The faculty of Engineering of the Vrije Universiteit Brussel invites you to attend the public defense leading to the degree of

DOCTOR OF ENGINEERING SCIENCES

of **Georgios Rekkas Ventiris**

The public defense will take place on **Monday 30th June 2025 at 2pm** in room **I.0.02** (Building I, VUB Main Campus)

To join the digital defense, please click here
Meeting ID: 310 841 225 974 0
Passcode: sn7vm2e2

DEVELOPMENT OF NOVEL COMPUTATIONAL FRAMEWORKS FOR PLASMA-ASSISTED COMBUSTION SIMULATIONS – APPLICATIONS USING DATA-DRIVEN METHODS AND CARBON-FREE FUELS

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Abstract of the PhD research

When a gas is heated or exposed to strong electrical energy, its atoms or molecules become ionized, producing free-moving, highly energized charged particles, namely electrons and ions, thereby forming plasma.

Thanks to its unique properties, plasma has found application in a wide range of technologies, from television displays to space propulsion and medical treatments. In this research, it is studied through numerical simulations as a tool to enhance fuel combustion. While the benefits of plasma-assisted combustion are widely recognized, modeling such systems remains challenging due to the complex coupling between plasma physics and combustion chemistry.

This work addresses these challenges by proposing novel numerical frameworks that reduce the computational cost of plasma-assisted combustion simulations while preserving an accurate description of the underlying plasma-combustion interactions.

A machine learning-based strategy is developed to efficiently reduce the size of chemical mechanisms. Additionally, a hybrid modeling approach is proposed to study plasma-assisted combustion in a computational fluid dynamics environment. This approach enables the incorporation of detailed state-to-state plasma kinetics into multidimensional simulations. Particular attention is given to ammonia, a carbon-free fuel with strong potential in the context of the energy transition, and to innovative combustion regimes characterized by high dilution.

The findings of this work aim to advance the state of the art in plasma-assisted combustion modeling and support the integration of plasma technologies into future low-carbon energy systems.