AAE SPECIAL SEMINAR

Stochastic and large eddy simulation models for turbulent high-speed flows

MONDAY, NOVEMBER 10TH, 2025
CHAFFEE AUDITORIUM 1:30PM-2:20PM

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Abstract

Computational fluid dynamics (CFD) can and should contribute to the design of high-speed combustors, with an aim to reduce both the time and cost of development. Recent modelling of rotating detonation engines at the University of Sydney and elsewhere give us good reason to be optimistic about the complementary role that CFD can play in the development cycle. However, existing and novel propulsion engines exhibit certain physical phenomena which pose challenges for CFD models, and this continues to drive fundamental research. This talk will present recent work on three key aspects of combustion in high-speed propulsion engines:

1. non-linear interactions between turbulent mixing, combustion reactions and shockwaves
2. turbulent flow transition and effects of compressibility
3. discontinuities at phase interfaces.

We will discuss stochastic and large eddy simulation models, and their hybrid combinations. Stochastic models are elegant approaches for solving continuum turbulent flow problems. Their great attraction is that they provide inherently closed formulations for non-linear, smallscale processes such as chemical reactions. Although stochastic approaches have traditionally been considered to be computationally expensive, it is possible to alleviate this by complementing them with low-dimensional manifolds. The talk will also outline the mission of the new Australian Research Council Training Centre for High-Speed Propulsion, Rocket and Launch Systems, and our vision for collaboration among AUKUS nations.

Biography

Matthew Cleary is a Professor in the School of Aerospace, Mechanical and Mechatronic Engineering at The University of Sydney. His research interests are in computational modelling of turbulent combustion and two-phase flows, with applications to high-speed propulsion, energy and environment. A particular interest is stochastic Monte Carlo models for combustion large eddy simulations, and in this area, Cleary is best known for developing the sparse- Lagrangian Multiple Mapping Conditioning model (MMCLES) and its related opensource solver - mmcFoam. Cleary's team has recently developed new two-phase LES models for interfacial and droplet-laden flows, introducing the Explicit Volume Diffusion (EVD) concept which is proving to be both accurate and uniquely computationally convergent and tractable. Since 2021, Cleary has been the supervisor the University of Sydney Rocketry Team; two-time winners of the International Rocket Engineering Competition. In 2025, their hybrid-engine rocket Pardalote won the title in Midland, Texas. Cleary has been active in mentoring Australian rocketry teams. He is Director of the Australian Rocket Systems Training Network (ARSTN), a national endeavour involving universities, vocational training institutions, companies and the government sector, to create a skilled workforce for sovereign Defence and Space industries. Cleary is also Director of the Australian Research Council doctoral training centre for High-Speed Propulsion, Rocket and Launch Systems (HiPR-LS), a partnership between Australian universities and US and UK collaborators along with over 20 industry and government sector partners. It will educate up to 20 PhD students, while developing internship and Grand Challenge flight test programs.

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