Coherent anti-Stokes Raman scattering on N_2 and CO_2 in a (sub-)atmospheric pressure plasma

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In molecular plasmas at sub-atmospheric pressures (~100 to 1000 mbar), the vibrational degree of freedom of the electronic ground state molecules can contain a significant amount of energy. Therefore, detailed knowledge about the corresponding vibrational distribution functions is crucial to understand the dynamics of the system. While molecules with dipole allowed vibrational transitions can readily be measured by quantum cascade laser absorption spectroscopy, this is not possible for homo-nuclear molecules like nitrogen. To circumvent the apparent limitation, in this work coherent anti-Stokes Raman scattering is employed to measure the vibrational distributions of nitrogen and carbon dioxide. The method was previously demonstrated for pure nitrogen [1,2] and is now extended to carbon dioxide. By an appropriate choice of the pump and probe wavelength (see Figure 1), both molecules can be probed simultaneously, making it possible to investigate the interaction between them. Further, the use of pulsed Nd:YAG and dye lasers to produce the CARS input beams results in a time resolution in the order of 10 ns. The spatial resolution – determined by a folded BOXCARS phase matching geometry – is in the order of 100 µm in the direction perpendicular to the traveling direction and 5 mm along the beam paths. An important aspect in the analysis of CARS spectra obtained in transient plasmas is the non-equilibrium distribution of the vibrational modes. Its consequences for the data analysis are discussed.

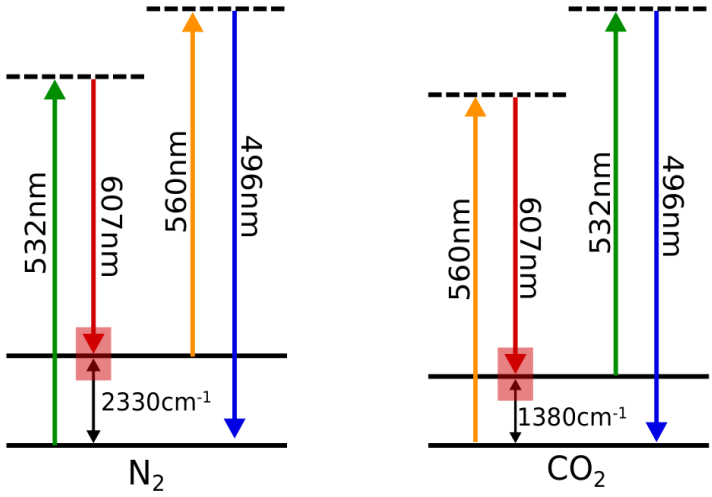

Figure 1. CARS scheme for the simultaneous measurement of vibrational excited nitrogen and carbon dioxide molecules.

[1] J Kuhfeld *et al* 2021 *J. Phys. D: Appl. Phys.* **54** 305204.

[2] J Kuhfeld *et al* 2021 *J. Phys. D: Appl. Phys.* **54** 305205.

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