LIVRET DES RESUMES
ABSTRACTS BOOKLET

20ème Journée des Doctorants du CORIA
5 Février 2026

Today's program

Time	Presentation	Speaker	Chair
8h30	**Badges / Goodies / Welcome Coffee**		
9h00	**Presentation of the day**	JDD Organizing Committee	
9h05	**The Director's Welcome**	A. Cessou	
9h15	Data-driven correction of a RANS-predicted turbulent heat flux applied to high-order CFD	C. Levillain	L. Voivenel
9h35	Study of flame/spray interactions under low-temperature conditions for the validation of two-phase combustion models	O. Jegou	
9h40	Light Field Imaging applied to fluid flow measurements	A. Marszalek	
10h00	**Coffee Break**		
10h15	Docteur dans l'industrie : témoignage de Florestan Guichard, ingénieur combustion Safran Helicopter Engines et ancien doctorant du CORIA (2015-2018)	F. Guichard (*Invited Speaker*)	C. Dumouchel
11h05	Airborne Pollutants Mitigation Strategies	O. Rahal	
11h10	Gas-phase Thermometry during Flame-Wall Interaction using Two-Line Atomic Fluorescence	A. Blondel	G. Magnotti
11h30	Bulles de cavitation générées par plasma induit par laser	F. Ehrari	
11h35	Numerical and Experimental Study of High-Pressure Rich burn – Quick mix – Lean burn Combustion	A. Karrouk	P. Bénard
11h55	Numerical modeling of cryogenic tanks in microgravity	T. Laurent	
12h00	**Lunch Break**		
13h30	CH4/air & H2/air Head-On-Quenching flame wall interaction	M. Laignel	J.B. Blaisot
13h50	Modélisation de la rétrodiffusion de particules fines carbonées pour l'exploitation de données LIDAR	Y. Raynaud Diarra	

13h55	Transition probabilities determination of neutral and singly ionized chromium by laser-induced breakdown spectroscopy	S. Hadi	J. Carmona
14h15	Characterization of under-ventilated fires: Experimental investigation of oxygen depletion effects on flame structure and pollutant emissions using PIV and OH/CH* Chemiluminescence	B. Kondorkuzhi	
14h20	A LES framework for two phase flows with heat transfer: application to sloshing tanks	D. Fouquet	J.C. Brandle de Motta
14h40	Implementation of Magnetohydrodynamics (MHD) in ARCHER: Application to Liquid Metal Batteries (LMBs)	Q. Fang	
14h45	On the limits of stability of CO2 diluted turbulent oxyflames for CCUS applications	L. Pirateque	
15h05	**Coffee Break**		
15h20	Predicting the dispersion of accidental atmospheric releases using high-fidelity numerical simulation	P. Launay	G. Lartigue
15h25	Développement d'un réseau de neurones convolutifs (CNN) pour le traitement en temps quasi-réel des spectres CPP fs-DRASC	C. Bonnefoy	
15h45	Study at High-Pressure of Helicopter Injection Systems using Sustainable Aviation Fuel (SAF) through Advanced Laser Diagnostics	R. Jucá Pinheiro	
15h50	3D CFD Modeling and Simulation of Adsorption Physics	M. Najib Nadamani	V. Moureau
16h10	Modelling and simulation of oxy-combustion	N. Moslimani	
16h15	Heat transfer enhancement using elastically rotated tubes	H. Zhang	F. Thiesset
16h20	Implementation of the weighted discretization in the ADDA code	P. Bouillon	
16h40	Modélisation multiphasique du drainage d'une cavité de pressurisation d'un turboréacteur	P. Portais	
16h45	**Voting**		
17h00	**Awards Ceremony & Cocktail**		

Clément Levillain

Data-driven correction of a RANS-predicted turbulent heat flux applied to high-order CFD

