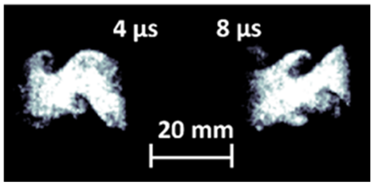
DEPARTMENT OF MECHANICAL & AEROSPACE ENGINEERING
WILLIAM MAXWELL REED SEMINAR SERIES

"High-repetition-rate Laser Diagnostics of High-Enthalpy Hypersonic Environments Targeting Nitric Oxide."

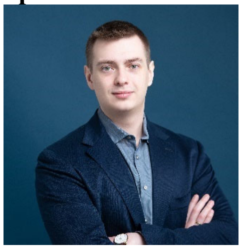
Boris S. Leonov, Ph.D.
Texas A&M University

Abstract:
High repetition rate diagnostics are essential for hypersonic ground testing facilities because of the fast timescales of phenomena of interest and the dynamic nature of the testing environment, where the characteristic frequencies were identified to exceed 100 kHz. Following the Nyquist-Shannon sampling theorem, this sets the minimum probing rate requirement for the diagnostic tool at 200 kHz. High repetition rate laser diagnostics allow for fast, high-resolution measurement of flow velocity, temperature, species concentrations, and other physical properties. This is particularly important in hypersonic wind tunnels, where conditions are extreme and the flows are prone to instability development, making it challenging to obtain accurate data using other methods. In addition, laser diagnostics are nonintrusive in nature, which is essential in hypersonic wind tunnels where the presence of instrumentation can greatly affect the flow through shocks or expansion fan structures as well as heat transfer to or from the probes. It is also a strictly engineering challenge of making instrumentation that can withstand such hostile environments. Information acquired during experimental campaigns is critical for understanding and ultimately controlling the complex phenomena that occur in high-speed regimes, such as high-temperature chemical kinetics, shockwave interactions, and boundary layer transitions.

In this talk, we will discuss three examples of quantitative measurements performed in hypersonic wind tunnels using nitric-oxide-based laser diagnostics. Firstly, a measurement of dominant frequencies within mixing layers will be presented as an example of quantitative analysis of otherwise purely qualitative NO laser-induced fluorescence data. Secondly, a quantitative version of NO LIF measurements of concentrations for CFD validation will be discussed. Lastly, a new flow velocimetry method based on ionized nitric oxide will be presented. Nitric oxide is an appealing target molecule for these measurements since it is naturally produced in high-enthalpy air flows and provides a sensitive test of chemical reaction rates in non-equilibrium environments. It is also a stable molecule if compared to characteristic fluid dynamic timescales, and its major electronic transitions could be reached with equipment standard for a laser diagnostics laboratory. Additionally, targeting a molecule that is produced in high-temperature air and primarily absent under ambient conditions allows studying the evolution of high-temperature regions including the turbulent structures within shear layers.



Speaker Bio:



Boris Leonov is currently a Research Engineer at Bush Combat Development Complex at Texas A&M University. He received his doctoral degree from Texas A&M University in 2023 focusing on development of new diagnostic capabilities based on high-repetition-rate tunable laser systems. During his graduate studies he was awarded the Department of Defense SMART scholarship as well as the College of Engineering Fellowship and the Aero Graduate Excellence Award. Prior to coming to TAMU in College Station, he received his bachelor's degree from the School of Aeronautical and Astronautical Engineering at Purdue University in 2018. In his current research, he focuses on developing and implementing novel laser-based diagnostics such as slow-light imaging spectroscopy (SLIS) and nitric oxide ionization induced flow tagging and imaging (NiiFTI) in relevant environments including cold and hot hypersonic flows. Among other applications, he uses laser diagnostics for quantitative analysis of high-enthalpy chemical kinetics and flow turbulence.

Date: Friday, February 16, 2024
Time: 3:00 PM EST
Place: Whitehall Classroom Building 110
Contact: Dr. Jonathan Wenk

Attendance open to all interested persons

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