Collisional process of H_2O + He supersonic jets by Raman spectroscopy

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Supersonic jets of pure gases and gas mixtures are relevant for different areas of physics, chemistry, and engineering [1]. The properties of these systems can differ markedly from those of a gas at thermodynamic equilibrium, since they are conditioned by the collisional dynamics.

In this work we report the diagnostic of several H_2O + He supersonic jets, with H_2O mole fractions from 1.4% to 33%, particularly their fluid dynamic properties. With H_2O partial pressures around 12 mbar, all these jets were checked to be free from H_2O condensation, a must for the quantitative analysis of the collisional kinetics. The jets have been probed by Raman spectroscopy, a non-intrusive technique with a spatial resolution of a few microns.

The primary experimental data obtained are number densities and rotational populations along the flow lines. It is found that the distribution function of the lowest rotational energy levels very nearly obeys a Boltzmann distribution for all our stagnation conditions. This enables accurate determination of rotational temperatures by means of the Raman spectra of Q branch of the symmetric stretching mode ($v_1 \sim 3657$ cm^{-1}) and the simulation of its profile using literature reference data [2]. Translational temperatures (T_t) have been obtained from number densities and rotational temperatures by conservation of mass, momentum, and enthalpy along the jet [3].

Employing a Kinetic Master Equation that describes the time evolution of the rotational populations we have determined the average rate coefficients, both for H_2O:He and H_2O:H_2O collisions, for the 6 lowest of ortho-H_2O between T_t= 40 and 100K. Our results for H_2O:He inelastic collisions will be compared with calculated [4,5] state-to-state rate coefficients.

References

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