HIGH-TEMPERATURE HYPERSONIC LAVAL NOZZLE FOR NON-LTE CAVITY RINGDOWN SPECTROSCOPY

ESZTER DUDÁS, *Département "Physique Moléculaire", Univ Rennes, CNRS, IPR (Institut de Physique de Rennes) - UMR 6251, Rennes, France*; ROBERT GEORGES, ABDESSAMAD BENIDAR, *IPR UMR6251, CNRS - Université Rennes 1, Rennes, France*; SHUVAYAN BRAHMACHARY, VINAYAK KULKARNI, *Department of Mechanical Engineering, Indian Institute of Technology Guwahati, Guwahati, India*; SAMIR KASSI, *UMR5588 LIPhy, Université Grenoble Alpes/CNRS, Saint Martin d'Hères, France*; CHRISTINE CHARLES, *Research School of Physics, Australian National University, Canberra, ACT, Australia*; NICOLAS SUAS-DAVID, *Department of Chemistry, University of Missouri, Columbia, MO, USA*.

The SMAUG apparatus (Spectroscopy of Molecules Accelerated in Uniform Gas flows) was developed to produce hot spectra of various molecules of interest for hot astrophysical atmospheres, like the one surrounding hot Jupiters, reaching up to 2500 K. High-temperature IR spectroscopic data is needed to retrieve temperature and concentration profiles from astronomical spectra. A small dimension Laval nozzle connected to a compact high enthalpy source equipped with cavity ringdown spectroscopy (CRDS) is used to produce high-resolution infrared spectra of polyatomic molecules in the 1.67 μm region.[a]. The experimental setup can operate according to two complementary working regimes: non-local thermodynamic equilibrium (non-LTE) (vibrationally hot and rotationally cold) and LTE conditions, to interpret the complex pattern of highly-excited vibrational states. Two different gases, carbon monoxide (CO) and methane (CH_4) were used as test molecules. Using non-LTE conditions vibrational (T_{vib}) and rotational (T_{rot}) temperatures were extracted from the recorded infrared spectrum leading to T_{vib} = 1346(52) K and T_{rot} = 12(1) K for CO. A rotational temperature of 39(3) K was measured for CH4, while two vibrational temperatures were necessary to reproduce the observed intensities. The population distribution between vibrational polyads was correctly described with $T_{vib,I}$ = 825(50) K" , while the population distribution within a given polyad was modelled correctly by $T_{vib,II}$ = 39(5) K" , testifying to a more rapid vibrational relaxation between the vibrational energy levels constituting a polyad. Using a "post-shock CRDS" technique CO and CH_4 LTE spectra were recorded at 950 K and 1400 K.

[a] *E.Dudás* et al. *High-temperature hypersonic Laval nozzle for non-LTE cavity ringdown spectroscopy. J Chem Phys 2020;152:134201. https://doi.org/10.1063/5.0003886.*