Two-equation RANS models, such as those of the $k - \omega$ class, are ubiquitous in CFD due to their affordability compared to high fidelity computations. Despite their widespread use, their predictive accuracy remains limited by the many modeling assumptions required to close their equation sets. Heat transfer is a particularly challenging case, as the commonly used Gradient Diffusion Hypothesis suffers from many shortcomings. The introduction of Machine Learning to CFD has brought on a wave of new proposals to tackle this issue, with most proposals focusing on the direct prediction of a high-fidelity turbulent diffusivity $\alpha_t = \mu_t/Pr_t$ [1] or on the enrichment of the Turbulent Heat Flux through the use of higher-order tensor bases [2]. We propose in the present work the introduction of a corrective Prandtl number Pr_c, tailored to our chosen turbulence model using the relevant μ_t, to better constrain the prediction of α_t. A Deep Neural Network is trained to evaluate said Pr_c on a set of heated periodic channels at nominal Re_τ = 395, 530, 1000, for various wall temperatures, and integrated in an in-house compressible Spectral Differences code [3]. The approach showed, on these cases, an increase in fidelity w.r.t the high-fidelity Nusselt number, and a decent improvement in the RANS temperature and Turbulent Heat Flux profiles.

Adrian Marszalek

Light Field Imaging applied to fluid flow measurements

Light-field imaging is a technique based on the acquisition of dense photographic data, which constitutes a sampling of the outgoing radiance field of a scene in both spatial and angular dimensions. Plenoptic cameras are a practical implementation of this concept. From a single acquisition, such dense datasets allow for numerical refocusing, synthetic viewpoint changes, extended depth-of-field images (so-called “total focus images”), depth map estimation, and volumetric reconstructions, all performed a posteriori, from a single shot. In this presentation, we first briefly introduce the operating principles of a focused plenoptic camera, as well as the experimental setup available in our laboratory, namely the Raytrix R29 camera. In his PhD thesis, Pierre Schleuniger (CORIA – URN) demonstrated the potential of plenoptic imaging for fluid mechanics applications, such as determining bubble positions in a cylindrical tank and analyzing surface curvature distributions of four coaxial jets. These works relied on total focus images and depth maps combined with conventional image-based granulometry tools developed by Blaisot, Yon, and Fdida. Accurate results were obtained because the investigated objects were sufficiently large to yield high-quality depth maps and refocused images. More recent experiments were conducted on fine sprays at high magnification. Under these conditions, the limitations of plenoptic imaging become apparent, as increased magnification leads to a reduced depth estimation range. In addition, the dense depth map reconstruction algorithm fails to detect a significant number of small and low-contrast particles, resulting in degraded global statistics in the depth dimension. We show that these missed particles can nevertheless be revealed using a simple image-processing approach based on Laplacian filtering. In the same work, we also present ongoing developments toward a calibration method based on fitting a thin-lens model to the plenoptic camera and linking this model to the depth maps provided by RxLive, the manufacturer’s reconstruction software. This calibration procedure is performed sequentially and aims to improve the understanding of the information contained in each micro-image. Finally, we will briefly present use cases beyond the scope of this PhD thesis, such as particle image velocimetry (PIV) or volumetric reconstruction for reactive flows.

Artémis Blondel

Gas-phase Thermometry during Flame-Wall Interaction using Two-Line Atomic Fluorescence

Flame-Wall Interaction (FWI) describes various multiphysics and multiscale phenomena resulting from the intricate interaction between a solid wall and a reactive flow [1]. With the introduction of new manufacturing processes (e.g. additive manufacturing) and innovative architectures, energy systems can and have to be further optimized in order to reduce pollutants emissions at the wall and enhance the material durability with an improved cooling or heat treatment. To do so, the temperature in the near-wall region has to be known precisely since significant instantaneous heat losses occurring during FWI are controlled by this key scalar. This study aims to measure the near-wall temperature in the gas-phase using Two-Line Atomic Fluorescence (TLAF) of indium for the first time, to the authors' best knowledge. Temperature is obtained using TLAF via the Boltzmann distribution from the measurement of a ratio of fluorescence, generated by the sequential excitation of two low-lying states of an atom [2]. The platform AURYGA (Atomic fluorescence platform for thermometry in gases) has been developed at the CORIA laboratory to allow the seeding of a flame using trimethylindium (TMI) [3]. External-Cavity Diode Lasers (ECDLs) have been chosen as to be able to scan the fine absorption profile of the indium atom, hence enabling to select a calibration-free detection scheme with only one detector [4]. Using this approach, gas-phase temperature is measured inside a conical laminar premixed CH_4/air Bunsen flame interacting with a water-cooled plate (304L stainless steel) placed above it (head-on quenching configuration). Preliminary results aim to select the best parameters (laser energy, seeding concentration, etc.) to perform TLAF in the near-wall region.

