AEROSPACE & MECHANICAL ENGINEERING

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INFORMAL COFFEE PERIOD BEFORE THE SEMINAR IN ROOM 365 FITZPATRICK HALL

UNIVERSITY OF NOTRE DAME, NOTRE DAME, INDIANA 46556

SPEAKER: **Professor Joanna M. Austin**
Department of Aerospace Engineering
University of Illinois at Urbana-Champaign
Urbana, Illinois

TOPIC: **THE ROLE OF THERMOCHEMISTRY IN HYPERSONIC SHEAR FLOWS**

DATE: Tuesday, October 5, 2010

TIME: 3:30 p.m.

PLACE: 136 DeBartolo Hall

ABSTRACT

In high enthalpy hypersonic flight, thermochemical relaxation times are typically comparable to flow residence times, leading to nonlinear coupling between chemical reactions, vibrational excitation, and fluid mechanics. The chemical species and internal energy of the gas depart significantly from equilibrium. Experimental data in hypervelocity flows are scarce, partly because creating high enthalpy conditions in ground test facilities is extremely challenging and flight tests are expensive.

A new expansion tube facility capable of test gas Mach numbers from 3.0 to 7.4 has been built at Illinois and carefully characterized with experimental measurements and numerical simulations. Two canonical shear flows are being examined in the high enthalpy free stream: triple-point generated free shear layers and boundary layers flows. Initial experiments identified an opposing wedge configuration used to generate a Mach reflection with associated triple-point shear layers. The experimental configuration is chosen to give well-characterized inflow and boundary conditions. In addition, a Mach reflection results in a shear layer that separates a gas stream that has passed through a normal shock from a gas stream that has passed through two oblique shocks, leading to dramatically different temperatures and degree of dissociation across the shear layer. Key diagnostic tools include spectroscopic measurements confirming the presence of dissociated NO behind the Mach reflection, flow visualizations, and temperature measurements benchmarked against calculations using detailed and reduced chemical kinetic mechanisms.

The experimental work is complemented by spatial linear stability analysis. This study is the first linear stability analysis of a hypersonic shear layer to include detailed modeling of molecular effects. An existing molecular-molecular energy transfer rate model is extended to higher collisional energies. Non-equilibrium model results are compared with calculations assuming equilibrium and frozen flow over a range of (frozen) convective Mach numbers from 0.341 to 1.707. Non-equilibrium effects appear in the creation of nitrous oxide due to dissociation. Dissociation and vibration transfer effects on the perturbation evolution remain closely correlated at all convective Mach numbers.

NOTE: ***If you are interested in meeting individually with Prof. Austin, please contact Evelyn at 631-5431***