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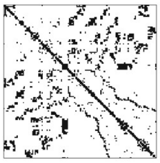
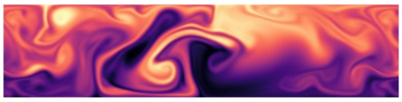
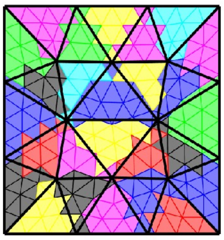
CENTRE EUROPÉEN DE RECHERCHE ET DE FORMATION AVANCÉE EN CALCUL SCIENTIFIQUE

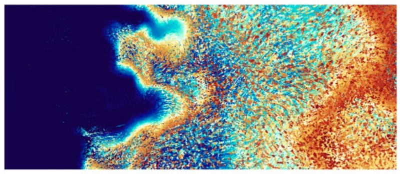
Ph.D. Students' Day
(JDD 2025)
Thursday June 19th 2025

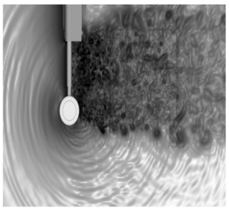


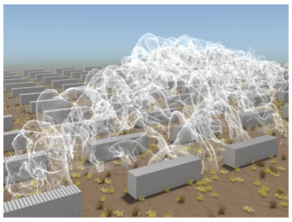
Algo-Coop

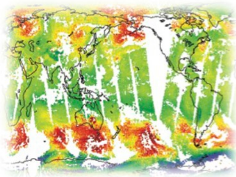




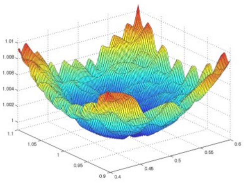


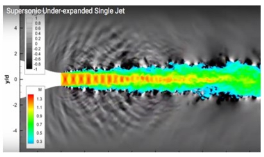


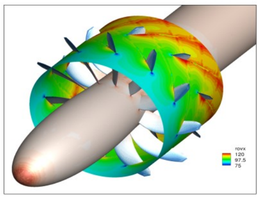


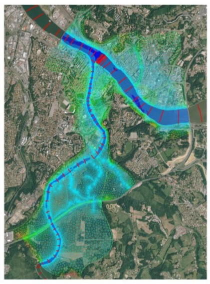


Climate Modeling & Global Change

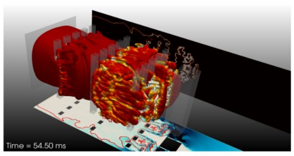


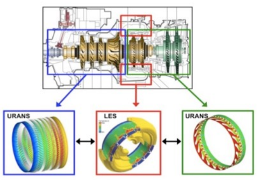


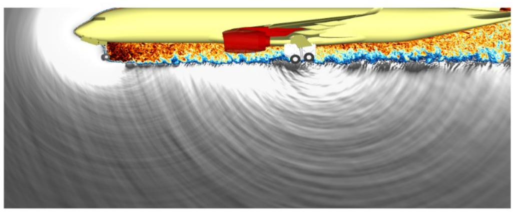




Computational Fluid Dynamics







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9:15	**Welcome Coffee**		
9:30	**Welcome speech : Catherine Lambert**		
Session 1		**Chair : Julien Boé**	
9:45	Théo Garin	Socio-economic impact of flooding assessment using remote sensing, hydrodynamic modeling and GIS	GlobC
9:50	Etienne Charles	Modelling of two-phase combustion for the Large Eddy Simulation of combustion instabilities	E&S
9:55	Camille Le Gloannec	The seasonal cycle of the Arctic Ocean in a summer ice-free climate	GlobC
10:00	Solène Hoflack	Modelisation and simulation of turbulent ammonia/air flames	E&S
10:05	**Coffee break and Poster Session n°1**		
Session 2		**Chair : Laurent Gicquel**	
11:00	Marc Chen	Numerical simulations of a hydrogen / air coaxial dual-swirl RQL-type injector for combustion chambers of aircraft engines	E&S
11:05	Giulio Pelenghi	Impact of Deep Throttling on Liquid Rocket Engine Combustion Stability and Performance	E&S
11:10	Amine M'hamdi	Internal Tides impact on chlorophyll in the oceanic region off the Amazon Shelf	GlobC
11:15	Florian Mitanchey	Order adaptation in numerical simulation for premixed turbulent combustion with a spectral difference code	AAM
11:20	**Coffee break and Poster Session n°2**		
12:30	**Lunch**		
Session 3		**Chair : Luciano Drozda**	
14:00	Pierre-Antoine Baranger	Development of high-fidelity simulation tools to compute the efficiencies of torches at all scales	E&S
14:05	Théo Briquet	Learning to predict the rank of hierarchical matrices	Algo
14:10	Christophe El Hachem	Reconstruction of OH*/NO* emission for direct experimental/numerical comparison of H2-air flames	E&S
14:15	**Coffee break**		

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My thesis in 3 minutes		**Chair : Matthieu Pouget**	
14:35	Anthony Bergaud	Development of simplified chemical kinetics for sustainable aviation fuels	E&S
14:40	Noémie Lourme	Improving combustion models for spinning combustion technology (SCT) operability	E&S
14:45	Gobins Ojars	Modelling of plasma-assisted combustion for the control of combustion instabilities	E&S
14:50	Kevin Turgut	Numerical study of the shock/detonation transition in a H2/O2/N2 premixed gas	E&S
14:55	Mateus de Magalhães Barcelos Costa	Numerical simulations of hydrogen-related explosions in gas turbines	E&S
15:00	**Coffee break and Poster Session n°3**		
16:00	**Voting for best poster and "My thesis in 3 minutes" presentations**		
16:15	**Closing speech : Catherine Lambert**		

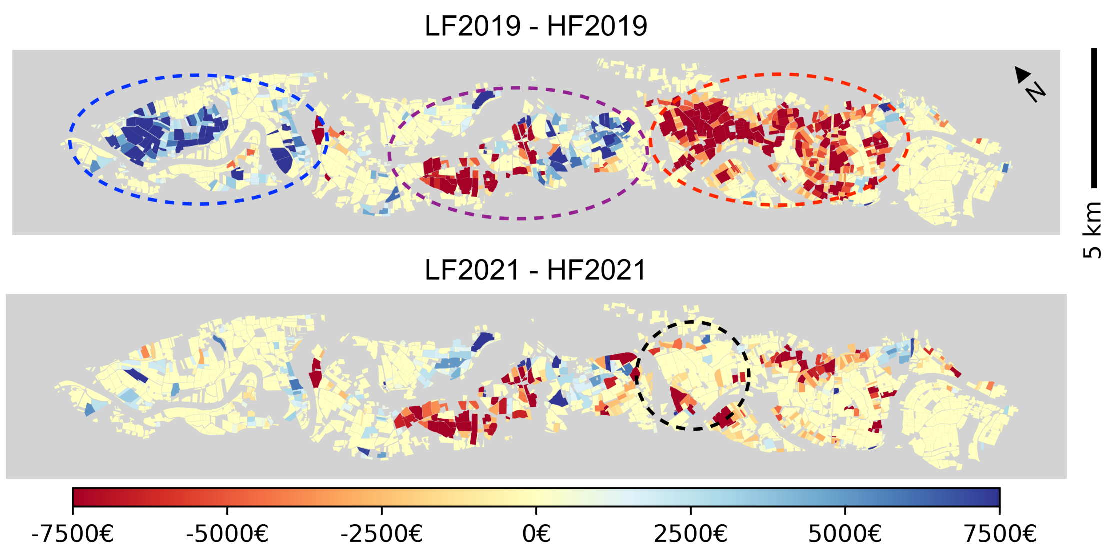
Théo Garin

9:45 (poster 10:05)

