JOB OFFER – STAGE

Numerical Investigation of Plasma Discharge Formation in the Presence of Sustainable Aviation Fuel Droplets

OFFER INFORMATION

Reference: E&S-2025-NB-2
Location: 42 Avenue Gaspard Coriolis – 31057 Toulouse
Team: E&S

Supervisors:
- Nicolas Barléon
- Thomas Lesaffre

Gratification: 800€ net per month - M2 level or last year at engineering school

Period: 6 months - from: 09/02/2026

Key words: Plasma - HPC – Liquid Fuel – SAF – Plasma-Assisted Combustion - Streamer

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HOSTING TEAM - E&S

The Energy & Safety team focuses on cross-disciplinary activities aimed at developing, optimizing and deploying scientific codes dedicated to advanced combustion calculations in industrial geometries. The team focuses on the simulation of flows, applying them to aircraft, rockets, helicopters, car engines, turbines and more. The result is essential tools for a wide range of applications, with the leitmotiv: let's calculate systems before we build them. More specifically, team members develop models and tools covering chemical reduction, turbulence, combustion, two-phase systems, combustion instabilities, etc., to meet both academic and industrial challenges. Thanks to its position, the team collaborates with numerous academic laboratories, design offices of Cerfacs associates, and other Cerfacs teams.

CONTEXT

Today, it is crucial for our society to have access to a reliable energy source with a low impact on the environment and climate. In the aviation context, projects are currently underway to use low-carbon fuels commonly named as Sustainable Aviation Fuels (SAFs). These fuels can be produced either from intermittent renewable energy sources (e-SAFs) or from biomass and waste. However, their use in current combustion chambers is not yet fully compatible, Sustainable Aviation Fuels can only be blended up to 50% with kerosene, and an adaptation phase is required to meet operability, safety, and emission standards. In this context, non-equilibrium plasma discharges have demonstrated their potential to extend gas turbine operability (lean blowout limits extension), mitigate thermoacoustic instabilities and reduce pollutant emissions by enabling operation under leaner combustion regimes. Plasma-assisted combustion has received considerable attention over the past two decades, particularly for gaseous fuels. However, SAFs are injected in liquid form, and the presence of fuel droplets can significantly affect discharge formation. Understanding plasma behavior in two-phase (gas–liquid) media is thus essential for the future application of non-equilibrium plasma actuators in aero-engine combustion systems.

MISSION

The objective of this internship is to develop a numerical framework capable of accounting for the presence of liquid droplets during the simulation of plasma discharge formation (also known as the streamer phase). The work will build upon the existing plasma modeling capabilities of the AVBP solver (https://avbp-wiki.cerfacs.fr), which solves the self-consistent charged species transport equations (drift–diffusion approach) coupled through the electric field computed from the Poisson equation.

In a first step, a one-way coupling will be investigated, focusing on the influence of a liquid droplet on the discharge. The droplet will be modeled as an abrupt change in dielectric permittivity, acting as a dielectric medium on which charged particles can accumulate at the surface. This requires implementing a jump condition for the normal electric field within the Poisson equation.

The implementation will be tested in a pin-to-pin configuration (Fig. 1), varying the inter-electrode distance and droplet geometry. As illustrated in the figure, the resulting discharge structures differ significantly depending on these parameters. Starting with water droplets, the study may later be extended to fuel-representative droplets by adjusting the relevant physical properties. The objective is to characterize the discharge morphology and intensity, and to evaluate the spatio-temporal power density of the plasma. These results will serve as a foundation for future two-phase flow simulations, enabling the assessment of energy deposition effects on droplet behavior, such as deformation and evaporation.

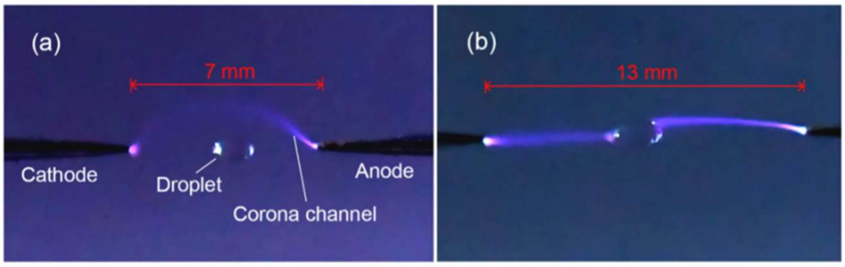

Fig 1: Discharge formation with the presence of liquid droplet for different inter-electrode distance (reproduced from [Chen2025])

Scientific Program:

- Implementation of a new Boundary Condition in the Poisson equation solver to model dielectric medium
- Simulate plasma formation with and without liquid droplets to evaluate their impact

Technical Program:

- Familiarization with the plasma module of the AVBP solver
- Pre and post processing developments
- Python and Fortran coding

[Chen2025] Chen et al, Characteristics of corona and ionic wind interacting with suspended droplets in air, Journal of Physics D: Applied Physics 2025

DESIRED PROFILE

- Master's degree (M2) or engineering school
- Background in fluid mechanics and energy
- Training in CFD (Computational Fluid Dynamics)
- Knowledge of combustion and/or plasma is a plus
- Programming skills (Fortran, C, or C++ and Python)
- Solving linear systems is a plus.
- Proactive, curious, and autonomous

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- 50% reimbursement of public transport costs.

HOW TO APPLY?

To apply, please send your CV and covering letter to N. Barléon (barleon@cerfacs.fr) and T. Lesaffre (lesaffre@cerfacs.fr), applications are open until 31/01/2025.

See you soon at CERFACS!