Afaf Karrouk

Numerical and Experimental Study of High-Pressure Rich burn – Quick mix – Lean burn Combustion

The Rich burn - Quick mix - Lean burn (RQL) concept is a promising staged combustion technology that ensures flame stability and significantly reduces pollutant emissions at the outlet of an aeronautical combustor. The aim of the current study is therefore to present the design of a novel RQL combustion module which is integrated into the HERON high-pressure test bench and equipped with a new-generation fuel injection system from Safran Helicopter Engines, as well as large optical accesses. It is devoted to perform, by means of advanced optical diagnostics, a simultaneous study into the RQL sections of the physico-chemical processes involved in soot production/oxidation and NOx formation, under realistic high-pressure/high-temperature operating conditions such as those encountered in helicopter combustors, which will provide a reference basis for the modelling of these processes. The optimized geometry of the RQL module was achieved by performing iterative Large-Eddy Simulations (LES) of the reactive flowfield of a kerosene vapor / air mixture, with the AVBP numerical solver at a nominal operating condition, then by LES simulations performed with a liquid kerosene / air mixture. Numerical LES results highlight the ability to provide distinct RQL areas, a V-shaped jet opening at the injector outlet, a swirling flame topology, a predominant premixed/partially-premixed combustion regime in the primary rich area, as well as a high combustion efficiency of ~100 % at the outlet of the combustor. An experimental study has been initially conducted with liquid kerosene (Jet A-1) at 8.5 bar / 600 K. In a first step, OH* chemiluminescence experiments highlighted the ability to visualize well-separated RQL areas. Sampling measurements of gaseous and soot emissions were also performed at the outlet of the combustor, demonstrating the effectiveness of the RQL module in reducing NOx, CO, unburned CxHy and soot concentrations at the outlet of the combustion chamber. Following these results, new experimental studies with various advanced and coupled laser-based diagnostics will be conducted to obtain an improved understanding of the underlying physico-chemical processes within the different RQL areas.

Mathieu Laignel

CH4 / air and H2 / air Head-On-Quenching flame wall interactions

Flame–wall interaction (FWI) denotes the weakening and potential extinction of a flame as it approaches and interacts with a cold solid wall, governed by strong coupling among chemical kinetics, transport processes, and wall-induced heat losses [1]. The one-dimensional head-on-quenching (1D HOQ) configuration is widely used as a canonical benchmark for isolating these mechanisms under controlled conditions and for quantifying their impact on two key FWI metrics: quenching distance and wall heat flux. In this HOQ configuration, a laminar flame propagates frontally toward a wall, producing a transient interaction characterized by coupled temporal and spatial scales. Consequently, this configuration is difficult to characterize experimentally and remains challenging to reproduce accurately in numerical simulations [2, 3]. This study focuses on numerical simulations of the 1D HOQ configuration for methane–air and hydrogen–air flames using detailed chemical kinetics and multicomponent transport, including thermal diffusion (Soret effect). A modeling framework is established to evaluate multiple modeling approaches and to assess sensitivity to near-wall transport modeling through predictions of wall heat flux. A parametric study quantifies the effects of unburned-gas temperature and equivalence ratio on wall heat flux for each fuel. For methane–air flames, the results indicate that molecular diffusion modeling has only a minor influence on the predicted wall heat flux. For hydrogen–air flames, the predicted wall heat flux shows strong sensitivity to the diffusion model. These findings are evaluated by comparing wall-heat-flux histories with experimental measurements for stoichiometric methane–air and lean hydrogen–air flames.

Susilo Hadi

Transition probabilities determination of neutral and singly ionized Chromium by laser-induced breakdown spectroscopy