Socio-economic impact of flooding assessment using remote sensing, hydrodynamic modeling and GIS

Supervisors : Ludovic Cassan, Raquel Rodriguez-Suquet, Sébastien Le Corre, Sophie Ricci

Estimating the impact of flood events is essential for flood management policies and is based on a variety of tools, including hydrodynamic models, remote sensing imagery, land cover and damage models. The impact of a flood event is an incredibly complex phenomenon, involving multiple types of damage: direct economic (destruction of buildings and infrastructure), indirect economic (unemployment, disruption of supply chains), direct social (deaths and injuries) and indirect social (psychological and physical trauma, forced migration). Accurate and exhaustive assessments are generally made *a posteriori* by regional authorities using the full range of available data, but *a priori* studies must also be carried out to prepare human settlements for such disasters. In the case of forecasting, however, only a small and uncertain sample of tools and data is available, resulting in degraded damage estimates. The same considerations apply to emergency assessments carried out in the first hours or days after a catastrophic flood event, when the situation is still unfolding. Under these conditions, we want to assess *how bad* these estimates are, in other words, how sensitive our damage models are to a change in the water hazard or land cover representation. To this end, we are developing a pipeline prototype that concatenates existing sporadic toolkits to assess direct economic damage from flood impacts using (almost) any type of input data.



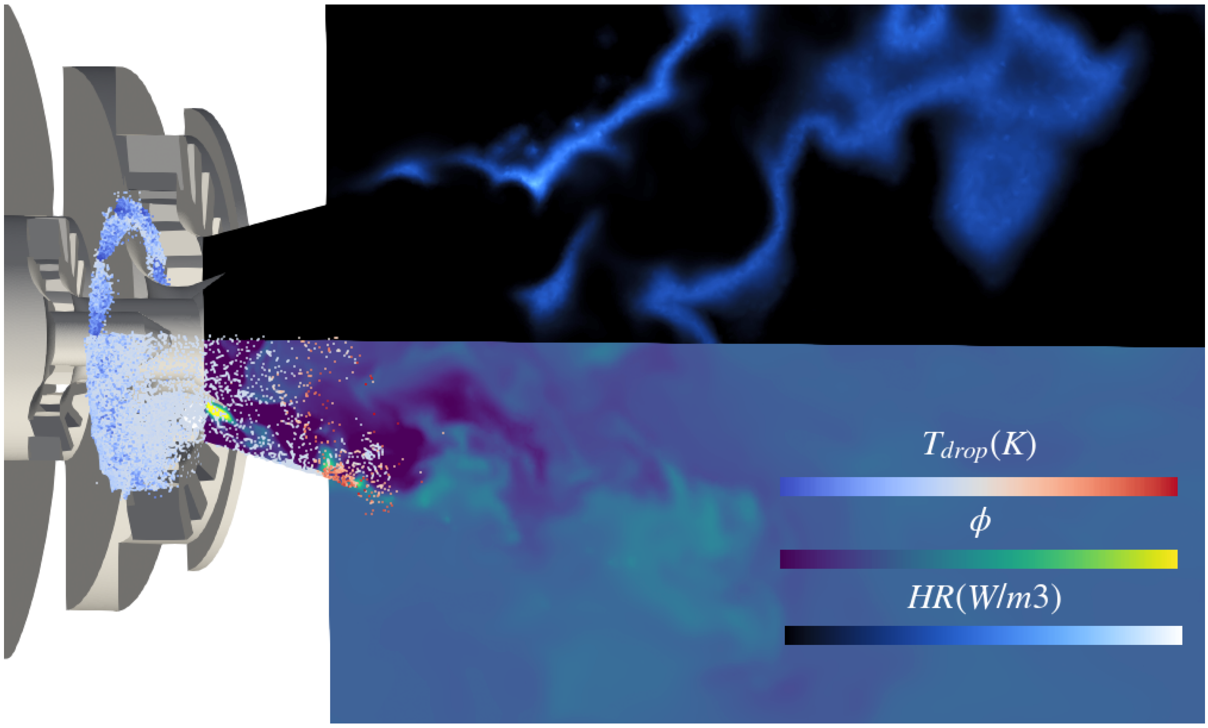
Etienne Charles

9:50 (poster 10:05)

Modelling of two-phase combustion for the Large Eddy Simulation of combustion instabilities

Supervisors : Laurent Gicquel, Aymeric Vié

As the aeronautical industry is seeking to reduce its pollutant emissions, new gas turbines combustors architectures are considered to decrease nitric oxides productions through leaner combustion regimes. Composed of two parallel injection levels, staged combustors enhance flexibility by allowing fuel rich combustion in deprecated conditions and lean combustion in steady cruise conditions. Despite those benefits, the stability of lean combustion always represents a challenge to which is added the new complexity of the fuel injection device. In particular, experimental and numerical evidences could highlight an important sensibility of the flame unsteady response to the fuel injection conditions and modeling. It is consequently essential for the design of staged lean combustion chambers to accurately represent the injectors response to steady and unsteady conditions in order to predict combustion instabilities through numerical simulation. The goal of this thesis is then to model the liquid jet in crossflows and pressure swirl injectors composing staged combustors as well as the various events occurring in individuals' droplets life such as secondary atomization or walls interaction in formulations adapted to the phase-dispersed Lagrangian formalism. The modelling elements are then to be used to estimate the flame transfer function of the BIMER academic staged combustors and assess current capability of the AVBP solver to predict combustion instabilities in such architectures.



