N_2 influence on the vibrational distribution of the asymmetric level of CO_2

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Abstract: This work contributes towards a detailed kinetic model to study the plasma chemistry in CO_2-N_2 plasmas, in order to explore the possibility of admixing nitrogen to enhance CO_2 dissociation. A particular interest is dedicated to the pumping of the asymmetric vibrational mode of CO_2, considered as a promising way for the CO_2 dissociation at lower energy costs than by direct electronic impact. For this purpose, 0-D simulations are performed reproducing the conditions of the experiments lead in parallel at LPP. The input data of the simulations must comprise sets of reaction rates for the vibrational-translational exchanges (VT) and the vibrational-vibrational exchanges (VV) between N_2, CO_2 and the derived products. This presentation focus on the computation and the validation of these data sets and the first results obtained from a simplified kinetic model.

1. Introduction

Carbon dioxide dissociation is a way of both reducing one of the main greenhouse gases and providing a source of synthetic fuels, avoiding the carbon footprint and the restructuring problems linked to energy distribution. Non-equilibrium plasmas seem to be a very interesting medium to efficiently dissociate the CO_2 molecule, with reported energy efficiencies of about 45% under industrial conditions [1, 2]. This work explores the possibilities of admixing nitrogen to the CO_2 plasma to enhance the dissociation efficiency. The aim is to develop a kinetic model to study the plasma chemistry in CO_2-N_2 plasmas.

2. Discussion

The VT and VV reaction rates between CO_2 and N_2 molecules have been computed for the first vibrational levels, using a temperature power law which fits the results from previous experiments [3]. For the upper levels these rates have been scaled using the SSH theory [4]. In total, vibrational levels up to $v \leq 5$ for N_2, and $v_1 \leq 3$, $v_2 \leq 6$, $v_3 \leq 5$ for the symmetric stretching, bending and asymmetric stretching modes of CO_2, respectively, are taken into account in the model.

Figure 1 shows the time evolution of the population of the $CO_2(00^01)$ level in the afterglow of a dc discharge for p=5 Torr. The gas temperature profile in the afterglow and the initial densities of CO_2 molecules in the different vibrational modes are taken from experiments in a pure CO_2 dc discharge at a current I=50 mA. The results confirm the potential of N_2 addition to enhance the vibrational pumping of the CO_2 asymmetric mode, whenever the characteristic vibrational temperature of N_2 is larger than that of the CO_2 asymmetric mode.

3. References

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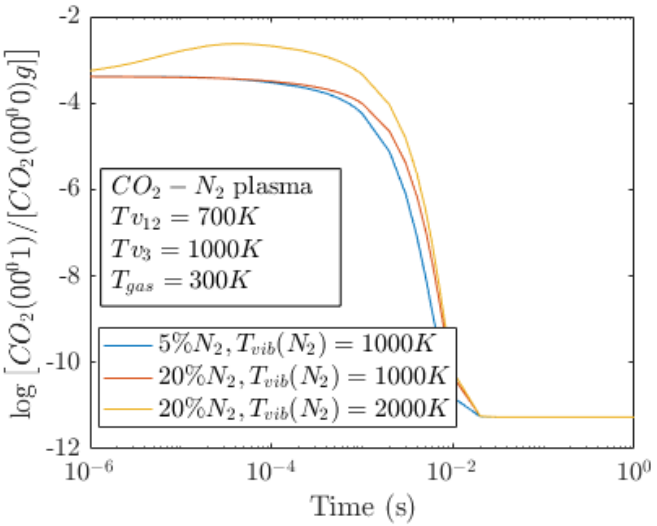

Fig.1: Time evolution of the population of $CO_2(00^01)$ level in a CO_2-N_2 afterglow, at 5 Torr, for different N_2 concentrations and vibrational temperatures.

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