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 **Pedro Dinis Caseiro Jorge**

The public defense will take place on **Thursday 11th December 2025 at 4 pm** in room **LIC.0.04 Learning Theatre** (Building LIC, VUB Main Campus)

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GAS AND PLASMA SURFACE INTERACTIONS IN HYPERTHERMAL RAREFIED FLOWS: APPLICATIONS TO VERY LOW EARTH ORBIT PLATFORMS

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Abstract of the PhD research

Satellites in very low Earth orbits (160-250 km altitude) operate in a denser atmosphere than common satellites, which creates important challenges for their operation. Atmospheric particles, in particular atomic oxygen, impact satellites at approximately 8 km/s and can erode satellite materials and create drag, reducing satellite speed. To develop new air-breathing propulsion systems that collect atmospheric gases to compensate drag and maintain orbit, it is important to understand how the atmospheric gases interact with spacecraft surfaces.

This work investigates how high-velocity atoms interact with satellite materials. A combination of experiments and simulations revealed that many existing models fail to predict gas-surface interactions accurately, especially in high-velocity orbital conditions. To improve these predictions, models incorporating surface roughness were developed, an important factor influencing how particles scatter from surfaces. Additionally, experimental data were collected for samples with different roughnesses showing that the model captured experimental trends reliably. Therefore, using the model in simulations should improve estimates of both atmospheric drag and gas collection efficiency.

A method was also developed to evaluate the efficiency of intake-collectors for air-breathing propulsion systems using an orbital-velocity plasma beam. Argon plasma beams were generated using a plasma source and the probability of the beams being transmitted through an intake-collector model was measured. These measurements aligned well with particle simulations that included plasma effects, validating our approach.

Finally, material degradation was studied using the same plasma source fed with oxygen. Compared to neutral gases, plasma caused significantly more erosion, especially when surface charging occurred. These results showed that contamination of satellite surfaces from plumes of air-breathing electric thrusters can cause significant erosion of materials prone to charging.

Together, these findings improve our ability to model gas-surface interactions, and test spacecraft components and materials under relevant conditions, supporting the design of more efficient, longer-lasting satellites for very low Earth orbit missions.