Keynote Mrs Jacob

From ground based Environmental testing to Hypersonic flights – A Challenge for Laboratories

Abstract

Ground based Environmental and Structural testing is a necessity to demonstrate the survivability of hardware – system or component - during air carriage, firings and flight of missiles. Particularly for hypersonic flights, where the extreme situations are generated from a combination of significantly high temperatures and complex mechanical loadings, dynamic and static. Hence, developing facilities and test methodologies is fundamental for MBDA not only to refine models that predict hypersonic flight behaviour and performance but also to evaluate if the vehicles can withstand the severe conditions encountered during flights

Bio

Alice Jacob graduated from ENSMA Engineering School (École Nationale Supérieure de Mécanique et d'Aérotechnique), France, in 2010. She joined MBDA in 2011, where she began her career in the Environmental Engineering Department, contributing to the specification of test procedures used to validate hardware. In 2017, she moved to the test Laboratory as a Structural test engineer. In 2018, she took over responsibility for the Structural test activities and teams, including the preparation of hypersonic test campaigns. In 2019, she became head of the Environmental and Structural Test Laboratory. Since 2025, she has been leading the Environmental, Structural and Special Testing Department.

Keynote Prof. Kasahara

Space Flight Experiments of Detonation Engine System by Using Sounding Rockets S-520-31 and S-520-34 and Detonation Engine Basic Studies

Abstract

The detonation engine generates detonation and compression waves at extremely high frequencies (1–100 kHz) to drastically increase reaction speed, leading to radical reduction of rocket engine weights and high performance by easy generation of thrust. The research group of Nagoya University, Keio University, JAXA/ISAS, Muroran Institute of technology, Shizuoka University, Sojo University, University of Tokyo has successfully demonstrated a detonation engine in space flights. The Detonation Engine System (DES) and Detonation Engine System 2 (DES2) developed in these study were loaded onto the mission sections of the sounding rockets S-520-31 and S-520-34 respectively, and launched from the JAXA Uchinoura Space Center on July 27, 2021 and November 14, 2024. By the sounding rocket S-520-31, the gas-methane-GOX rotating detonation engine and pulse detonation engine were successfully operated. And by the sounding rocket S-520-34, the liquid propellant (ethanol-N2O) detonation engine system were successfully operated in space. The success of these space flight demonstrations will bring the detonation engine much closer to practical use as a kick motor for deep space exploration, and as a first and second stage engine for rockets. The recent progress of the project and fundamental research of detonation engines will be also addressed.

Bio

Jiro Kasahara is a professor of Institute of Materials and Systems for Sustainability, Nagoya University, Japan from 2019. He received PhD from the Graduate School of Engineering, Nagoya University at 1997. From 1997 to 1999, he was a JSPS fellow (PD) at Nagoya University. From 1999 to 2003, he was a research associate of Muroran Institute of Technology, Japan. From 2003 to 2013, he was a lecturer and an associate professor of University of Tsukuba, Japan. From 2013 to 2019, He was a professor of Nagoya University, Department of Aerospace Engineering, before taking his current position. He specializes in detonation basics, and detonation engine system for aerospace propulsion.

Keynote Prof. Leonov

Recent progress in plasma-based control of duct-driven flow and combustion relevant to hypersonic systems

Abstract

Control of supersonic/hypersonic flows, both external and internal, is one of the major problems relevant to high-speed flight, including supersonic ducts, high-speed air compression, scramjet flowpaths, and other configurations involving shock-dominated flows. Shock-dominated flows are sensitive to geometry deviations as well as flow parameters distribution/dynamics, including the state of the boundary layer and the structure of compression/expansion waves. Without active control of the shocks' structures, operation at off design conditions is challenging, resulting in narrowed operational margins. Mechanical control schemes, such as stationary or movable components, suffer from increased total pressure loss, have a lack of flexibility, and a long response time compared to a gasdynamic time scale. In contrast, fast, inertia-free action can be provided by electrical discharges. On another hand, a demand for airbreathing high-speed propulsion systems has led to intense study of the mixing and ignition dynamics of directly injected fuel in supersonic flow. The short residence time in a practical-length combustor makes sustained combustion challenging as fuel-air mixing must occur on a molecular level before ignition, and flame propagation speed is orders of magnitude below the freestream gas velocity. This is especially true at engine startup or after a loss of thrust event (unstart, blowoff, etc.) where the conditions for autoignition may not be met. For supersonic combustion engines, the active control of mixing, ignition and flame stability is urgent. The upcoming talk will be focused on recent research results related to active flow and combustion control in hypersonic systems: fundamental and applied aspects. This includes the active control of shock-dominated flow, active flameholding, and some aspects of ground test instrumentation.

Bio

Sergey B. Leonov received his PhD from The Baltic State University in 1990, and a senior Doctor of Science degree from the Russian Academy of Sciences in 2006. He worked in research and higher education institutions, including Joint Institute for High Temperature RAS where he was a Head of Department, and, concurrently, Moscow Open University where he was a Professor. In 2013-2014, he was a Visiting Professor at The Ohio State University, USA. Since 2014, he is a Professor at the University of Notre Dame, USA. His research interests and contributions are in plasma aerodynamics, flow physics, supersonic combustion, active flow control, weakly-ionized plasmas, and experimental methods/instrumentation. He has over 400 publications, including over 100 peer-reviewed journal papers, book chapters, and patents. Prof. Leonov is an Associate Fellow of AIAA and an IEEE Senior Member, Coordinator of Plasma Aerodynamics Discussion Group, AIAA Plasmadynamics and Lasers Technical Committee Member, EUCASS Flow Physics Technical Committee Member, FLUCOME Honorary Member, J Aerospace Section Lead Editor, Journal Technical Physics Letters Section Editor, etc. He has extensive experience in managing of international and national research projects, including projects funded by US AFOSR, DARPA, UCAH, AFRL, Boeing Co, MDBA France, DERA-UK, FP-6/EU.