Laser-induced breakdown spectroscopy (LIBS) is a method for analyzing the elemental composition of a sample by producing plasma on its surface using a focused laser pulse. Material quantification can be performed without a standard material using Calibration-Free LIBS (CF-LIBS). An important requirement of CF-LIBS is that the plasma is in a Local Thermodynamic Equilibrium (LTE) condition. Collisional processes in the plasma should dominate the radiative decay processes. To achieve this, the electron should be sufficiently high, which can be verified using the McWhirter Criterion. The distribution of electrons, atoms, and ions in the LTE plasma is governed by the Maxwell and Saha-Boltzmann equations. The Saha-Boltzmann plot was introduced, which can be used to analyze the LTE conditions further to determine the transition probabilities, as it requires the transition probabilities. The purpose of this study is to determine the transition probabilities of neutral and singly ionized chromium by applying the Saha-Boltzmann plot approach [1]. The Saha-Boltzmann plot was constructed by measuring the radiance of the lines. It was calculated from spectra obtained by picosecond LIBS measurements on a pure chromium surface. The sample was placed in a vacuum chamber filled with argon gas at atmospheric pressure. The picosecond laser beam was focused on the sample to produce plasma, which was collected parallel to the laser beam using a Czerny-Turner spectrometer and recorded using an emI-CCD camera. The spectra were in the spectral ranges of 311-322 nm and 391-405 nm due to the absence of transition probability values in the NIST database. The Saha-Boltzmann point was established using additional information available in the NIST database and the measurement of the electron density for the point of the ionic species. The transition probabilities of the unknown chromium lines were determined using the leave-one-out cross validation approach (LOOCV), which uses the predicted linear regression from the Saha-Boltzmann plot of the reference lines. The uncertainty was calculated using the uncertainty of the Saha-Boltzmann plot and the individual contributions of the unknown lines on the Saha-Boltzmann plot. The reference lines contained 15 atomic and 5 singly ionized lines. The unknown lines were 24 atomic and 15 singly ionized lines. The Saha-Boltzmann plot of the reference lines employs the equilibrium of the excitation and ionization temperatures of chromium by the linearity of the point distribution. It gives the excitation-ionization temperature of

(7361 ± 396) K with an electron density of (2.21 ± 0.21) × 1022 *m*–3 obtained using the hydrogen alpha Stark broadening measurement. After verifying the McWhirter criterion, the plasma achieved the LTE condition. Each point of the unknown line is placed on the linear regression, and the transition probability is obtained. The results of the transition probabilities of the unknown lines are in satisfactory agreement with previous numerical and experimental results, with an uncertainty of approximately 49-83%. The uncertainty of the unknown lines is relative to the transition probability uncertainty of the reference lines. These results can be further analyzed by comparing the simulated spectra of the unknown chromium lines with several references that will be provided to corroborate these results.

Damien Fouquet

A LES framework for two phase flows with heat transfer: application to sloshing tanks

Within the past decades, many methods have been developed to study two-phase flows with heat and mass transfer. Mainly applied within a Direct-Numerical-Simulation (DNS) framework, these methods rely on two key ingredients: i) capturing or tracking of interface position, and ii) an accurate calculation of heat/mass/momentum exchange terms. For the first ingredient, Sharp Interface-Methods, such as the Accurate-Conservative-Level-Set (ACLS) method, enable to retrieve the interface position on structured or unstructured grids. However, the calculation of heat/mass/momentum exchange terms requires a high resolution at the interface to estimate with sufficient accuracy the temperature, species mass fraction, and velocity gradients. Although this resolution can be reached in a DNS framework but at the expense of a high CPU cost, it is generally not possible in the simulation of industrial processes, where characteristic length scales can range from nanometers to meters, as encountered in cryogenic tanks. In this work, a rigorously derived Large-Eddy Simulation (LES) framework is presented and applied to two-phase heat transfer. It relies on a multi-fluid approach where a temperature is defined in each phase, weighted by a sharp phase indicator, and then filtered. As the resolution is not high enough to capture interface temperature gradient, a heat transfer model for interface terms has been derived based on an out-of-equilibrium hypothesis. With this framework, simulations of sloshing induced pressure drops are carried out and compared to experimental results

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Laura Pirateque-Henao

On the limits of stability of CO2 diluted turbulent oxyflames for CCUS applications

