Electron detachment in N_2O

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This work deals with a study of collisional electron detachment in N_2O with a pulsed Townsend technique. An avalanche simulator has been used to reproduce the measured pulse shapes. It has been found that pulses at the same value of E/N (E is electric field and N is gas density) and different pressures can be fitted with the same set of swarm parameters, among which the relevant coefficent for this study is that of electron detachment, with values of order $\delta/N \sim 10^{-16}$ cm^2.

Nitrous oxide (N_2O) is used in various types of discharges for a wide range of applications. For example, N_2O is used in N_2O/SiH_4 mixtures to deposit SiO_2 thin films [1]. Nitrous oxide is also a greenhouse gases that contributes to global climate change and participates in the destruction of the ozone layer [2] through complex reactions with other atmospheric gases. Gas discharge removal of N_2O is a possible means of destroying it prior to its release into the atmosphere, hence the importance of knowing and improving our knowledge on swarm and cross section data.

A recent study on electron transport, ionization and attachment in N_2O and N_2O-N_2 rendered a set of adjusted cross sections [3]. The present study deals with the analysis of electron detachment from negative ions formed in the N_2O Townsend avalanche. A sample electron transient is shown in Fig. 1.

A pulsed Townsend apparatus was used for this study [4]. The currents measured at the early times of avalanche development bear an excess aftercurrent that cannot be explained in terms of ionization or attachment only. Thus we assumed that this current was due to collisional electron detachment from the negative ions formed during the first electron transit. Futher insight into this hypothesis was accomplished by simulating the whole process with the avalanche simulator, SIMAV [5]. The measurements were performed over the density-reduced field strength E/N=10-50 Td (1 Td = 10^{-17} V cm^2), and gas pressures below 5 Torr. The reaction scheme consists of O^- produced by dissociative attachment (reaction 1), and its destruction by collisional electron detachment (reaction 2)

$$e^- + N_2O \rightarrow O^- + N_2 \quad (1)$$
$$O^- + N_2O \rightarrow e^- + O + N_2O \quad (2)$$

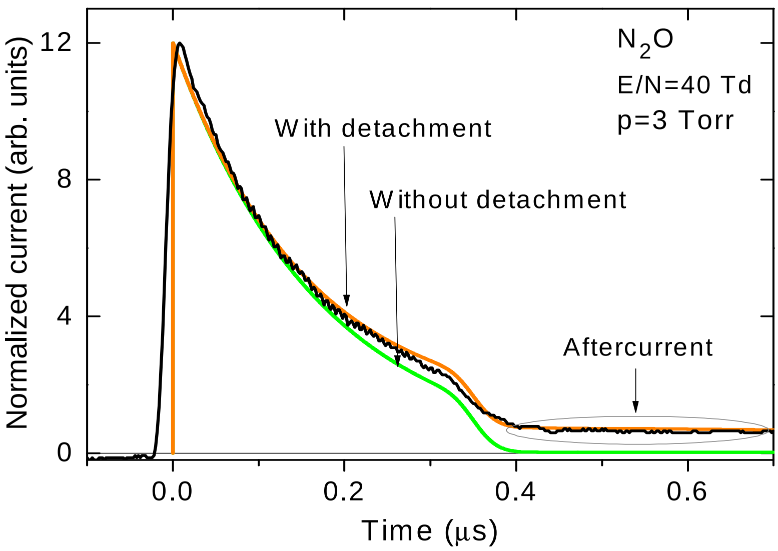

Figure 1. Simulated (green and orange lines) and measured (black line) currents in N_2O at E/N=40 Td and a gas pressure of 3 Torr

The electron drift velocity (v_e = 8.71x10^6 cm s^{-1}) and the dissociative attachment coefficient (η/N = 6.9x10^{-18} cm^2) used for the simulations at *E/N*=40 Td shown in Figs. 1 and 2 were taken from measurements [3], while the electron longitudinal diffusion coefficient (ND_L = 3.3x10^{21} cm^{-1}s^{-1}) was adjusted from measured data of Yoshida et al. [6]. The ion drift velocity (v_i = 2.08x10^4 cm s^{-1}) and the detachment coefficient (δ/N = 3x10^{-16} cm^2) were adjusted to fit the measurements. With these data, we estimate an electron detachment rate constant $k_d= (\delta/N)v_e$=6.2x10^{-12} cm^{3}s^{-1}.

Figure 1 shows the simulated current with and without detachment and its comparison with that measured at *E/N*=40 Td and *p*=3 torr. One can clearly see that the excess aftercurrent cannot be reproduced unless the electron detachment process is considered.

Further evidence of electron detachment in N_2O is provided in Fig. 2, showing measured and simulated currents for N_2O pressures of 2, 2.5 and 3 Torr at *E/N*=40 Td. The simulations were made with the same set of parameters given above, and reproduce very well the pressure dependence of the excess aftercurrent due to electron detachment, as it is shown in the insert of Fig. 2.

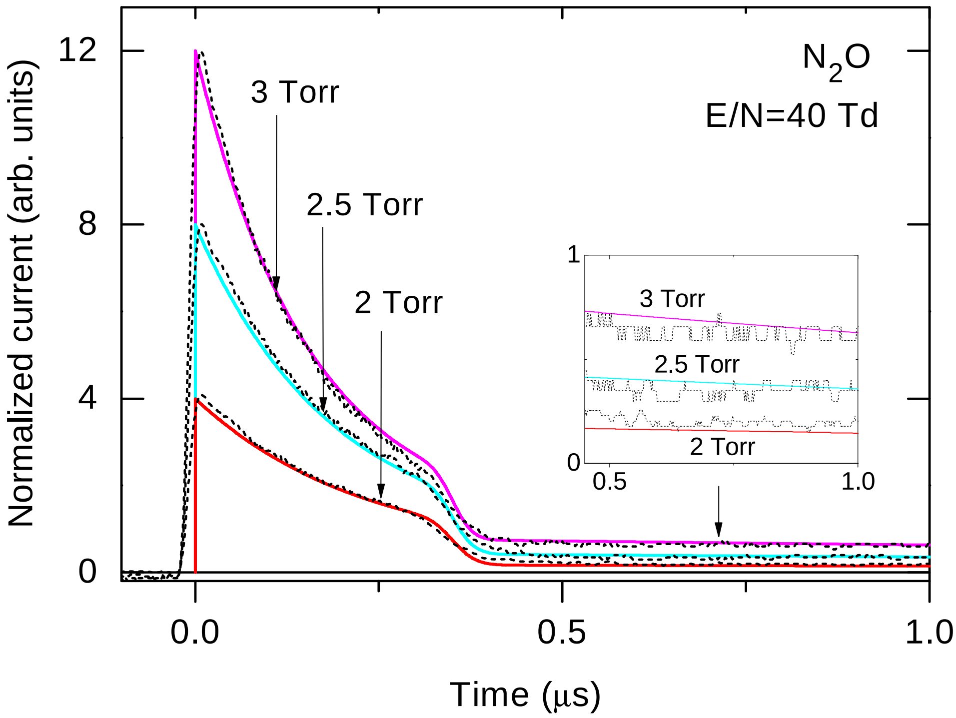

Figure 2. Simulated (red solid lines) and measured (black dotted lines) currents in N_2O at E/N=40 Td, for gas pressures of 2, 2.5 and 3 torr. The insert shows the detail of the calculated and measured aftercurrents.

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