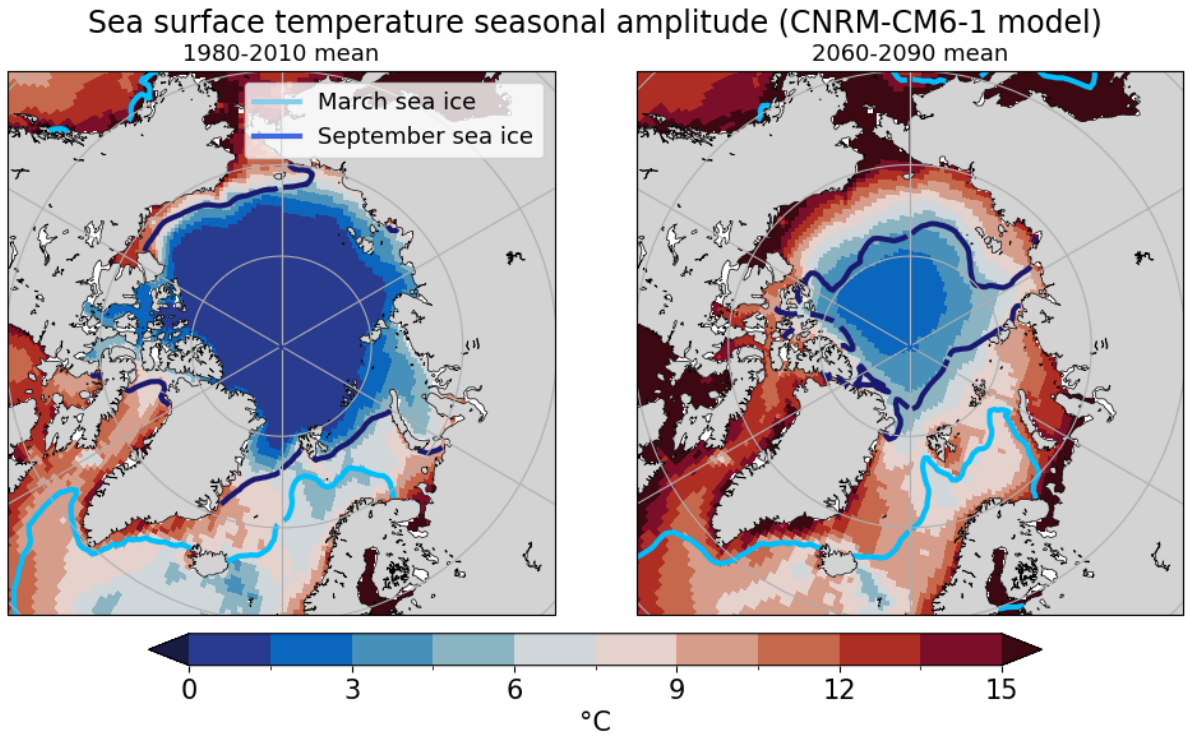
Camille Le Gloannec

9:55 (poster 10:05)

The seasonal cycle of the Arctic Ocean in a summer ice-free climate

Supervisors : Rym Msadek, Camille Lique

The Arctic Ocean is a hot spot of climate change, with enhanced warming and freshening of near-surface waters and a rapid decline of sea ice in recent decades. Climate model projections suggest that the Arctic Ocean may be ice-free in summer as early as 2030-2050, accompanied by an intensified seasonal cycle of sea ice characterized by earlier melting and later growth seasons. This transition will enhance interactions between the ocean, atmosphere and sea ice, likely altering the stratification of the Arctic Ocean during summer. The projected retreat of summer sea ice in the coming decades raises the question of how the seasonal cycle of the ocean may change, which is critical in regulating chemical, biological and physical processes in the region. Given the non-uniformity of sea ice loss across the Arctic, pan-Arctic averages fail to capture the spatial variability of these changes. In this study, we analyze 36 climate models from the Coupled Model Intercomparison Project Phase 6 (CMIP6) under the SSP5-8.5 scenario to characterize regional changes in the Arctic Ocean seasonal cycle in the near future. Our results reveal an intensified seasonal cycle of sea surface temperature and a weakened seasonal cycle of sea surface salinity with significant regional variability and model dependence. Changes at depth are primarily confined to the mixed layer. By analyzing the mixed layer temperature and salinity budget for each region, we identify the key processes driving these changes. These insights enhance our understanding of the evolving seasonal dynamics of the Arctic Ocean and their broader implications in a rapidly changing climate.



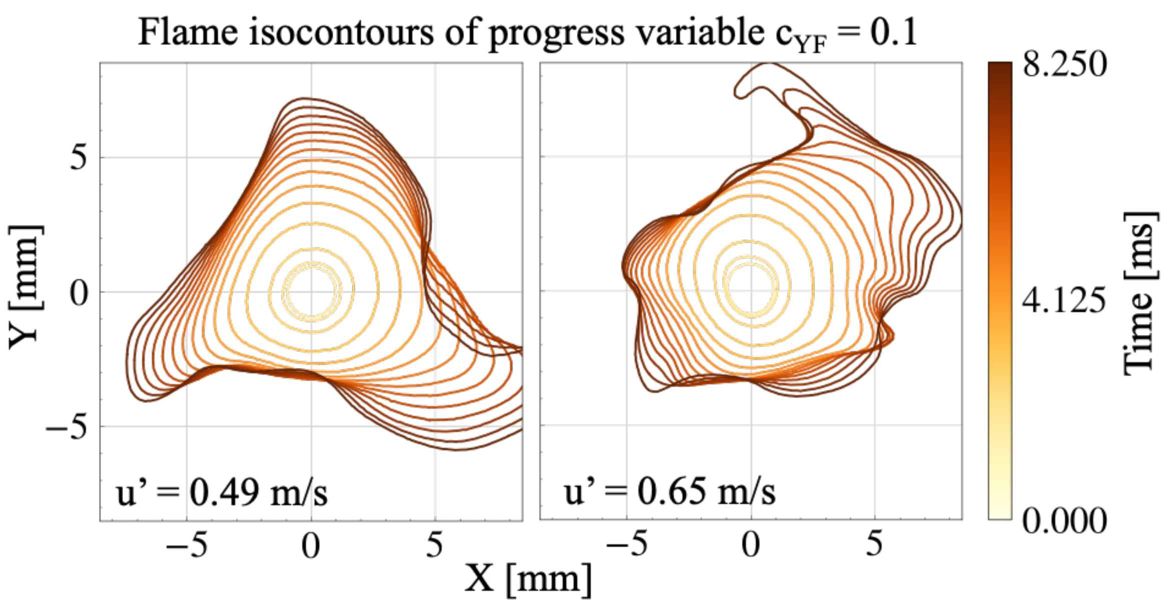
Solène Hoflack

10:00 (poster 10:05)

Modelisation and simulation of turbulent ammonia/air flames

Supervisors : Eleonore Riber, Quentin Douasbin

In the context of climate change induced by anthropological greenhouse gas emissions, the need to find renewable and low-carbon energy sources is growing even more. While green hydrogen (H_2) is a promising carbon-free fuel, its storage and transport induce challenges, including risks of leaks and, potentially, fast deflagration or detonation. Ammonia (NH_3) stands out as a convenient hydrogen carrier and zero-carbon fuel. However, limited knowledge of its combustion hinders its use. Improving our understanding and modeling of ammonia combustion is then crucial.
To do so, PRISME laboratory designed a spherical constant-volume chamber with integrated fans to study NH_3/air flames, at ambient pressure and at $T = 423$ K, under forced homogeneous isotropic turbulence (HIT). The experimental study focus on the flame propagation and the importance of the fuel mixture under turbulent conditions. In this work, two Direct Numerical Simulations (DNS) of turbulent NH_3/air flames are performed using the compressible Navier-Stokes solver AVBP, reproducing the experimental conditions at two turbulent intensities $u' = 0.49$ m/s and $u' = 0.65$ m/s. A turbulence forcing method, based on the addition of energy at large scales, is used to counteract the decay of turbulence. A semi-detailed Analytically Reduced Chemistry (ARC), derived from NUIG detailed chemistry, is derived to accurately reproduce laminar NH_3/air flames under experimental conditions.
Flame topology, displacement speed, and wrinkling ratio are analysed. A good agreement is found between results from experimental 2D Mie-Scattering tomography and 2D flame iscontours from DNS. The simulations correctly capture the effect of turbulence on the flame development, as the flame distortion at larges scales. The influence of the barycentre displacement on the flame speed and the wrinkling ratio resulting from 2D DNS and experimental diagnostics is then discussed. Results from 3D DNS isosurfaces are also determined to account for the full flame dynamics. Differences between 2D and 3D results finally highlight the need for 3D diagnostics techniques to achieve greater measurements accuracy.