The present study focuses on oxyfuel combustion as a method for carbon dioxide capture for sequestration and utilization (CCSU). However, in the absence of nitrogen as a thermal ballast, combustion temperature increases rapidly, which poses a risk of damaging the equipment. In order to regulate the high temperature and enable the retrofitting of current industrial installations, CO_2 can be recirculated from the flue gas (RFG) and mixed with O2 oxidizer, maintaining a high CO_2 concentration to also facilitate its capture. Interest in CCS applications increases with the use of renewable fuels, such as biogas, which is mainly a blend of methane and carbon dioxide. In the present lab-scale study, the stability limits of long turbulent methane-oxygen flames are investigated in the presence of CO2 in both the fuel (biogas) and the oxidizer (RFG). While progressively increasing the CO2 proportion in the oxidizer, a particular behavior is observed when approaching the unstable limit, where the CO production of the flame increases sharply with only a 1% variation in oxidizer dilution. This behavior is reproduced for an increase of CO2 content in the biogas (CH4-CO2), but it appears for a slightly lower oxidizer dilution. All unstable limits were identified within a 2% range of the total CO2 injected, regardless of whether it comes from the fuel or from the oxidizer. The different diluted oxyflames are characterized with a combination of several measurement techniques, such as OH* chemiluminescence for flame imaging, flue gas emissions (CO, CO2, CH4, O2, NOx), and finally temperature and thermal flux profiles throughout the combustion chamber. The flames obtained near the unstable limits are studied with advanced laser diagnostics. This is done with a combined high-speed Particle Image Velocity (PIV) and OH Planar Laser-Induced Fluorescence (PLIF) analysis. This approach allows for a time-resolved observation of the aerodynamic behavior and the flame structure, as well as their coupled influence, to better understand the CO2 dilution effects on the flame instabilities with local extinctions.

Célia Bonnefoy

Développement d'un réseau de neurones convolutifs (CNN) pour le traitement en temps quasi-réel des spectres CPP fs-DRASC

Pour lutter contre le réchauffement climatique, le développement de dispositifs de combustion propres et performants utilisant des carburants décarbonés demande une connaissance détaillée des mécanismes physicochimiques associés. La technique de spectroscopie DRASC (Diffusion Raman anti-Stokes Cohérente) femtoseconde en régime de sonde à dérive de fréquences (CPP fs-CARS) est un outil optique clé permettant de mesurer instantanément et précisément la température au sein de ces flux turbulents à la cadence de mesure de 1 kHz. Son potentiel a été démontré dans le cadre de thèses précédentes (F. Berthillier, S. Legros) réalisées au laboratoire CORIA et au cours desquelles de nombreuses données expérimentales ont été enregistrées [1, 2]. Toutefois, cette grande quantité de données représente un challenge dans leur traitement lorsqu'on utilise une approche d'analyse conventionnelle fondée sur l'utilisation d'un code de simulation de spectres DRASC lancé par un algorithme génétique multi-paramètres [3]. Cette méthode nécessite l'optimisation de quatorze grandeurs physiques inconnues par une minimisation par moindres carrés entre les spectres simulés et le spectre expérimental [4]. La génération itérative de populations de spectres, nécessaire à la convergence des variables d'ajustement, conduit alors à des durées d'analyse de plusieurs dizaines d'heures par spectre, ce qui limite grandement notre capacité à analyser un nombre important de données expérimentales enregistrées pendant des campagnes de mesure effectuées sur des foyers de combustion. Pour lever ce verrou, un traitement de données utilisant un réseau de neurones convolutifs (CNN) a été développé [5]. Ce modèle de deep learning permet d'extraire la température lors de l'analyse d'un spectre DRASC de manière quasi-instantanée (quelques centièmes de seconde), ce qui offre une alternative performante et rapide à la méthode de traitement jusqu'alors utilisé pour traiter de grandes séries de données expérimentales. Entraîné et validé sur deux millions de spectres synthétiques, le modèle CNN démontre une excellente justesse de mesure de la température ainsi qu'une reconstruction fidèle des signatures spectrales. Appliqué à des spectres expérimentaux bruités, le CNN affiche des performances comparables à celles de l'algorithme génétique tout en réduisant drastiquement le temps d'analyse. Ainsi, le traitement de 1000 spectres DRASC est ramené à seulement 30 secondes. Cette méthode de traitement innovante offre désormais une alternative performante pour l'exploitation massive de données expérimentales issues de diagnostics laser appliqués en environnements réactifs.

