ELECTRON AND HEAVY PARTICLE COLLISION PROCESSES
IN GAS DISCHARGES AT HIGH E/n

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Studies of gas discharges at high values of E/n were initiated recently for two reasons. The first is the determination of the heavy particle processes and electron impact cross sections responsible for excitation and ionization. The second reason is the need to improve the understanding of gas discharge and associated devices. The experiment and theory in this area up to 1987 were reviewed previously. We review some of the studies of collisonal kinetics in discharges at high E/n carried out at the Joint Institute for Laboratory Astrophysics in Boulder (JILA) and at the Institute of Physics in Belgrade (IPB).

A single beam model for electron kinetics was found to be generally successful in describing the electron non-equilibrium processes at very high E/n. Heavy particle kinetics is described either by equilibrium model for ions of the parent gas, e.g. H⁺ in H₂, or by a beam model for fragmented or associated ions or neutrals, e.g. H⁺ and H₂⁺ in H₂.

At moderately high values of E/n (< 1kTd for H₂ and < 3kTd for N₂) absolute measurements of excitation coefficients are used to test the adequacy of the electron excitation cross sections. At the IPB the range of E/n values was extended beyond 10 kTd. Measurements were performed for C⁵⁺ level of N₂, D¹⁺ of N₂ and for the a¹Σ⁺ level of hydrogen. The nitrogen results are shown in Figure 1 where they are compared with calculations by Phelps and Pitchford. Measurements at very high E/n may be subject to errors due to back scattered electrons. Any cross section determination should take this effect into account.

Spatial scans of emitted radiation have been used at JILA to test the models and establish excitation mechanisms. Another test of the models, which will be discussed in this paper, is the measurement of charge transported across the gap on different time scales for voltages below the breakdown value. Photoelectrons are produced by a pulsed laser and the resulting current is integrated. Qe denotes the charge collected if no gas is present, Qg and Q denote the charge collected on electron and ion transit time scales respectively. The measurements have been made for N₂, Ne and H₂. In Figure 2 we show results for Ne together with the fit of the single beam model.

It was shown that heavy particle ionization is important in all
ions are abundant. Maximum transit times obtained from the waveforms are shown by the points in Figure 3. Also shown by the lines are the transit times for \( H^+ \), \( H_3^+ \), and \( H_2^+ \) ions predicted on the basis of the best available data.\(^{12}\)

Figure 3. Transit time for d=4cm gap, for ions in \( H_2^+ \).

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References
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