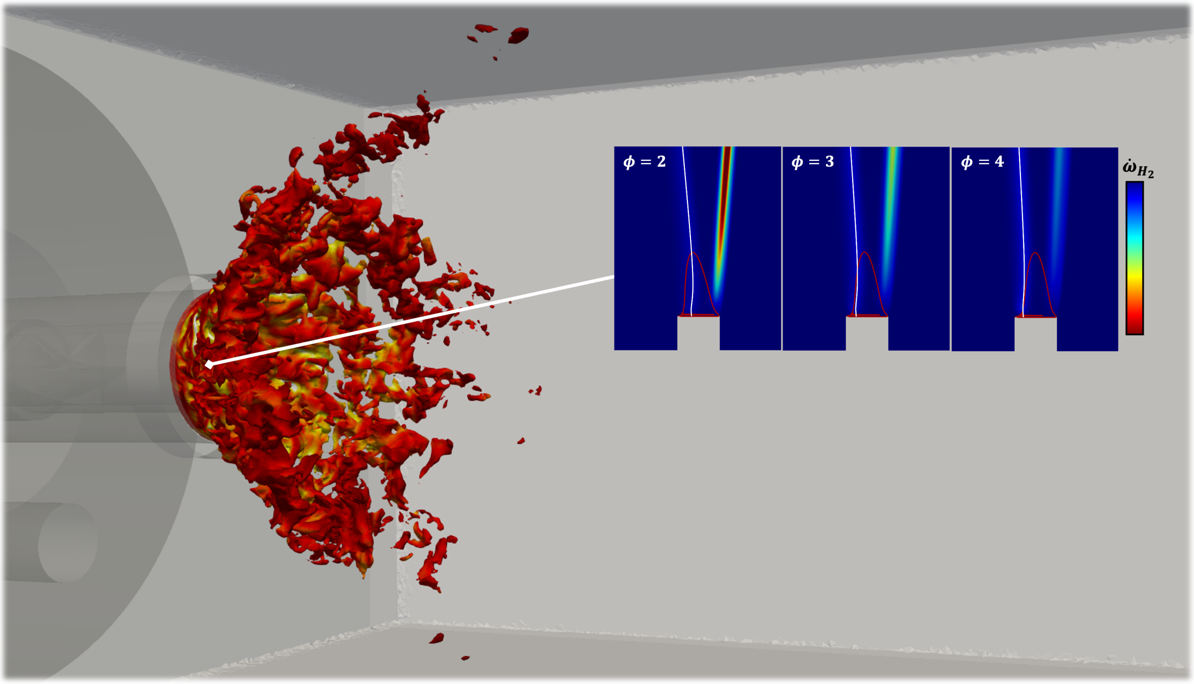
Marc Chen

11:00 (poster 11:20)

Numerical simulations of a hydrogen / air coaxial dual-swirl RQL-type injector for combustion chambers of aircraft engines

Supervisors : Thierry Poinsot, Laurent Gicquel, Nicholas Treleaven

Multiple injector designs to burn pure hydrogen are developed throughout Europe in a perspective to industrialize hydrogen combustion chambers for aircraft engines. This research work is part of the H2TECH program initiated by SAFRAN TECH, which aims at developing and selecting the most appropriate injection system for industrial gas turbines. This thesis focuses on the RQL-based injector concept: a dual-swirl coaxial injector with a rich H_2/air premix mixture injected through the central stream and air injected through the annular stream. This leads to a dual-flame front where a premixed flame and a subsequent diffusion flame are created above the injector lip. Using LES of a whole RQL combustor and complementary 2D DNS of restrictive regions of interest, the flame structure, stabilization mechanisms as well as flame dynamics are analyzed to help designing and optimizing an industrially operational RQL injection system.



Giulio Pelenghi

11:05 (poster 11:20)

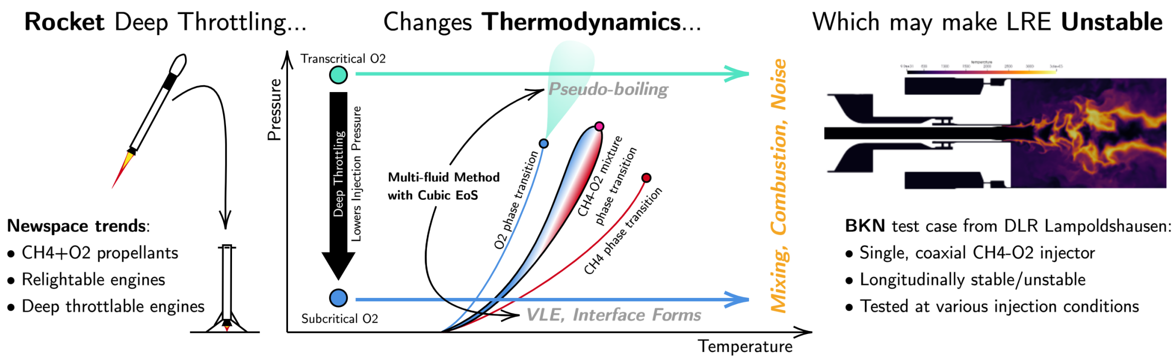
Impact of Deep Throttling on Liquid Rocket Engine Combustion Stability and Performance

Supervisors : Annafederica Urbano, Thomas Schmitt, Nicolas Odier

In the context of space launcher propulsion, the advent of NewSpace has brought new industry needs for the development of rocket engines. Among them: the use of methane as fuel (with oxygen as oxidizer), allowing improved performance and easier storage compared to kerosene and hydrogen respectively; deep throttlability, to execute more demanding missions, such as engine reentry and landing for reusable launchers; understanding and eventual prediction of combustion instabilities, reducing costly and time-consuming large-scale experiments.

For most of the operative phases of CH_4/O_2 rocket engines, the chamber pressure is higher than critical values. But when throttling down the engine, the pressure in the feed system and in the chamber is reduced and can reach subcritical pressure values. This can have an important impact on injection conditions, in particular for the cold O_2, with the establishment of two-phase flows (liquid/vapour). From the design point of view, this means that the system should be able to operate under stable and performant conditions both in supercritical (single-phase) and subcritical (two-phase) flow conditions.

The present research work aims to contribute to the understanding of the mechanism leading to combustion instabilities depending on the thermodynamic injection conditions, in a shear coaxial injector combustion chamber. A multi-fluid method capable of simulating both vapor-liquid equilibria in subcritical conditions, and pseudo-boiling in transcritical conditions, using real gas thermodynamics and thermophysical models, is used [Pelletier et al. Computers & Fluids, 2020]. The Combustion Chamber N (BKN) operated at DLR Lampoldshausen [Martin et al. Int. Journal of Spray and Combustion Dynamics, 2023] is considered as configuration for the simulations.