Mohamad Najib Nadamani

3D CFD Modeling and Simulation of Adsorption Physics

Adsorption in fixed-bed reactors is widely used for gas separation and purification, yet its predictive modeling remains challenging because hydrodynamics, mass transfer, adsorption kinetics, and heat effects are strongly coupled in complex porous structures. This PhD work focuses on the numerical modeling and simulation of fixed-bed adsorption, from continuum (macroscale) porous-medium descriptions to fully particle-resolved simulations. First, a critical literature review is presented. The review highlights the diversity of kinetic formulations and effective parameters commonly employed (e.g., LDF-type models, fitted mass-transfer coefficients, effective dispersion and film resistances), and discusses open questions related to parameter identification, scale consistency, and the transferability of fitted closures across operating conditions and geometries. Second, a coupled macroscale CFD model is developed for flow, species transport, adsorption, and heat transfer in porous media. The model is validated against experimental measurements from the literature by comparing breakthrough curves and outlet temperature evolutions under representative operating conditions. This part of the work has resulted in a manuscript available on arXiv and currently under review at Physics of Fluids. Finally, to overcome the intrinsic limitations of volume-averaged approaches, a new particle-scale framework is introduced by coupling an immersed boundary method (IBM) for CFD with an adsorption and heat-transfer model at the pellet level. This approach explicitly resolves packing heterogeneity, near-wall channeling, and local velocity and temperature gradients, enabling direct analysis of their impact on gas-phase composition and adsorption fronts. The particle-resolved model is validated against literature case studies on a full packed bed, providing mechanistic insight at the pore scale and supporting the development of more reliable closures for macro-scale fixed-bed adsorption models.

Paul Bouillon

The discrete dipole approximation (DDA) [1] simulates absorption and scattering of light by arbitrary shaped particles. The scatterer is replaced by a set of interacting point dipoles (mathematically equivalent to a set of voxels approximating the particle volume). This leads to a large linear system of equations to be solved for the internal fields (or polarizations p_i).

$$E_i^{inc} = \overline{\alpha}_i^{-1} p_i - k^2 \sum_{j \neq i} \overline{G}_{ij} p_j,$$

where E_i^{inc} corresponds to the incident field, $\overline{G}_{ij}$ represents point dipole interactions between two voxels and $\overline{\alpha}_i$ is the voxel polarizability. Among the different types of DDA errors, shape errors [2] arise from the mismatch of the particle boundary with some voxels for a traditional discretization (TD) scheme. Weighted discretization (WD) for those boundary voxels is designed to decrease those errors. The most advanced WD scheme [3] uses a secant plane of normal $\hat{n}_i$ as a local approximation of the particle boundary at voxel scale, from which the fraction f_i of the domain that contains the voxel center is determined. In addition to this, electric boundary conditions are used to relate electric fields in both voxel subvolumes (p) and (s) as $E_i^s = \overline{T}_i E_i^p$, which results in the weighting of the susceptibility as $\overline{\chi}_i^e = f_i \chi_i^p \overline{I} + \left(1 - f_i\right) \chi_i^s \overline{T}_i$. The structure of the DDA equation is kept intact (1), while the polarizability of the boundary voxels is replaced by an effective one:

$$\overline{\alpha}_i^e = V_i \overline{\chi}_i^e \left[\overline{I} + \left(\overline{L}_i^p - \overline{M}_i^p \right) \chi_i^p + \left(\overline{L}_i^s - \overline{M}_i^s \right) \chi_i^s \overline{T}_i \right]^{-1},$$

with self-term dyadics $\overline{L}_i^{p,s}$ and finite-size corrections $\overline{M}_i^{p,s}$. Values of $\overline{L}_i^{p,s}$ can be evaluated analytically using cumbersome computational geometry [4], while $\overline{M}_i^{p,s}$ can be ignored with small influence on the final accuracy. These expressions have been implemented in the open-source ADDA code [5]. As the first test, we compared the sum of voxel volumes (accounting for f_i in WD) to the scatterer volume for a homogeneous sphere. Both WD and TD yield quadratic convergence but their behavior remains very different: large oscillations are observed for TD (consistent with sign-alternating errors for individual voxels) whereas WD demonstrates a much smoother convergence with significantly smaller errors. Next, we tried to reproduce the results of the original publication [3] for small spheres. Although some discrepancy remains (due to uncertainties of specific discretization scheme), qualitative agreement was obtained over a wide range of discretization levels. Once again, WD yields a smoother convergence compared to TD, which potentially allows further accuracy improvement using the extrapolation technique [6].