AUFRANDE

Position Description

1. General Information

Name of the position	- Theoretical study targeting laser-driven nuclear interactions
Position is funded by	- **COFUND**, Marie Skłodowska-Curie Actions (MSCA), Horizon Europe, European Union - **FR Partner**, Centre National de la Recherche Scientifique - Bordeaux (CNRS-UBx) - **Au Partner**, University of New South Wales (UNSW)
Research Host	**FR Partner** Centre National de la Recherche Scientifique - Bordeaux (CNRS-UBx)
PhD awarding institutions:	**FR University**, Université de Bordeaux, **AU University**, University of New South Wales (UNSW)
Locations	- **Primary**: Bordeaux, France - **Secondary**: Sydney, Australia
Supervisors	**Name FR supervisor + name AU supervisor** Didier Raffestin (UB), Dimitri Batani (UB), François Ladouceur (UNSW)
Group of discipline	Nuclear engineering, plasma physics, photonics

2. Research options:

Project 1: Theoretical 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 behavior 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 federate existing theoretical contributions, to implement them in code when appropriate and to validate them experimentally. This project is in

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

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Research Fields: Nuclear engineering, plasma physics, photonics

Project 2: Theoretical 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 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 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.

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Project 3: Theoretical 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 thus aims to federate existing theoretical

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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.
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3. Employment Benefits and Conditions

CNRS offers a 36-months full-time work contract (official working time 38.5 h/week).

The remuneration, in line with the European Commission rules for Marie Skłodowska-Curie grant holders, will consist of a gross annual salary of approx. *25 620* EUR gross per year. Of this amount, the estimated net salary to be perceived by the Researcher is approx. *1715* EUR per month. However, the definite amount to be received by the Researcher is subject to national tax legislation.

4. PhD enrolment

Successful candidates for this position will be enrolled by the following institutions:

FR University *Université de Bordeaux*

Admission

Master degree obtained in France or an equivalent qualification awarded following a training course.

More information: https://college-doctoral.u-bordeaux.fr/en/The-doctorate/Pre-requisites

AU University *UNSW Sydney*

Admission

- an appropriate UNSW bachelor degree with upper second-class honours; or
- a completed Masters by Research from UNSW with a substantial research component and demonstrated capacity for timely completion of a high-quality research thesis; or
- an equivalent qualification from a tertiary institution as determined by the Faculty Higher Degree Committee (HDC).

More information: *https://www.unsw.edu.au/science/study-with-us/postgraduate-research/doctor-of-philosophy-phd*

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