PhD topic 2026:
Experimental study of the interaction between a thermal plume and droplets

A thermal plume is a natural convection current that rises above a heated plate, for example. How do droplets passing through such a plume alter its morphology, velocity, and temperature? How are the droplets deflected? How do they evaporate? Do they bounce off or spread out on the plate generating the plume? This thesis aims to measure and model these phenomena, from single droplets to spray.

The objective is therefore to experimentally study the interaction between a thermal plume and one or more droplets. This topic lies at the interface between natural convection, heat transfer, and two-phase fluid dynamics. It is both fundamental and application-oriented, particularly for understanding the phenomena of hot surface cooling (spray cooling).

Fig 1. Visualization of the plume using laser techniques

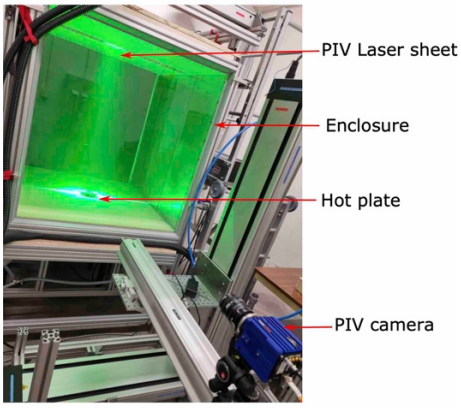

Fig 2. Experimental setup for velocity measurement

The study will be conducted using an approach of increasing complexity:

(i) Thermal plume alone (reference case): characterisation of the plume's velocity and temperature field, highlighting instabilities and fluctuations specific to the flow.

(ii) Suspended droplet: influence of the droplet's presence on the plume, measurement of evaporation, droplet deformation, etc…

(iii) Interaction with free-falling droplets:

(a) impact of a single droplet,

(b) train of drops with controlled spacing,

(c) polydisperse spray.

This step-by-step approach will help us figure out the main interaction patterns and the physical mechanisms involved: evaporation, fragmentation, and the possible Leidenfrost effect when the plate temperature goes over a critical point. To this end, the parameters explored will include plate temperature, droplet size, drop height/impact velocity.

This work will draw on a wide range of experimental skills: fast imaging, optical thermometry, microthermocouples, PIV (Particle Image Velocimetry) and visualisation to characterise flow, droplet dynamics and heat exchange.

Scientific objectives:

- To precisely characterise the structure and instabilities of a thermal plume in a cavity with and without droplets.
- To study the influence of the plume on the trajectory, deformation and evaporation of isolated droplets.
- To identify the interaction regimes between a spray and a hot plume.

Build an experimental reference database on plume/drop interactions (trajectories, PIV fields, evaporation rates) for model/CFD validation.

Impact and applications:

The expected results will contribute to a better understanding of the thermal and dynamic exchanges between hot sources and two-phase flows. They will find applications in:

- spray cooling and surface thermal management processes,
- certain natural phenomena where thermal plumes interact with precipitation or liquid aerosols.

Start of thesis: October 2026

Location: Institut Pprime / ENSMA, Téléport 2, 1 Av. Clément Ader, 86360 Chasseneuil-du-Poitou

Required Profile:

- M2 or engineering school, specialising in thermal engineering, fluid mechanics, energy or applied physics
- Strong interest in experimental work
- Desirable skills: image processing, Python, Matlab

To apply:
Send an email with your CV and a cover letter.
The selection process begins now and runs until 29 March.
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