UCI Samueli School of Engineering | Department of Mechanical and Aerospace Engineering

Seminar Series

Interactions of Shock Waves and Turbulence through Numerical Simulations

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McDonnell Douglas Engineering Auditorium (MDEA)

Abstract: Hypersonic flight and propulsion pose fundamental challenges that arise from interactions between shock waves and turbulence. These interactions can be beneficial, enhancing the mixing of fuel and oxidizer in a scramjet engine, but they can also be detrimental, compromising the integrity of the flying vehicle through uncontrolled aerothermostructural coupling. This presentation will highlight recent developments on the prediction and understanding of these phenomena by means of high-fidelity numerical simulations. First, focus will be placed on interactions of shock waves reflecting off turbulent boundary layers that develop along rigid and flexible walls, by loosely coupling a wall-modeled large-eddy simulation solver for the fluid flow with an elastic solid structural solver that accounts for geometric nonlinearities. Strong shock/boundary-layer interactions will be emphasized, resulting in mean flow separation and low-frequency unsteadiness that can couple with natural frequencies of the solid structure. Simulation results will be compared with supersonic wind-tunnel experiments. Second, the enhancement of scalar mixing under canonical shock-turbulence interactions will be addressed by means of shock-capturing direct numerical simulations, evaluating the effects of the shock and turbulence Mach numbers, and the Reynolds number. Statistical analyses will highlight changes along the mean flow direction of scalar variance and dissipation-rate budgets, flow topology, and alignments of the scalar gradient with vorticity and strain-rate eigendirections. A novel methodology to track the time evolution of geometric and physical quantities of turbulent flow structures will be introduced and applied to study the dynamics of isoscalar surfaces across the shock-turbulence interaction.

Bio: Ivan Bermejo-Moreno received an engineer's degree from the School of Aeronautics at the Polytechnic University of Madrid, Spain (2001). He then worked for two years in the aerospace industry (GMV) and received a Fulbright Fellowship to pursue M.Sc. (2004) and Ph.D. (2008) degrees in aeronautics from the California Institute of Technology. Afterwards, he held a postdoctoral research fellowship at the Center for Turbulence Research, Stanford University/NASA Ames Research Center (2009-2014). He joined the Aerospace and Mechanical Engineering Department at the University of Southern California as assistant professor in 2015. His research combines numerical methods, physical modeling, and high-performance computing for the simulation and analysis of turbulent fluid flows involving multi-physics phenomena. He is a recipient of the Rolf D. Buhler Memorial Award, the William F. Ballhaus Prize, the Hans G. Hornung Prize, the NSF CAREER Award, and the NASA Early Career Faculty Award.