Characterization of High Enthalpy Flows (Arc Jet)

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Motivation

High enthalpy air arc jet facilities have been very important in developing and testing of the spacecraft thermal protection materials. Planetary entry vehicles or hypersonic flight vehicles are exposed to harsh conditions due to aerothermodynamic heating. To simulate such conditions in the ground-based facilities, arc-heating facilities have been developed and used with a converging-diverging nozzle to generate hypersonic high temperature flows.

Overview

NASA Ames Research Center has unique Arc Jet Complex including 60 MW Interactive Heating Facility (IHF), built in 1995. IHF can deliver 75 MW for a 30 minute duration or 150 MW for a 15 second duration. The uncertainty in performance of the thermal protection material is dependent on the accurate measurements of the flow conditions. However real time diagnostics is not simple. Not only very high temperature, but high current (~ a few thousand ampere) and high voltage (up to 10 kV) power supply to the arcjet heater make many traditional diagnostics inadequate.

Tunable Diode Laser Absorption Spectroscopy (TDLAS) has been developed and applied as a plasma diagnostics. Our aim is measuring number densities and temperatures of the most dominant species in the heater and in the test room as shown in Fig.1. Estimated temperature and pressure in the heater, where laser beams are delivered through optical fibers, is 7000 K and 3 atm. At such a high temperature, significant portion of molecules are dissociated. Target species of our measurements are N, O, Ar, and Cu in near infra-red.

Fig.2 shows absorption of these atomic species in IHF heater. Temperatures and number densities are calculated based on Doppler broadening, Boltzmann distribution, and integrated area of the absorbance with known Einstein A coefficients. Temperature and number density of O was plotted in Fig. 3 during a test.

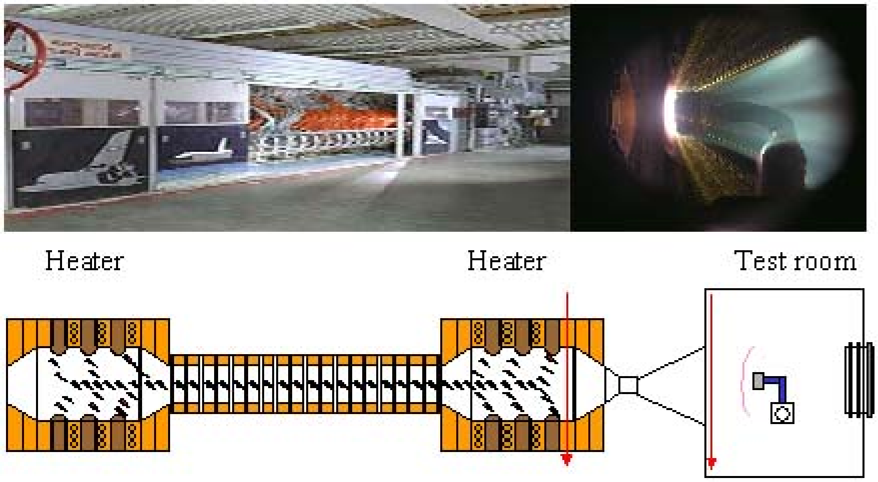

Figure 1: Picture and schematic of Interactive Heating Facility at Ames Research Center (~7000K, 3 atm, at NASA Ames).

