WAAE 2026 Track 6 Description

Basic Information:

专栏题目 **Title**	中文：计算空气动力学前沿方法 英文：Advanced Methods in Computational Aerodynamics

专栏介绍和征稿主题
Introduction and topics

中文： 计算空气动力学（CA）已成为现代飞行器设计、优化和适航认证中不可或缺的基石。在追求更高飞行效率、极端飞行流态以及低碳绿色航空的背景下，航空航天领域对数值模拟的保真度和计算效率提出了前沿挑战。传统的计算流体力学（CFD）方法在面对多尺度、强非线性的流动现象时（如复杂的流场分离、高雷诺数壁湍流以及气动声学约束下的多学科耦合）正面临着巨大的技术瓶颈。

为了打破这些壁垒，计算空气动力学的研究范式正在经历一场深刻的变革。本专题分论坛旨在聚焦计算空气动力学领域的最新突破和新兴方法，架起严谨的数学理论与工程实际应用之间的桥梁。我们将重点关注数据科学与流体力学的深度融合，包括数据驱动建模、高保真度湍流框架以及物理信息机器学习的最新进展。至关重要的是，针对"黑箱"神经网络在关键航空工程应用中所面临的可信度质疑，本论坛也特别强调因果分析、符号回归、先进模态分解等可解释性 AI 方法，以期从根本上挖掘主导复杂流动的潜在物理机理。

本论坛旨在汇聚全球顶尖学者、计算科学家和工业界专家，共同交流创新思想、探讨模型泛化性与物理一致性等关键挑战，并促进国际合作，以期共同塑造未来智能航空流动分析与控制的新格局。

征稿主题

我们诚挚欢迎包括但不限于以下方向的学术投稿：

- **高超和高速空气动力学：**面向高超和高速空气动力学的流动问题。
- **流体力学中的可解释性 AI：** 因果分析、控制方程自发现、符号回归以及神经网络的物理可解释性研究。
- **物理信息机器学习：** 物理信息神经网络（PINN）、算子学习（傅里叶神经算子、DeepONet）以及面向空气动力学的几何自适应学习。
- **降阶模型与模态分析：** 先进动态模态分解（DMD）、本征正交分解（POD）以及减阻/控制相干结构的稀疏发现。
- **数据驱动湍流建模：** 机器学习辅助的 RANS/LES 封闭模型、特征提取与湍流物理机理发掘。
- **数据同化与多保真度融合：** 非线性数据同化、多保真度气动数据融合以及实验-数值流场对齐。
- **智能优化与流动控制：** 智能气动几何优化、基于强化学习的主动流动控制以及基于代理模型的健壮设计。
- **高阶格式与多物理场耦合：** 结合智能框架的高阶数值方法（DG、FR）、流固耦合（FSI）及计算气动声学（CAA）。
- **智能 CFD 中的不确定性量化：** 敏感性分析、数值验证与确认（V&V）以及智能预测模型的不确定性评估。

英文：Computational Aerodynamics (CA) has evolved into an indispensable cornerstone for the design, optimization, and certification of modern aerospace vehicles. Driven by the relentless pursuit of higher flight efficiency, extreme flight regimes, and low-emission air transportation, the aerospace community demands unprecedented fidelity and efficiency from numerical simulations. Traditional computational fluid dynamics (CFD) approaches face significant bottlenecks when encountering multi-scale, highly non-linear flow phenomena, such as complex flow separation, high-Reynolds number wall-bounded turbulence, and multidisciplinary coupling under aeroacoustic constraints.

To overcome these barriers, the paradigm of computational aerodynamics is undergoing a profound transformation. This Special Session focuses on the latest breakthroughs and emerging methodologies in computational aerodynamics, with a strong emphasis on the fusion of data science and fluid mechanics. We highlight advancements in data-driven modeling, high-fidelity turbulence frameworks, and physics-informed machine learning. Crucially, as black-box neural networks face skepticism in critical engineering applications, this session shines a spotlight on interpretable AI methods—such as causal analysis, symbolic regression, and advanced modal decompositions—to uncover the underlying physical mechanisms governing complex flows.

This forum intends to gather leading researchers, computational scientists, and industry experts worldwide to exchange innovative ideas, discuss remaining challenges in model generalization and physics alignment, and foster international collaborations shaping the future of intelligent aerospace flow analysis and control.

