PhD Dissertation Defense Announcement
Mechanical and Aerospace Engineering Department
University of Texas at Arlington

DEVELOPMENT OF FEMTOSECOND LASER ELECTRONIC EXCIATION TAGGING (FLEET) AND FEMTOSECOND TWO-PHOTON ABSORPTION LASER INDUCED FLUORESCENCE (FS-TALIF) DIAGNOSTICS FOR SPECIES NUMBER DENSITY AND VELOCITY MEASUREMENTS IN ARC-JET FLOWS

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Abstract

Arc-jet flows are the only ground-test facilities that can recreate hypersonic high-enthalpy flight conditions for long durations. Characterizing these complex flow regimes, generally under thermo-chemical non-equilibrium, is crucial to establishing a relationship between the ground-test environment and flight conditions. This work presents the development of two innovative and world's first successful application of advanced non-intrusive laser-based diagnostic techniques for characterizing the 1.6 MW ONR-UTA Arc-Heated Wind Tunnel, Leste's plasma flow. The arc-jet flow represents a unique challenge for the application of laser-based diagnostics due to the highly emitting background across a wide spectral range. Femtosecond Laser Electronic Excitation Tagging (FLEET) provides a direct measurement of flow velocity. Femtosecond Two-photon Absorption Laser-Induced Fluorescence (fs-TALIF) non-intrusively measures the atomic number density of oxygen and nitrogen. The work presents the detailed study, experimental results and analysis of the world's first FLEET application to arc-jet flows measured a freestream velocity of 1.78 km/s, as well as the world's first fs-TALIF measurements of atomic oxygen number density found to be 5.256 x 1023 1.526 x 1023 m-3. The fs-TALIF signal for atomic oxygen and nitrogen were successfully captured, including oxygen within the shock-layer. The calibration procedures and techniques, including in-house software, have been developed to determine the regions of fs-TALIF signal where quantitative measurements are viable and evaluate the uncertainty in the measurements. The successful application of these techniques, proven here, provide advancements in the understanding of the complex gas-surface interactions associated with thermal protection systems in hypersonic flow, reduced uncertainties compared to current state-of-the-art as well as the ability to better relating ground-test results to flight environments, and simulation validation. The techniques developed at the ARC are in the process to be implemented in the large government-operated arc-jet facilities.