CERFACS

JOB OFFER – POST-DOCTORAL

Detailed numerical investigation of flame/droplet interaction

OFFER INFORMATION

Reference: E&S-25-OD-01
Team: E&S

Location: 42 Avenue Gaspard Coriolis – 31057 Toulouse
Contact person: O. Dounia, N. Odier and E. Riber

Period: 1 year - from: 05/01/2026 (with the option to renew for one year)
Salary: 40 K€/year (gross)
Level of education required: PhD

Key words: combustion, two-phase flows, Particle-Resolved-DNS, Lagrangian modeling

CERFACS

Cerfacs is a private research, development, transfer and training center for modeling, simulation and high-performance computing. Cerfacs designs, develops and proposes innovative software methods and solutions to meet the needs of its partners in the aeronautics, space, climate, environment and energy sectors. Cerfacs trains students, researchers and engineers in simulation and high-performance computing.
Cerfacs works closely with its seven partners: Airbus, Cnes, EDF, Météo France, Onera, Safran et TotalEnergies.

HOSTING TEAM - E&S

The Energy & Safety team, formerly the CFD-Combustion 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 scientific groups, design offices of Cerfacs associates, and other Cerfacs teams.

CONTEXT

High-fidelity modeling of two-phase flows (liquid-gas or solid-gas) is of critical importance for many applications: liquid fuel atomization for combustion, powders or aerosols for flame mitigation, cavitation processes, marine aerosols, etc.). One particular problem which arises in many of these applications is related to the modeling of the complex interaction between droplets and flames, which often controls the performance of combustion engines or the efficiency of fire/explosion mitigation devices for example. This configuration is illustrated in Fig. 1 for the case of an isolated Fuel droplet interacting with a planar flame front. Accurately predicting this interaction requires:

(i) Tracking the time-evolving droplet interface and the transfer of heat and mass across it.
(ii) Discretizing discontinuous quantities (jumps in density, pressure, and possibly velocity and viscosity) across the liquid/gas interface
(iii) Accounting for the impact of the droplet on the flame burning rate during their interaction: Local hydrodynamic, surface-wrinkling, equivalence-ratio effects and their time evolution.
(iv) The two-way coupling with turbulence

Resolving all these processes at the scale of a few droplets O(1mm) is possible with advanced numerical techniques (see Section Mission below) but is currently out of reach for practical applications which often involve O(10^6-10^9) droplets interacting with flames at much larger scales O(10cm-1m). There is therefore a crucial need to develop Subgrid-scale models which can accurately account for the complex processes controlling droplet/flame interaction (both two-phase flow and turbulent combustion processes). **The objectives of this postdoctoral position are**: **(i)** to perform resolved-particle DNS simulations of the flame/droplets interaction problem; and **(ii)** to develop novel Subgrid-scale models capable of capturing the intricate processes controlling flame/droplets interaction at scales relevant for potential applications.

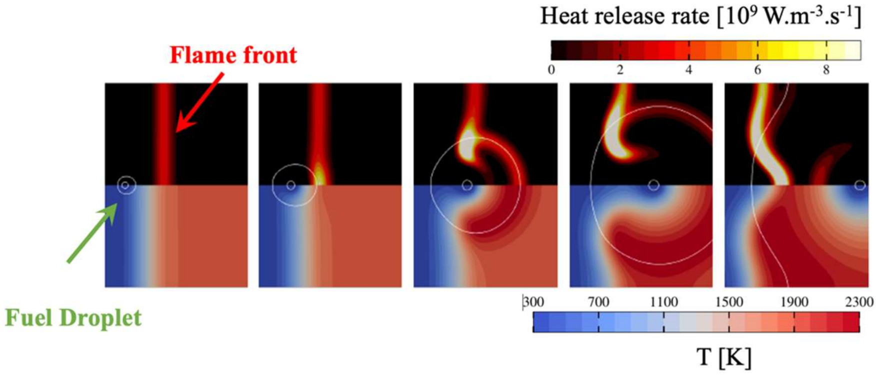

Figure 1 : Illustration of the transient Fuel droplet/flame interaction

The postdoctoral position is funded in part by an internal CERFACS project on advanced methods for two-phase flows as well as by a national ANR project called METAFOR on the combustion of aluminum particles. All the developments of the postdoctoral researcher will also be of interest for another ANR, as well as for CERFACS academic and industrial partners.

MISSION

The postdoctoral researcher will be in charge of:

+ *Performing resolved-particle DNS simulations of the flame/droplets interaction problem*. The code used for this first task is DIVA [1-5] developed at IMFT. Preliminary simulations have already been performed in the context of the PhD thesis of H. Cléris [5]. The objective will be to extend this first database of numerical results by: (i) including the effects of Fuel and droplet diameter, (ii) accounting for the presence of more than a single droplet, (iii) including turbulence.
+ *Using this first database of numerical results to benchmark another DNS code tailored for two-phase flows: BASILISK [6].*
+ *Developing novel Subgrid-scale models capable of accounting for the dominant processes during flame/droplet interaction. This includes both laminar and turbulent combustion models as well as heat, momentum and mass transfer models between liquid and gas phases.*
+ Help in the supervision of PhD candidates and in the coordination of projects.

References:

[1] G. Mialhe, S. Tanguy, L. Tranier, E. Popescu, D. Legendre, An extended model for the direct numerical simulation of droplet evaporation. Influence of the Marangoni convection on Leidenfrost droplet, J. Comp. Phys. 491 :112366, 2023.
[2] A. Urbano, S. Tanguy, C. Colin, Direct numerical simulation of nucleate boiling in zero gravity conditions, Int. J. Heat Mass Trans. 143:118521, 2019.
[3] H. Cléris, J. Estivalezès, S. Tanguy, O. Rouzaud, A. Urbano, Direct Numerical simulation of the evaporation-combustion interaction of fuel droplets in a turbulent flow, 11th Int. Conf. Multiphase Flow, 2023.
[4] A. Urbano, M. Bibal, S. Tanguy, A semi-implicit compressible solver for two-phase flows of real fluids, J. Comp. Phys. 456:111034, 2022.
[5] H. Cléris, PhD thesis, INPT, 2025
[6] http://basilisk.fr/

DESIRED PROFILE

- PhD defended less than 3 years ago.
- Expertise in combustion and/or multiphase flow simulations and keen interest in developing numerical schemes for reactive multiphase-flows are mandatory

WHAT WE OFFER AT CERFACS

- Broad access to technology, a rich interpersonal environment, in-house skills recognized nationally and internationally.
- An inclusive and equitable work environment.
- A structure accessible to people with disabilities.
- A complementary health insurance scheme offering excellent health care coverage in addition to social security, with the possibility of enrolling family members (spouse and children).
- 6 weeks' annual leave (with the possibility of 22 extra days' leave per year linked to your choice of a 39-hour rather than 35-hour working week).
- Flexible working arrangements, with the possibility of working from home up to two days a week.
- A sustainable mobility package enabling employers to pay up to a maximum of 500 euros a year to cover the home-to-work travel costs of staff who cycle to work.

HOW TO APPLY ?

To apply, please send your CV and covering letter to dounia@cerfacs.fr, odier@cerfacs.fr and riber@cerfacs.fr , applications are open until 01/11/2025.

See you soon at CERFACS!