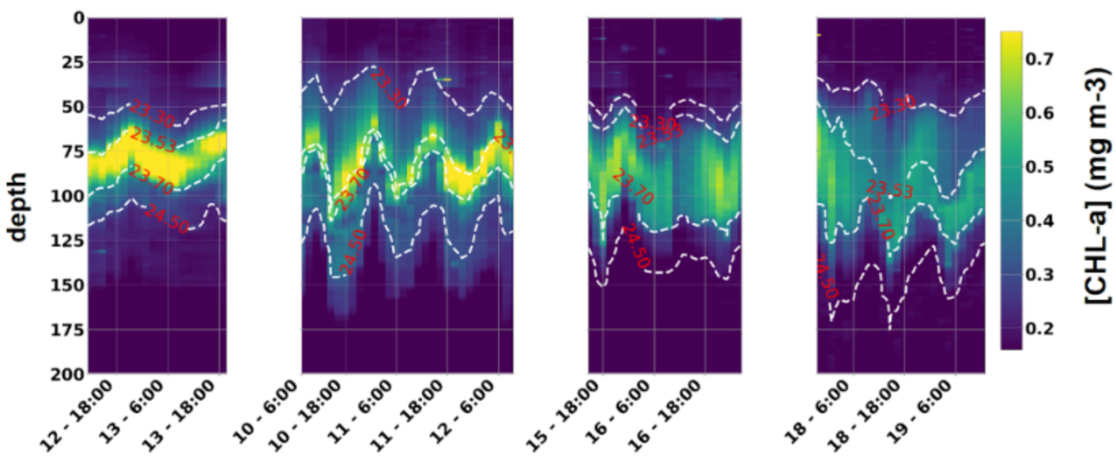
Amine M'hamdi

11:10 (poster 11:20)

Internal Tides impact on chlorophyll in the oceanic region off the Amazon Shelf

Supervisors : Ariane Koch-Larrouy, Isabelle Dadou, Alex Costa da Silva , Vincent Vantrepotte

The ocean region off the Amazon shelf including shelf-break presents a hotspot for Internal Tides (ITs) generation, yet its impact on phytoplankton distribution remains poorly understood. These baroclinic waves, generated by tidal interactions with topography, could modulate nutrient availability and primary production both by mixing and advection. While previous studies have extensively examined the physical characteristics and dynamics of ITs, their biological implications particularly in nutrient-limited environments remain underexplored. To address this question, we analysed a 26-day glider mission deployed in September–October 2021 sampling hydrographic and optical properties (chlorophyll-a) at high resolution along an IT pathway, satellite chlorophyll-a and altimetry data to assess mesoscale interactions. Chlorophyll-a dynamics were analysed under varying IT intensities, comparing strong (HT) and weak (LT) internal tide conditions. Results reveal that ITs drive vertical displacements of the Deep chlorophyll Maximum (DCM) from 15 to 45 meters, accompanied by a remarkable 50% expansion in its thickness during HT events. This expansion is observed with a dilution of the chlorophyll-a maximum concentration within the DCM depth. Turbulent cross-isopycnal exchanges driven by tides redistribute chlorophyll-a into adjacent layers above and below the DCM. At the surface, turbulent fluxes contribute to 38% of the chlorophyll-a supply, which directly influences primary production. Notably, the total chlorophyll-a content in the water column increases by 14-29% during high internal tide phases, reflecting a net enhancement of primary productivity. This increase results from the combined effect of vertical mixing and stimulated biological activity in the surface layer. These findings highlight the role of ITs as a key driver of chlorophyll-a distribution and short-term biological variability, reshaping the vertical chlorophyll-a profile and regulating primary productivity and potentially carbon cycling in oligotrophic oceanic systems.

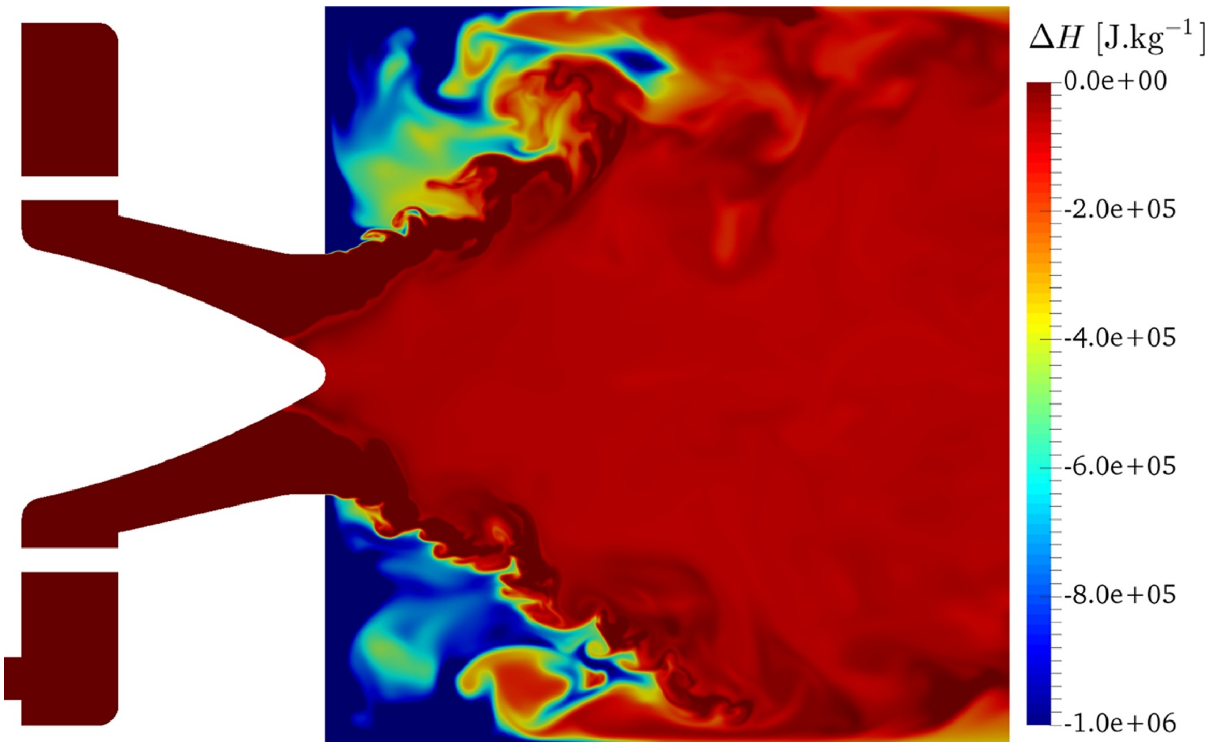


Florian Mitanchey 11:15 (poster 11:20)

Order adaptation in numerical simulation for premixed turbulent combustion with a spectral difference code

Supervisors : Jean-Mathieu Senoner, Hugues Deniau

The Jaguar code, developed by ONERA and CERFACS, employs the spectral difference method for high-fidelity simulations of turbulent reactive flows. It leverages a high-order polynomial approximation on a small number of cells to resolve flame fronts and reduces computational costs through spatial p-refinement, where lower polynomial orders are used downstream. However, this refinement lacks robustness due to the inconsistent discretization of the diffusion operator. A stability study comparing the BR2, IC, and dGRP schemes identified the superiority of dGRP, which was successfully tested on a 1D flame case and currently extended for the 3D. Another focus is reducing aliasing errors in nonlinear terms. Ensuring discrete conservation of kinetic energy is a promising avenue for improving robustness, inspired by adapted formulations from other high-order methods. For turbulent premixed combustion modeling, a geometric thickening method based on the curvature of the reaction rate is being developed. This method, combined with Level-Set techniques, aims to limit artificial flame front thickening while maintaining accurate chemical gradient resolution. These improvements will be implemented and evaluated in LES simulations of reactive flows. Validation will focus on experimental configurations, such as the Preccinsta burner, to assess the effectiveness of these developments in achieving robust, high-fidelity results.



