EXCITATION OF THE (001) MODE OF CO_2 IN 2.45 GHz MICROWAVE E FIELD AND DC B FIELD

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1. INTRODUCTION

Carbon dioxide conversion to ecologically friendly fuels is one of the prominent directions in research aimed at reducing carbon dioxide emission in the atmosphere. Highest energy efficiency of CO_2 splitting is achieved in plasma produced in a microwave (MW) discharge device that usually operates at 2.45 GHz with the reduced electric field, E_R/N of 50 Td (Britun and Silva 2018). The key process that starts the vibrational ladder-climbing(which eventually leads to dissociation) is low energy excitation of the (001) state of CO_2.

As continuation of our recent study (Vojnović et al. 2019), we determined the (001) excitation rate coefficients, obtained for 2.45 GHz electric field and static magnetic field, since these data are useful for plasma modeling.

2. SIMULATION

Monte Carlo simulation was used to determine non-equilibrium electron energy distribution functions (EEDFs). Electron position and velocity in each small time step in the simulation are obtained by solving differential equation of motion using numerical procedure. Random numbers are generated to simulate collision events and angular distribution of electrons. The probabilities of these events rely on the cross section database successfully tested for self-consistency. Since study is performed for low E_R/N, superelastic collisions were also incuded. After steady state is reached, electron transport data are sampled within one period.

3. RESULTS AND DISCUSSION

Rate coefficients were calculated based on the normalized EEDF at the specific time and cross sections for excitation of the (001) mode. Calculations were performed for the field frequency of 2.45 GHz and for E_R/N of 50 Td. The value of the reduced DC magnetic field, *B/N*, was varied from 0 up to 5000 Hx.

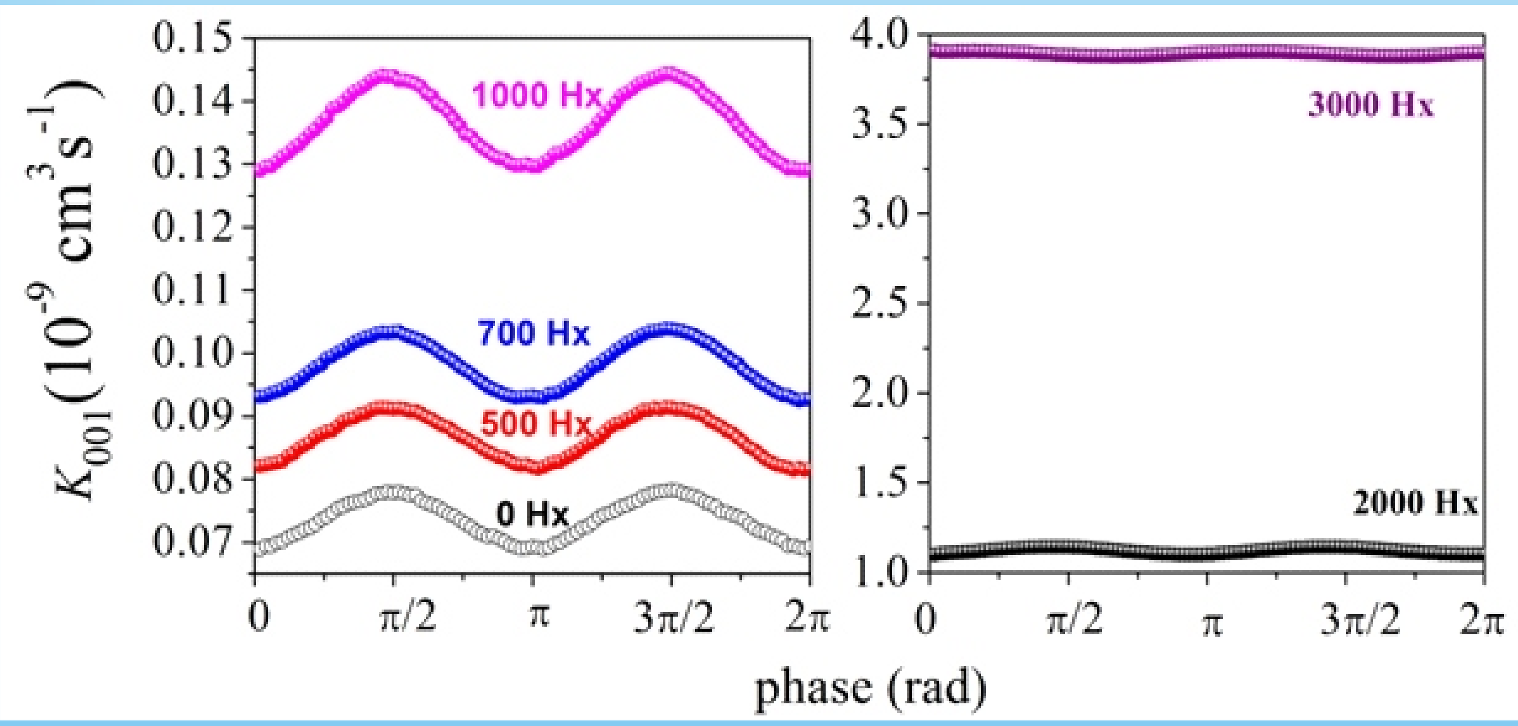

Figure 1: Time modulated (001) mode excitation rates for different *B/N*.