Topics of Interest

We invite submissions on various topics, including but not limited to:

- **Hypersonic and High-Speed Aerodynamics:** Complex flow problem for hypersonic and high-speed aerodynamics.
- **Explainable AI (XAI) in Fluid Mechanics:** Causal analysis, discovery of governing equations, symbolic regression, and physical interpretability of neural networks.
- **Physics-Informed Machine Learning:** Physics-Informed Neural Networks (PINNs), operator learning (Fourier Neural Operators, DeepONet), and geometry-adaptive learning for aerodynamics.
- **Reduced-Order Models and Modal Analysis:** Advanced Dynamic Mode Decomposition (DMD), Proper Orthogonal Decomposition (POD), and sparse discovery of coherent structures.
- **Data-Driven Turbulence Modeling:** Machine learning-assisted RANS/LES closure modeling, feature extraction, and turbulence physics discovery.
- **Data Assimilation and Multi-Fidelity Fusion:** Non-linear data assimilation, multi-fidelity aerodynamic data fusion, and experimental-numerical alignment.
- **Intelligent Optimization and Control:** Intelligent aerodynamic shape optimization, reinforcement learning for active flow control, and surrogate-based design.
- **High-Order Schemes and Multiphysics Coupling:** Advanced high-order numerical methods (DG, FR) integrated with intelligent frameworks, fluid-structure interaction (FSI), and 計算气动声学 (CAA).
- **Uncertainty Quantification in Intelligent CFD:** Sensitivity analysis, model validation and verification (V&V), and robust design under uncertainty.

Track Chair(s):

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Organizer’s Brief Biography

中文：寇家庆，工学博士，现任西北工业大学航空学院教授，国家级青年人才。博士毕业于马德里理工大学，曾先后作为欧盟“玛丽·居里学者”和德国“洪堡学者”开展博士及博士后研究。寇教授的主要研究方向为智能空气动力学、计算流体力学与飞行器设计。他在 Progress in Aerospace Sciences、Journal of Fluid Mechanics、Journal of Computational Physics 以及 AIAA Journal 等流体力学和航空航天领域顶级期刊上发表学术论文 60 余篇，Google Scholar 引用超 3500 次，连续六年入选全球前 2% 顶尖科学家榜单。寇教授目前是英国皇家航空学会会士（FRAeS），并担任国际权威期刊 Aerospace Science and Technology 的副主编。

英文：Dr. Jiaqing Kou is currently a National Young Talented Professor (Overseas) in the School of Aeronautics at Northwestern Polytechnical University (NPU). He obtained his Ph.D. from the Universidad Politécnica de Madrid (UPM) and previously conducted research as a Marie-Curie Fellow and a Humboldt Postdoctoral Fellow. Dr. Kou’s research focuses on intelligent aerodynamics, computational fluid dynamics, and aircraft design. He has published over 60 papers in leading fluid mechanics and aerospace journals, including Progress in Aerospace Sciences, Journal of Fluid Mechanics, Journal of Computational Physics, and AIAA Journal, gaining over 3,500 citations on Google Scholar. He has been continuously listed among the "World's Top 2% Scientists" for six consecutive years. Dr. Kou is a Fellow of the Royal Aeronautical Society (FRAeS) and serves as an Associate Editor for Aerospace Science and Technology.

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Organizer's Brief Biography

中文：李炳华，工学博士，现任北京航空航天大学国际创新研究院/中西智能学院副教授。博士毕业于马德里理工大学，并获杰出博士毕业生及最高学术荣誉。主要从事数据科学与湍流流动控制（AI4Science）的交叉前沿研究，在降阶模型、模态分析、因果分析以及高保真湍流数值模拟等方向具有长期的学术积累。其在 Journal of Computational Physics、Physics of Fluids、Aerospace Science and Technology 等流体力学与航空航天领域顶级期刊发表高水平学术论文 14 篇（其中 SCI 10 篇，EI 4 篇），并作为核心撰写人参与撰写学术专著《湍流流动控制减阻技术》。先后主持或核心参与国家自然科学基金、中欧国际合作项目、工业和信息化部专项等国家级及企业合作项目 10 余项。目前担任《力学学报（英文版）》（TAML）青年编委，以及 PoF、OE、RESS 等多个国际权威期刊的审稿人。

英文：Dr. Binghua Li is an Associate Professor and Master's Supervisor at the International Innovation Research Institute / Sino-French Institute of Aviation, Beihang University (Hangzhou). He received his Ph.D. degree with the highest academic honors (Cum Laude) from the Universidad Politécnica de Madrid (UPM). Dr. Li's research interest lies at the cutting-edge intersection of data science and turbulence flow control (AI4Science), with specific expertise in reduced-order modeling, modal analysis, causal analysis, and high-fidelity turbulence simulation. He has published 14 peer-reviewed papers in top-tier fluid mechanics and aerospace journals, including Journal of Computational Physics, Physics of Fluids, and Aerospace Science and Technology, and co-authored the monograph Turbulence Flow Control and Drag Reduction Technology. Dr. Li has led or contributed to over 10 high-level research initiatives, including the National Natural Science Foundation of China (NSFC) and Sino-European international cooperation projects. He serves as a Junior Board Member for Theoretical and Applied Mechanics Letters (TAML) and a reviewer for PoF, OE, and RESS.