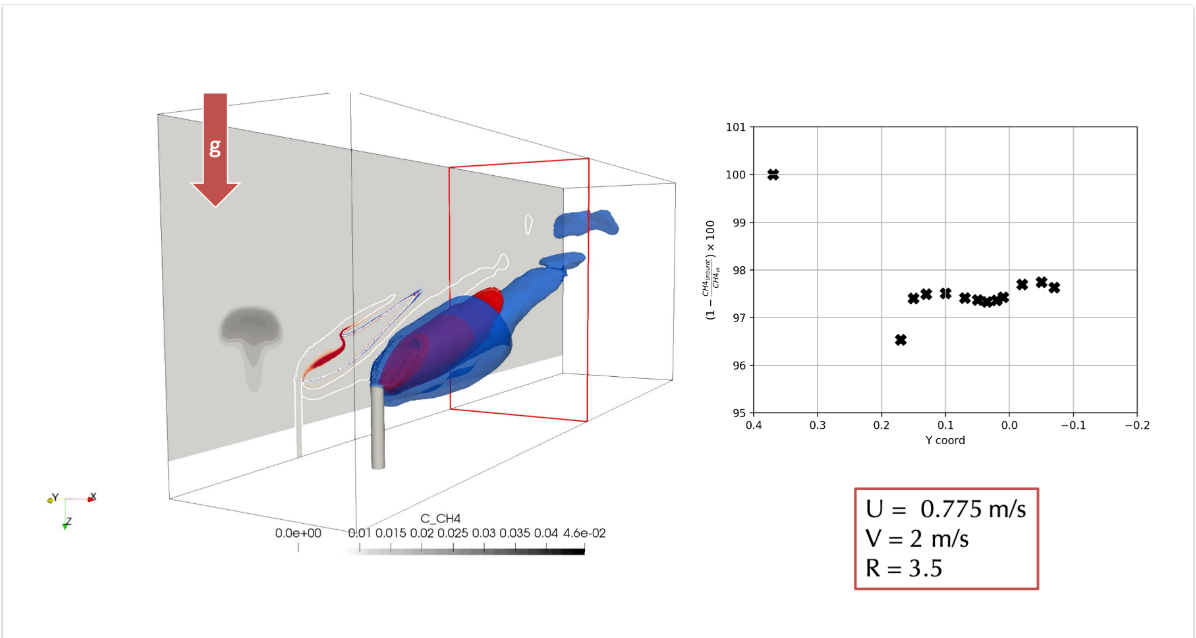
Pierre-Antoine Baranger

14:00 (poster 15:00)

Development of high-fidelity simulation tools to compute the efficiencies of torches at all scales

Supervisors : Thierry Poinsot, Ghislain Lartigue

Flares are largely used in the oil and gas industry to burn excess fuel for different reasons (safety or economy). Those flames aren't well described and their emission tracking is not easy (large scale, open atmosphere ...). This thesis has for objectives to give more insight on the combustion mechanisms and to develop tools to achieve the large scale simulation. It is believed that one of the first parameters controlling the combustion efficiency (CE) is the stabilization of the flame on the lip of the flare. When the flame is anchored, the CE is high and when the flame is lifted, the CE diminish. Thus, studied cases revolve around the analyses of the edge of the flame and its propagation speed. It has been found that the propagation speed is not retrieved on coarse meshes, so a correction model is calculated and applied, in order to simulate large scale flares.



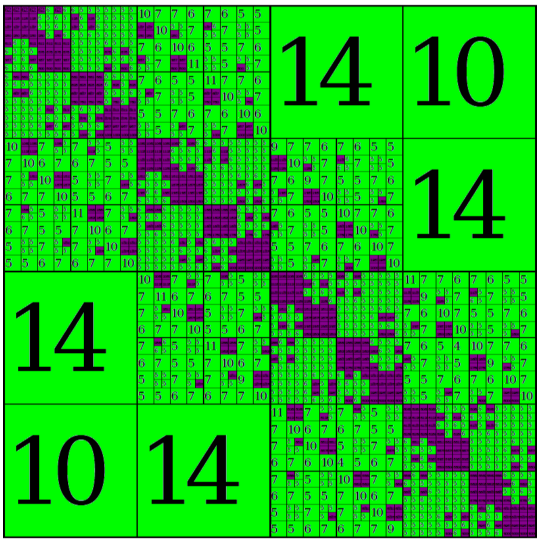
Théo Briquet

14:05 (poster 15:00)

Learning to predict the rank of hierarchical matrices

Supervisors : Luc Giraud, Paul Mycek, Pierre Benjamin, Sofiane Haddad, Guillaume Sylvand

In the context of simulating the propagation of acoustic waves and aerodynamic calculations, the Boundary Element Method (BEM) is commonly employed. This approach leads to the solution of dense complex linear systems of very large size, for which it may be impossible to form the complete matrix. Techniques of low-rank approximation of certain blocks can be used, leading to the definition of a hierarchical matrix (H-matrix) based on a hierarchical partition of the computational domain.



Hierarchical matrix and the rank of each blocks
Green → low rank
Purple → full rank

The main challenges of my work are twofold: first, determining the hierarchical block low-rank structure of the matrix—i.e., identifying which blocks have low rank and can be advantageously stored as the product of rectangular matrices significantly reducing memory requirements; second, estimating the actual ranks of these blocks to determine their memory footprint. In this work, we explore supervised statistical machine learning techniques to tackle these challenges. More specifically, we train models based on decision trees (specifically, random forests or gradient-boosted trees) on synthetic datasets generated from simple geometries and validate their generalization capabilities on 3D aircraft meshes.

