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

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The SMAUG apparatus (Spectroscopy of Molecules Accelerated in Uniform Gas flows) was developed to produce non-LTE spectra of various molecules of interest for hot astrophysical atmospheres, like the one surrounding hot Jupiters, reaching up to 2500K. High-temperature IR spectroscopic data is needed to retrieve temperature and concentration profiles from astronomical spectra. This work is done in the frame of the e-PYTHEAS project that focuses on high-temperature spectroscopy of small hydrocarbons. A small dimension Laval nozzle connected to a compact high enthalpy source equipped with cavity ringdown spectroscopy (CRDS) is used to produce vibrationally hot and rotationally cold high-resolution IR spectra of polyatomic molecules in the 1.67 μm region.[a] The nozzle was designed to operate with argon heated up to 2000 K and to produce a quasi-unidirectional flow to reduce the Doppler Effect responsible for line broadening. This novel approach was applied to carbon monoxide and methane. Vibrational (T_{vib}) and rotational (T_{rot}) temperatures were extracted from the recorded infrared spectrum leading to T_{vib} = 1346 $\pm$ 52 K and T_{rot} = 12 $\pm$ 1 K for CO. A rotational temperature of 30 $\pm$ 3 K was measured for CH_4, while two vibrational temperatures were necessary to reproduce the observed intensities. The population distribution between vibrational polyads was correctly described with $T_{vib,I}$ = 894 $\pm$ 47 K, while the population distribution within a given polyad (namely the dyad or the pentad) was modelled correctly by $T_{vib,II}$ = 54 $\pm$ 4 K, testifying to a more rapid intra-polyad vibrational relaxation.

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[a] E.Dudás *et al.* J. Chem. Phys. submitted (2020)