In these conditions, electrons move with cyclotron frequency, f_c, whereby they absorb more and more energy from the alternating electric field as the magnetic field increases, up to a certain point when f_c equals the field frequency, *f*. After that, the absorbed energy begins to decline. (This is the well-kown electron cyclotron resonance (ECR) effect.) For 2.45 GHz the condition of matched frequencies is achieved at B = 875 G.

Figure 1 shows the time resolved rates for (001) state excitation, for different *B/N* values in the range from 0 to 3000 Hx. The amplitude of oscillation is gradually rising with increasing magnetic field, until it is damped at 3000 Hx, which is very close to the *B/N* value corresponding to ECR conditions (2720 Hx). The fast increase of the rates with increasing magnetic field is also pronounced. Period averaged rates vs. *B/N* in the interval from 0 to 5000 Hx (figure 2) show how fast these rates are rising. In the inset of the figure 2, the dependence of the period averaged mean energy on *B/N* is presented. The maximal value of the both functions is reached at 2720 Hx, which, for the number concentration *N* set in our simulation corresponds to B value of 875 G.

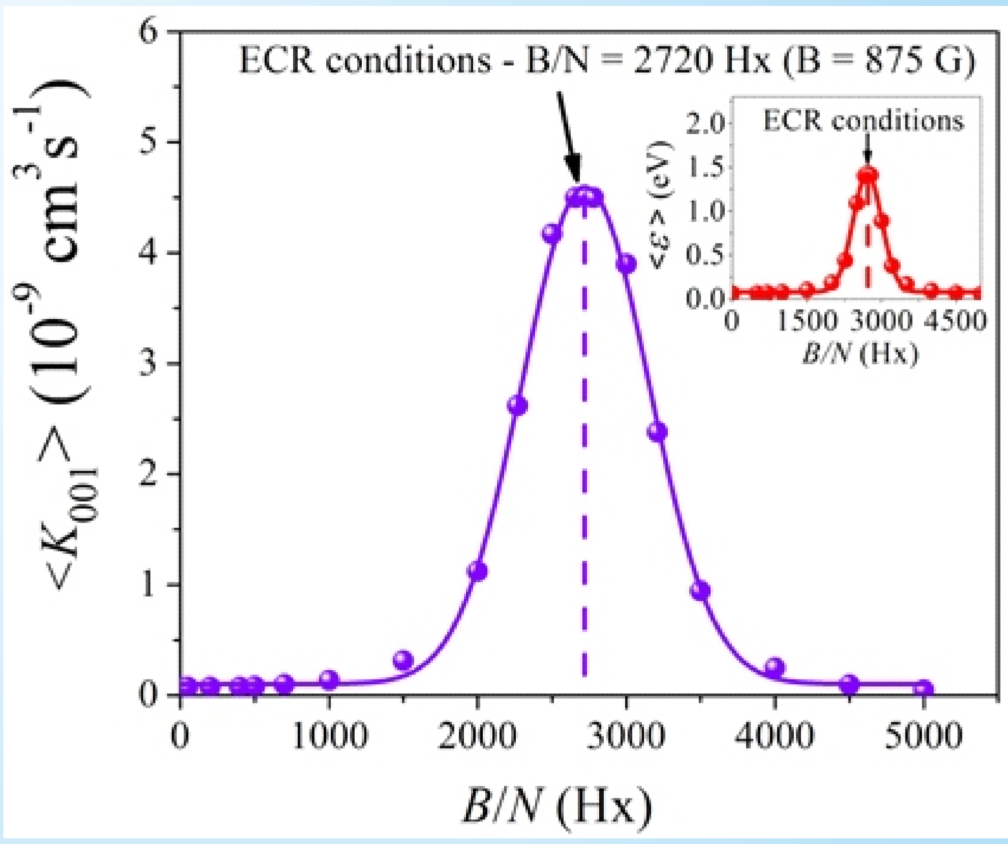

Figure 2: Period averaged rates vs. *B*/*N*: the simulation results (sphere), Gaussian function fit to data (full line), the position of ECR conditions (dash line); the inset: period averaged mean energy vs. B/N.

Acknowledgments

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References

Britun, N., Silva, T. : 2018, *Plasma Chemistry and Gas Conversion, IntechOpen, London*.

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