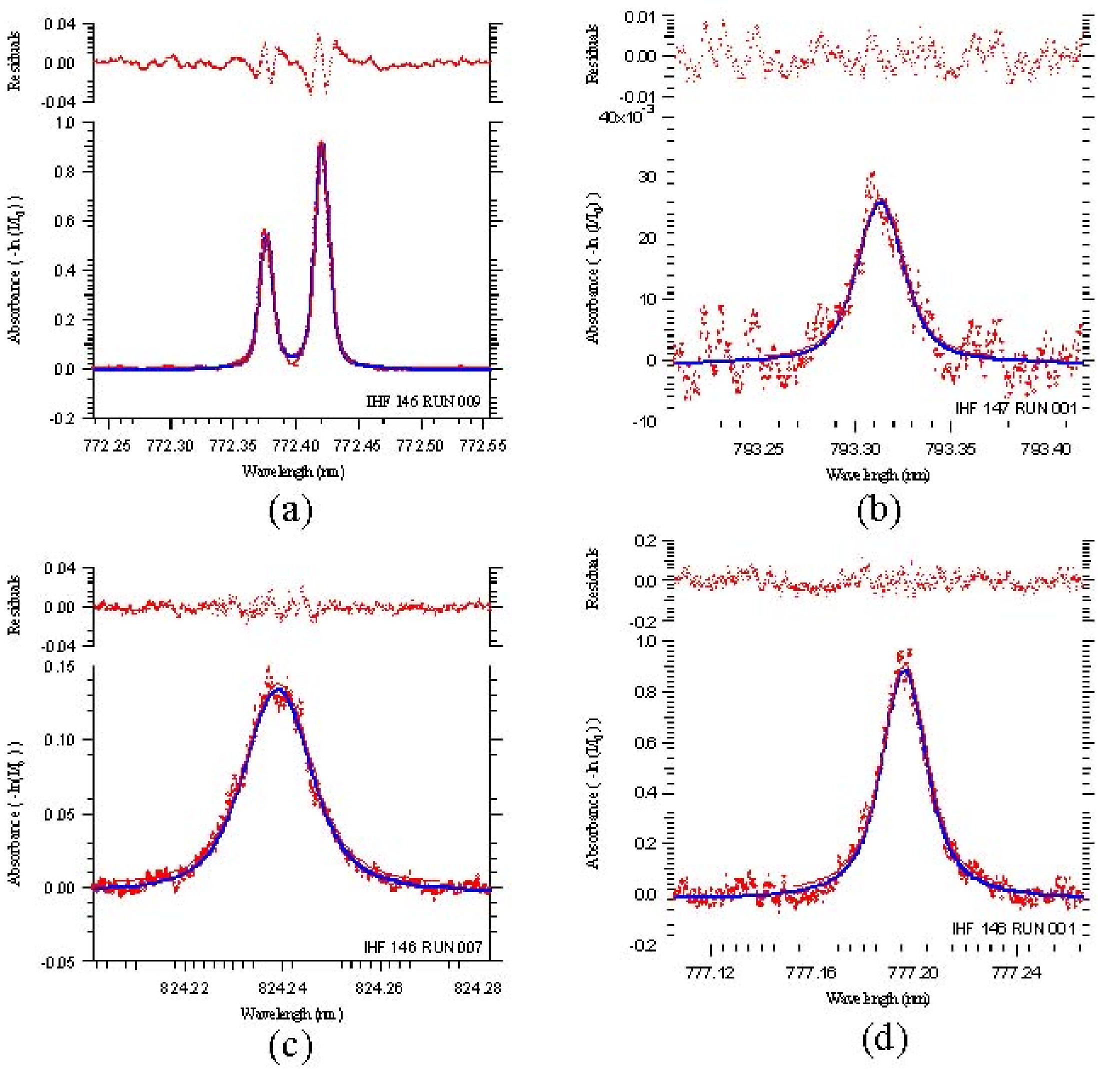

Figure 2: Absorbance of (a) Argon (b) Copper (c) Nitrogen and (d) Oxygen.

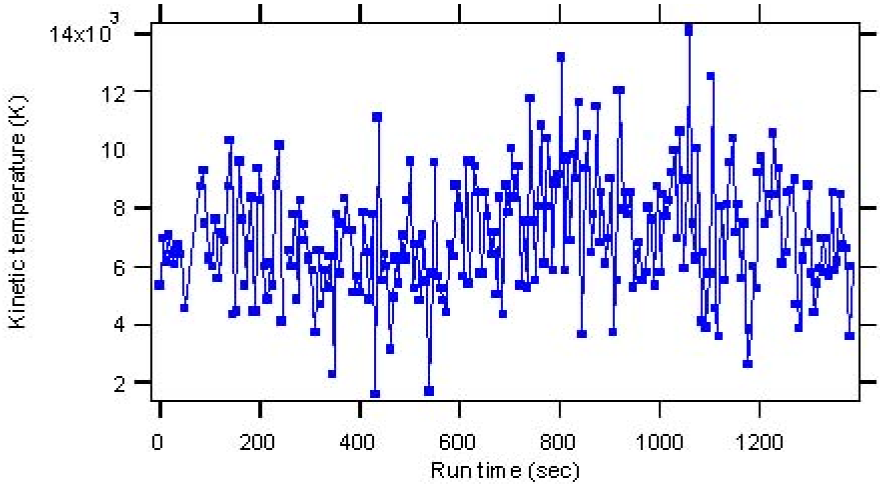

Figure 3: Temperature measured from Doppler broadening of atomic nitrogen during a material test.