Aerospace Seminar

James E. Knott Professor of Engineering in the Department of Aerospace Engineering at the University of Michigan.

Multi-Scale Modeling of Nonequilibrium Gas and Plasma Dynamics

April 28, 2017 | KOBL S127 | 12:00 P.M.

Nonequilibrium describes a physical process that is not able to reach a well-defined equilibrium state within a time scale relevant to a system. Such processes occur in the gas and plasma flows of a number of systems in aerospace engineering. For gas flow around a hypersonic vehicle, nonequilibrium energy transfer and chemistry of the molecules directly affect the heat transfer to the vehicle. For spacecraft electric propulsion systems, nonequilibrium in the plasma affects the thrust produced and the operational lifetime of the thrusters.

In this seminar, recent progress is presented in high fidelity computational modeling that spans length scales from atoms to the full system level. For analysis of nonequilibrium hypersonic flow, molecular dynamics is employed to model individual molecular collisions. The molecular information is integrated to construct a database of rate coefficients that enable the detailed simulation of nonequilibrium energy transfer and chemical reactions in macroscopic hypersonic gas flow. For analysis of an electric propulsion device, molecular dynamics is again used to analyze individual sputtering events caused by the impact of a high energy ion on a surface. The atomic-level information is used to construct databases that are employed in nonequilibrium modeling of a plasma thruster in order to assess macroscopic erosion.

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Iain D. Boyd is the James E. Knott Professor of Engineering in the Department of Aerospace Engineering at the University of Michigan. He received a Ph. D. in aeronautics and astronautics (1988) from the University of Southampton in England. He worked for four years at NASA Ames Research Center in the areas of aerothermodynamics and space propulsion. Dr. Boyd was a faculty member in mechanical and aerospace engineering at Cornell University for six years. He joined the University of Michigan in 1999.

His research interests involve the development and application of physical models and computational methods for analysis of nonequilibrium gas and plasma dynamics processes in aerospace systems.

He has authored over 200 journal articles, more than 300 conference papers, and recently published a book entitled “Nonequilibrium Gas Dynamics and Molecular Simulation.” Dr. Boyd is a Fellow of the American Institute for Aeronautics & Astronautics (AIAA), and has received the 1998 AIAA Lawrence Sperry Award, the 1997 AIAA Electric Propulsion Best Paper Award, and the 2011 AIAA Thermophysics Best Paper Award.

He is also a Fellow of the American Physical Society. Dr. Boyd serves on the editorial boards of the Journal of Thermophysics and Heat Transfer and Physical Review Fluids. Dr. Boyd is a member of the Air Force Scientific Advisory Board (AFSAB) and served as the Vice Chair of the Board (2013-2016).