<u>Keynote Dr. Zhang</u>

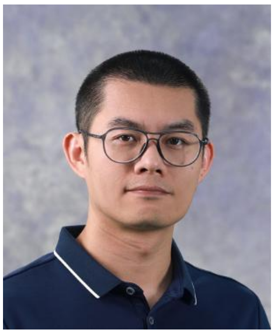
Physics-Informed AI for Next-Generation Hypersonic Aerodynamic Design

Abstract

In aerospace vehicle design, aerodynamic characteristic computation is pivotal, with its core challenge rooted in balancing accuracy and efficiency. Historically, reduced-order models (ROMs) for aerodynamic forces sought to resolve this dilemma by integrating physical knowledge into data-driven frameworks. Today, advancements in artificial intelligence (AI) have enabled unprecedented progress in embedding physical principles into neural networks. This presentation highlights our team's cutting-edge research in physics-informed aerodynamic modeling, including:

1. Structured Physics-Informed Neural Networks (PINNs) for high-fidelity flow field reconstruction;
2. Unified low-dimensional representation frameworks for multi-source heterogeneous data in aerodynamic modeling;
3. Interpretable aerodynamic models based on symbolic regression. Additionally, we demonstrate an application of AI-driven aerodynamic models to the design optimization of waverider configurations. Case studies reveal that these novel models enable the rapid discovery of previously unidentified geometric features under specific constraints, yielding insights unattainable through conventional methods. These breakthroughs not only enhance design efficiency but also deepen our understanding of hypersonic flight mechanisms.

Bio



Dr. Chen'an Zhang received the Ph.D degree in Fluid-Structure interaction and Control from Northwestern Polytechnical University, Xi'an, China in 2010. He is currently a professor at the Institute of Mechanics, Chinese Academy of Sciences. He has long been committed to the research of hypersonic vehicle design, unsteady aerodynamics and aeroelasticity. In recent years, Dr. Zhang and his team have systematically addressed key challenges in the field of hypersonic vehicle flight stability, and have made breakthroughs in the stability design of waveriders. They combined artificial intelligence with aerodynamic modeling methods and applied them to the optimization of the aerodynamic configuration of waverides, which greatly improved the practical aerodynamic performance. He was awarded the Outstanding Science and Technology Achievement Prize of the Chinese Academy of Sciences in recognition of his contributions to the field of aerospace engineering.

<u>Keynote Dr. Fischer</u>

Ceramic Matrix Composites for intermediate temperature (800-1200°C) applications

Abstract

Ceramic Matrix Composites (CMCs) are key materials for hypersonic flight vehicles. They can withstand high and very high temperature and their mechanical properties allows for their use as structural or semi-structural parts. An extensive use of carbon fiber / carbon matrix (C/C) has been made in various industrial fields. They are among the older CMCs and the most widespread. They can for instance be met in brakes or space and military engine parts. In terms of temperature of application, they can typically withstand temperatures up to 1800°C provided they are protected from oxidation. Adding a silicon carbide (SiC) phase to the C/C leads to a wide range of C/C-SiC variations with a better resistance to oxidation for a similar thermomechanical performance. The trend has led to SiC fiber composites (SiC/SiC) that can still target applications within the same range of high temperature (1500°C and above).

Among the past decades, a new class of CMCs arose with a lower temperature range of application. They are based on ceramic materials but strongly rely on processes inherited from the organic matrix composites (OMCs). These processes are fundamentally different from those used for the C/C, C/C-SiC and SiC/SiC, which involve densification from gaseous precursors, a long and costly process. As a result, the newer CMCs offer an alternative set of cheaper materials for a lower temperature range. Among these materials, oxide fiber / oxide ceramic matrix composites (ox/ox) are predominant. They are limited to applications up to 1200°C and are mostly obtained with prepregs, in a similar manner as some OMCs.

This family of materials brings opportunities thanks to their lower costs and the available design resulting from the processes they based-on. Theses CMCs fill a gap between so called “high temperature” OMCs, which have a physical limitation close to 400°C, and carbon and silicon carbide-based composites, which may be overqualified for applications below 1500°C. Some metallic materials can also be found in this gap and the competition between them and intermediate temperature CMCs can be discussed.

Bio

Guillaume Fischer is a research engineer from ESPCI (École Supérieure de Physique et de Chimie Industrielles de la Ville de Paris) engineering school, specialized in chemistry and polymer science. He obtained his PhD in materials science at INSA de Lyon, through a collaboration with Airbus Group in 2015. He joined the Materials and Processes team of MBDA France in 2016 as a specialist in composite materials. Getting more and more involved in high temperature applications over the years, he became the referent specialist on Ceramic Matrix Composites and thermal barrier materials in 2023. He took the technical responsibility, in 2024, of the growing high temperature composites group within the MBDA’s Materials and Processes team. He is also MBDA France’s representative at the French standardization committee on Technical Ceramics and Ceramic Matrix Composites.