions: Harmonising and generalising simulation models*

The Monte-Carlo (MC), Particle-in-Cell (PIC) and Magnetohydrodynamics (MHD) methods are commonly used to tackle the simulation of system out of equilibrium such as those founds in astrophysics. The same approaches can be used to study laser-induced fusion reactions whose evolution is described by the (relativistic) Boltzmann Transport Equation (BTE). Solving the BTE in this context is a daunting task as it must take into account: (1) the creation of new atomics species caused by the fusion reactions, (2) the strength of non-homogenous electromagnetic gradient fields and (3) potential avalanche effects.

As it stands, a large body of more or less disparate work exists mixing and matching the various simulation approaches but an actual framework that could guide reactor design and optimise fusion yield is yet to be assembled. This research project seeks to look for additional experimental data, to federate existing theoretical contributions, to implement them in code when appropriate and to validate them experimentally.

This project is in collaboration with the Centro de Laseres PUlsados (CLPU), Salamanca, Spain and HB11 Energy Pty Ltd, Sydney, Australia.

Supervisors: Gerard Malka (UB), Dimitri Batani (UB), François Ladouceur (UNSW)

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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 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 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 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's requirements

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

More information on UNSW's requirements

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

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