A SPECTROSCOPIC PRESSURE SENSOR TARGETING ATOMIC POTASSIUM FOR HYPERSONIC FACILITIES

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We apply laser absorption spectroscopy to design a diagnostic measuring bulk gas pressure from collisionally-broadened absorption lineshapes. This diagnostic targets atomic potassium with a measurement rate of 200 kHz. The diagnostic is intended to operate in hypersonic ground-based facilities, where atomic potassium is nascent in the freestream flow and where microsecond temporal resolution is often crucial.

Recent studies have found atomic potassium in trace amounts in the freestream of hypersonic ground-based facilities, making it an attractive spectroscopic target. Potassium also has convenient spectroscopic transitions in the near-infrared – the D-line transitions ($^2S_{1/2} \rightarrow {}^2P_{1/2}$ at 770.1 nm and $^2S_{1/2} \rightarrow {}^2P_{3/2}$ at 766.7 nm), which absorb strongly and are easily accessible with low-cost commercial lasers and optics.

This line-of-sight laser-based diagnostic infers bulk gas pressure from the spectroscopic lineshape of the potassium D_2 transition, specifically the collisional linewidth parameter $\Delta\nu_C$. We apply empirical correlations to extract pressures from a Voigt fit of these lineshapes. These correlations depend on gas composition and temperature, which must be known. Lineshape parameters must also be corrected to account for power broadening effects, and hyperfine splitting is considered at low pressures.

For verification, the diagnostic is deployed in a shock tube to generate the temperatures, pressures, and timescales relevant to freestream flows in hypersonic ground-based facilities. Since atomic potassium is not present in sufficient quantity for measurement in our shock tube, we implement a novel technique to uniformly seed potassium into the shock-heated gas. We achieve excellent signal-to-noise ratios and measure pressures in good agreement with expected values between 0.25-2 atmospheres.