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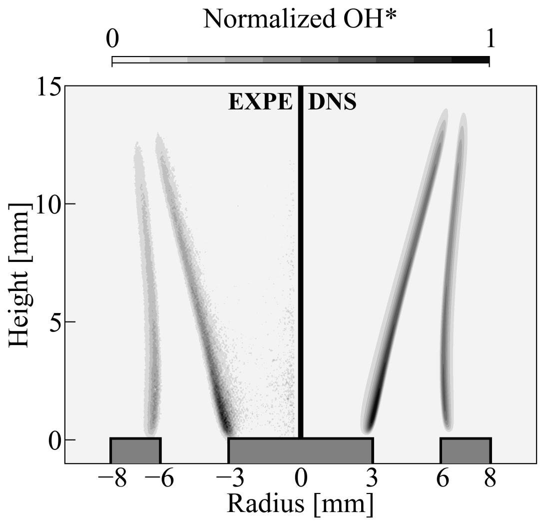
Christophe El Hachem

14:10 (poster 15:00)

Reconstruction of OH*/NO* emission for direct experimental/numerical comparison of H2-air flames

Supervisors : Eléonore Riber, Quentin Douasbin, Nicolas Barleon



In H_2-Air flames, and unlike in classical hydrocarbon flames, OH* chemiluminescence signal correlates poorly with heat release rate, requiring modeling of OH* in simulations. Previous studies have proposed OH* submechanisms, primarily validated through shock-tube experiments. In this work, the validation of these models is extended by investigating a laminar premixed M-shaped flame at ambient temperature and pressure with an equivalence ratio of $\phi = 0.5$. Direct numerical simulations with conjugated heat transfer are performed to assess the validity of three OH* sub-mechanisms. Very good agreement is obtained for both cold-flow and reactive velocity profiles when compared to experimental PIV. Normalized numerical OH and normalized experimental OH-PLIF results are in great agreement. The high level of confidence in the simulations enables a comparison between normalized experimental OH* chemiluminescence and normalized numerical OH* obtained for the three sub-mechanisms considered. A good general agreement between experiments and all sub-mechanisms is observed, further validating these OH* models. A 1D study reveals that at $\phi = 0.5$, similar results are expected across the different sub-mechanisms. However, increasing equivalence ratio leads to differences in the predicted OH* profiles. Therefore, a joint experimental-numerical campaign is planned at higher equivalence ratios to assess which sub-mechanisms is the most accurate.

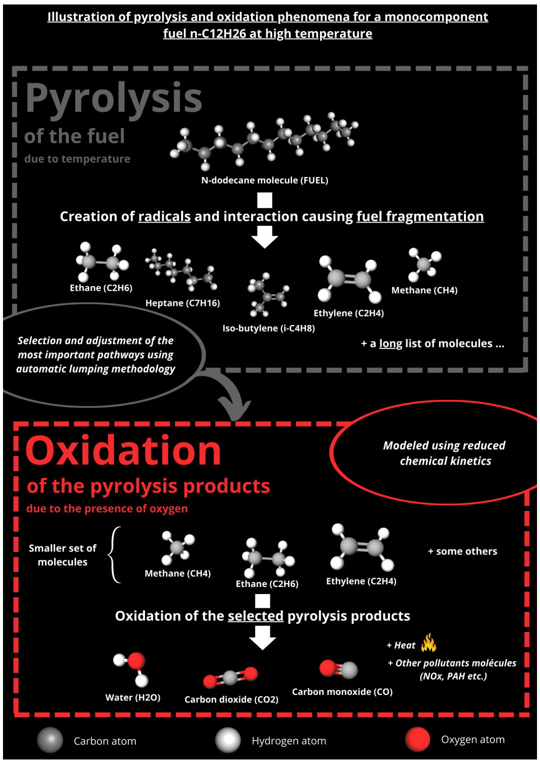
Anthony Bergaud

14:35 (poster 15:00)

Development of simplified chemical kinetics for sustainable aviation fuels

Supervisors : Eleonore Riber, Omar Dounia

In the context of decarbonizing the energy sector and, more specifically, the aeronautical field, engine manufacturers have committed to the path of alternative fuels (Sustainable Aviation Fuels, or SAFs). In addition to experimental campaigns, numerical simulation proves to be an essential tool, capable of reproducing even slight 'fuel effects' on engine performances. Over the past years, CERFACS has developed a methodology for producing ARC kinetics that are capable of accurately reproducing the studied behaviors at a much lower cost than detailed kinetics. While they are frequently used today for understanding and developing new systems, ARCs are still too costly and complex to be used in design.



The present work aims to develop a methodology for building more compact kinetics models that describe the combustion process for large molecules and blends of large molecules. Two key phenomena have to be modeled when dealing with this kind of fuels: Before burning, molecules decompose into smaller fragments, that is pyrolysis. The remaining molecules then oxidate to release heat.

It is known that these two events are decoupled at high temperatures. Thus, two models are applied to describe both parts independently to reproduce the combustion properties of a typical aeronautic fuel molecule. This kind of procedure has been introduced using experimental arguments in the literature. In this study, an automatic methodology is firstly used based on pyrolysis lumping to replicate the main pyrolysis pathways using few species and reactions. The oxidation of the resulting pyrolysis products is modeled by a reduced chemistry scheme.

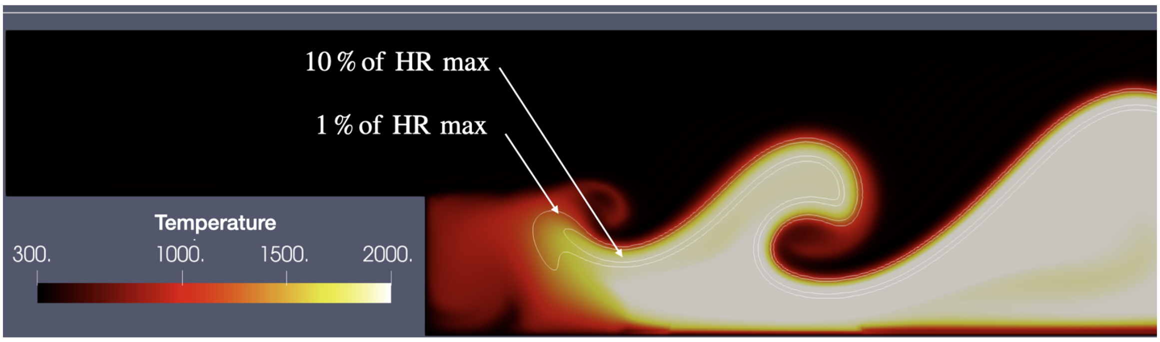
Noémie Lourme 14:40

Improving combustion models for spinning combustion technology (SCT) operability

Supervisors : Quentin Douasbin, Eleonore Riber

The lean blow-out (LBO) is a major criterion for dimensioning combustion chambers. The high-fidelity numerical simulation method used for the study and design of combustion chambers, Large Eddy Simulation (LES), has proved its worth in many fields: chamber exit quantities, ignition, etc. However, LES can only predict the LBO with a high degree of uncertainty. It is crucial to improve understanding of lean extinction mechanisms, improve numerical modeling for the prediction of lean blow-out and quantify the impact of uncertainties linked to the problem's input parameters on the prediction of lean blow-out. In contrast to local extinction, combustion chamber lean extinction relies on numerous properties of the combustion chamber which, depending on design choices, involve characteristic times of different physics, such as chamber residence time, recirculation times (central and corner), evaporation times, etc. In addition, lean extinction is a transient phenomenon for which the characteristic scales and times can be modified during extinction, thus complicating the analysis of the physical mechanisms driving extinction. In order to reduce the uncertainties in numerical simulations, the importance of the various sources of uncertainty identified needs to be quantified. In particular: sensitivities to mesh size, liquid fuel injection parameters and the turbulent combustion model. The aim of this thesis is then to highlight the mechanisms driving lean extinction in an aeronautical chamber, using unsupervised learning algorithms for transient analysis and implement a mesh adaptation method to capture physical mechanisms, taking into account the impact of sub-grids scale models on the prediction of quantities of interest.

