Measurements and kinetic computations of electron transport parameters in CO_2 in an extended E/N range

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The transport coefficients of electrons (bulk drift velocity, longitudinal diffusion coefficient, and effective ionization frequency) in CO_2 have been measured under time-of-flight conditions over a wide range of the reduced electric field, 15 Td ≤ E/N ≤ 2660 Td, in a scanning drift tube apparatus. These parameters are compared to the results of previous experimental studies, as well as to results of solutions of the electron Boltzmann equation under different approximations and of Monte Carlo simulations. The experimental results extend the range of E/N in comparison with earlier studies. The computational results demonstrate the need for further improvement of the electron collision cross section data for CO_2 taking into account the present experimental data.

1. Introduction

The reduction of CO_2 emission is one of the key challenges for the next decades. One of the solutions may be the recycling of CO_2 to produce hydrocarbon-based fuels, and non-thermal plasma technologies can contribute to this challenge. It is crucial, however, to improve our knowledge on the fundamental properties, in particular electron collision cross sections and the electron transport parameters. For this purpose swarm experiments play an important role.

2. Experimental apparatus

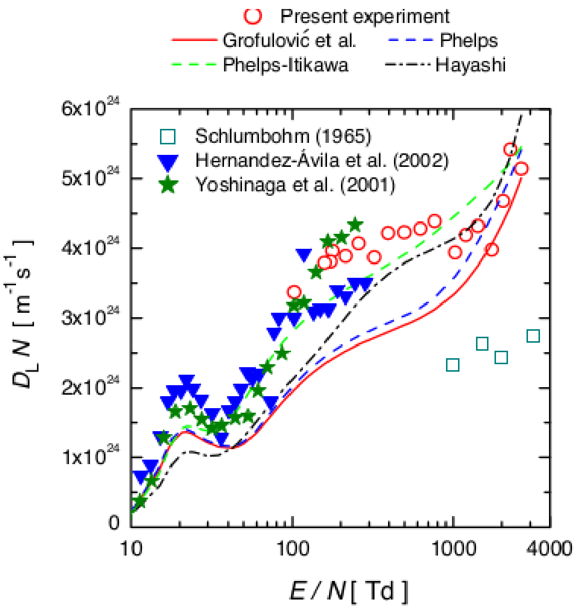
We have developed [1] an experimental apparatus operating under time-of-flight (TOF) conditions to record "swarm maps" that show the spatio-temporal development of electron clouds. The bulk drift velocity *W*, longitudinal diffusion coefficient D_L and effective ionization frequency υ_{eff}, are obtained by fitting the experimental and theoretical forms of this electron swarm, assuming hydrodynamic conditions. From these data the effective (steady-state) Townsend ionization coefficient, α, can also be derived.

3. Numerical methods

The experimental results are supplemented by numerical modelling and simulation. In addition to Monte Carlo simulation, three different methods have been applied to solve the electron Boltzmann equation: (i) a multiterm method for spatially homogeneous conditions, (ii) a multiterm method for spatially inhomogeneous conditions, and (iii) a density gradient representation of the electron velocity distribution function. The CO_2 cross sections available on LxCat [2] were used.

4. Results

We found significant differences between the present and other published experimental data, with the numerical results for all cross section sets tested, demonstrating the need for further improvement of the CO_2 electron collision cross section data [3]. The figure below exemplifies these differences for D_L.



Measured values (symbols) of D_LN in comparison with values computed (lines) using different cross sections sets [2].

5. References

[1] I. Korolov, M. Vass, N. Kh. Bastykova and Z. Donkó, *Rev. Sci. Instrum.* **87** (2016) 063102

[2] http://www.lxcat.net

[3] M. Vass I. Korolov, D. Loffhagen, N. Pinhão, Z. Donkó. *Plasma Sources Sci. Technol.* (in print)

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