Boulder Fluid and Thermal Sciences Seminar Series

Tuesday, February 27, 2018
3:30pm-4:30pm (refreshments at 3:15pm)
Clark Conference Room (ECAD 150)
Engineering Center Administration Wing, University of Colorado, Boulder

Autonomic Closure for Large Eddy Simulation of Turbulent Flows and Transport Processes

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Turbulent flows and the transport of mass, momentum, energy, and scalars within them are central to an enormous range of key applications in science and engineering, including most natural and built engineering processes, devices, and systems. All turbulent transport problems involve very wide ranges of length and time scales, which place a tremendous computational burden on direct simulations. Large eddy simulations coarse-grain the governing equations to remove intermediate and small scales, but this creates subgrid-scale terms that must be modeled to achieve a closed set of equations. This has been recognized for well over 50 years, however turbulence research has to date not provided any universal approach for modeling subgrid terms that can reliably provide a level of fidelity approaching that of direct simulation in the resolved scales.

Here a new and entirely different approach [Phys. Rev. E 93, 031301(R) 2016] will be presented that completely circumvents the need for such traditional model-based closure. In “autonomic closure” subgrid terms are formulated in highly generalized representation, and a high-dimensional nonlinear nonparametric system identification problem is solved at a test scale for each point and time in the simulation to find the optimal local relation between the subgrid term and the resolved variables. Autonomic closure freely adapts to the varying nonlinear, nonlocal, nonequilibrium and other characteristics of the turbulence state throughout the simulation. Results from this new approach to turbulence closure show exceedingly accurate representation of the detailed space- and time-varying fields for momentum and energy exchange between resolved and subgrid scales.

However, the computational cost of this new closure methodology exceeds that of traditional prescribed closure models. It will be shown that there are highly efficient implementations of autonomic closure that retain essentially all of this new approach’s accuracy but at computational costs that are many orders of magnitude smaller. These are efficient enough to make autonomic closure practical for use in large eddy simulations.

Biography: Werner J.A. Dahm has since 2010 been the ASU Foundation Professor of Mechanical and Aerospace Engineering at Arizona State University, where he leads the Laboratory for Turbulence and Combustion and is the Founding Director and Chief Scientist of the Security and Defense Systems Initiative. He is also Emeritus Professor of Aerospace Engineering at the University of Michigan, where he served on the engineering faculty for 25 years.

Previously he was the Chief Scientist of the U.S. Air Force in Headquarters Air Force, serving in the Pentagon as the direct science and technology advisor to the Secretary of the Air Force and the Air Force Chief of Staff. He has served on the Air Force Scientific Advisory Board since 2005, including as Chair of the Board from 2014-2017, and has served on numerous task forces of the Defense Science Board. He has also served on advisory boards for Lawrence Livermore National Laboratory and NASA, and in numerous defense-related reviews and advisory roles.

Dr. Dahm is a Fellow of the American Physical Society and the American Institute of Aeronautics and Astronautics. He is an author of over 200 refereed technical articles, conference papers, and technical publications, a holder of six U.S. and international patents, and has given over 260 technical presentations, including over 190 invited, plenary, and keynote lectures worldwide, on topics dealing with mechanical and aerospace engineering and defense science.