

DEPARTMENT OF AEROSPACE ENGINEERING  
COLLEGE OF ENGINEERING AND APPLIED SCIENCE

SUMMER RESEARCH OPPORTUNITIES FOR UNDERGRADUATE WOMEN

FOR APPLICATION YEAR: 2021

**PROJECT TITLE: Fundamental Processes of Atomization, Vaporization, Mixing and Combustion in Hypersonic Propulsion Systems**

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**Project Description**

In a typical scramjet engine, air is captured through the inlet nozzle and decelerated via a shock train in the isolator to low supersonic Mach numbers before it enters the combustion chamber. Fuel is then injected into this air that has a high static temperature and pressure, followed by fuel/air mixing and subsequent combustion. This higher enthalpy supersonic flow then expands in the diverging section producing thrust to maintain the vehicle at hypersonic speed.

One way to substantially increase the range of such air-breathing high-speed propulsion systems, including scramjets and rotating detonation engines (RDE) is to replace the currently used gaseous fuels with significantly higher energy-dense liquid fuels. Liquid is injected perpendicular to the flow which serves to atomize the flow. The replacement of gaseous fuel with liquid fuels adds two more time scales related to atomization and vaporization processes, further reducing the time available for the air to mix with the vaporized fuel, making fuel atomization the rate-limiting step. Similar processes are present in liquid-fueled RDEs, where the fuel is injected perpendicular to rotating shock waves (and supersonic flow in their wake) that leads to primary atomization, which is followed by vaporization, mixing and combustion processes. Therefore, to develop such liquid-fueled high-speed propulsion devices with a reasonably sized combustor length, it is critical to understand how liquid interfaces interact with highly compressible, often shock-laden supersonic flows. This is the overall goal of this research is to use high-fidelity computational techniques to quantitatively identify the mechanisms that dictate fuel atomization, vaporization and combustion in configurations representative of hypersonic propulsion engines.

The first year of this multi-year WISE project will involve a literature

review of the current state of knowledge of how liquid jets and droplets interact with supersonic air flows. The student will be trained on using the Linux operating system, and the use of visualization software such as Tecplot and ParaView. The student will work closely with a graduate student and learn how supercomputers are used in engineering practice and assist them in visualizing computational data of liquid jet and droplet interaction with shock waves.