Figure: Visualization of a blown-off flame behind a backward facing step

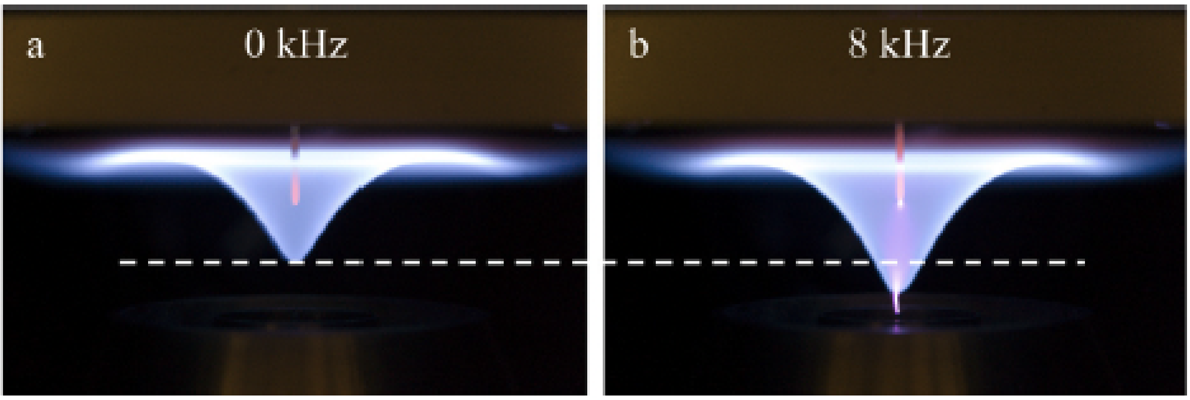


Gobins Ojars 14:45

Modelling of plasma-assisted combustion for the control of combustion instabilities

Supervisors : Nicolas Barléon, Florent Duchaine

The growing demand for carbon-free propulsion has spurred interest in hydrogen-fueled combustion systems, which offer clean energy potential but face challenges such as increased NOx emissions and flame instabilities, particularly under lean conditions. Nanosecond Repetitively Pulsed (NRP) plasma discharges have emerged as a promising solution to enhance ignition and stabilize flames in such environments. This study aims to deepen the understanding of NRP plasma effects on combustion and combustion instabilities, with a focus on hydrogen-air mixtures. The work involves the development of a reduced-order plasma model compatible with Large Eddy Simulations (LES) using the AVBP-PAC solver. Based on detailed simulations of plasma discharges in turbulent flows, a low-order model is derived to capture key plasma-combustion interaction mechanisms in both unburnt and burnt gases. The model is applied to simulate a lab-scale burner configuration under stable and unstable combustion conditions, both with and without plasma actuation, and validated against experimental data. The study further investigates how plasma modifies instability dynamics and identifies conditions under which plasma actuation is most effective. The expected outcomes include a validated NRP plasma model for 3D LES, insights into the mechanisms governing plasma-assisted stabilization, and design guidelines for future plasma-assisted combustion devices.



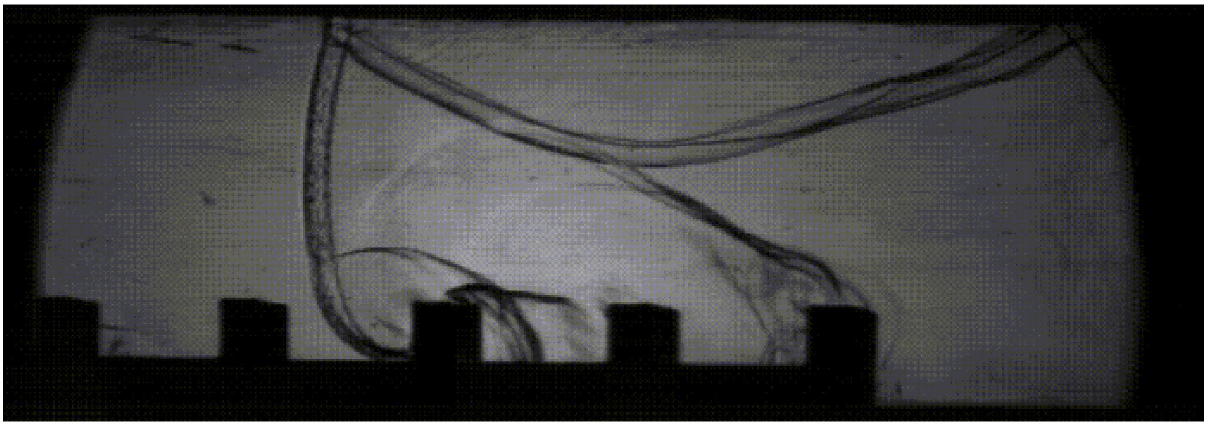
Kevin Turgut

14:50

Numerical study of the shock/detonation transition in a H2/O2/N2 premixed gas

Supervisors : Omar Dounia, Ashwin Chinnayya

This work aims to numerically investigate the fundamental mechanisms involved in the transition from shock waves to detonation (SDT) in a reactive hydrogen-based mixture. This phenomenon is of particular interest as a simplified framework to better understand the more complex deflagration-to-detonation transition (DDT), which is also being studied experimentally at PPRIME (Fig. **??**). The simulations are performed within a simplified configuration: a shock wave is propagated through a $H_2/O_2/N_2$ premixed gas inside a tube equipped with obstacles. Such geometry allows the amplification of shock interactions, leading to ignition and the formation of a self-sustained detonation wave. Before studying the full SDT process, emphasis is placed on identifying and characterizing the operating conditions that may lead to such a transition. In particular, the early stage of ignition is critical: it results from the interaction between the shock and the reactive mixture and eventually triggers the flame propagation. A key aspect of this work is the development and validation of a chemical mechanism that is both robust and computationally affordable. The first part of the thesis has therefore been dedicated to implementing and assessing such a reduced kinetic scheme, which accurately captures ignition delay times and key flame properties while remaining efficient for large-scale numerical simulations.



Example of experimental setup: SDT in H_2 + 1/2 O_2 reactive mixture under pressure P = 15 mbar

Mateus de Magalhães Barcelos Costa

14:55

Numerical simulations of hydrogen-related explosions in gas turbines
Supervisors : Thierry Poinsot, Omar Dounia

CERFACS is taking part in a European project called HYPOWERGT (2024-2028), which aims to run a Baker Hughes gas turbine on pure hydrogen. In the context of this project with numerous European partners, towards decarbonizing energy production in Europe, the goal of this thesis is simulating safety-related scenarios where hydrogen could be in an unintended place during ignition or shutdown sequences, leading to explosions. The large-scale simulation code AVBP is used for these calculations to simulate hydrogen-air mixing, hot-spot or auto-ignition and potential flame propagation in non-nominal scenarios defined in cooperation with the other project partners. Large-scale numerical simulation (LES) of several scenarios involving the presence of combustible hydrogen-air mixtures in the flow of a hydrogen-fired gas turbine during off-design transient operation are studied. These simulations take into account a detailed chemical scheme for H2-air flames (San Diego), the exact geometry of the gas turbine exhaust system, and the exact thermodynamic conditions. The specific features of hydrogen flames, such as thermodiffusive instabilities, and hot walls ignition will also be taken into account.