Experimental and Theoretical Studies of the Argon Pre-Breakdown Discharge.

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Abstract.

This work concerns the use of an optical absorption technique to measure the concentration of metastable excited argon atoms within a 'chopped' prebreakdown or Townsend discharge. A diode laser tuned to the argon $1s_5$ - $2p_9$ transition at 811.5 nm was used as the light source. The absorption was measured with a spatial resolution of less than 2 mm and a time resolution of as low as 0.1 ms. The reduced diffusion coefficient ND_m of the $1s_5$ state was determined by measurements of the decay of the discharge current in the afterglow. A value of $(1.57 \pm 0.05) \times 10^{-18}$ $cm^{-1}s^{-1}$ was returned, which is consistent with other published values. An approximate value of the efficiency with which the $1s_5$ atoms eject secondary cathodic electrons was determined from spatially-resolved measurements of the quasi-steady-state concentration of these atoms. The resulting value of 85% is broadly consistent with published values. The primary ionisation coefficient α_i/N was determined at 454 Td of reduced electric field by spatially- and time-resolved measurements of the $1s_5$ concentration in the first millisecond after the discharge was switched on. The measured value of 6×10^{-17} cm^2 is about 25 % lower than the previously accepted value. Measurements were also made from 36 to 82 Td, using just the current passed by the discharge: these values were about 10% lower than the canonical values. The $1s_5$ excitation coefficient α_m/N was measured at the same pressure and field using both the quasi-static technique and the time-resolved technique, returning values of 8.0 and 7.3×10^{-18} cm^2 respectively. The only previously published data report a value of 27×10^{-18} cm^2 for this quantity.

In the accompanying theoretical sections, a boundary condition for the metastable-particle diffusion equation is derived; the occurrence of complex exponents in the Molnar analysis is investigated; a simple relation is derived which describes the saturation of the absorption coefficient for a narrow-band light source restricted to a thin beam; the electron diffusion equation is solved for the case of a spatially extended source of cathode current, leading to useful techniques for extracting electron transport coefficients from optical absorption measurements; a spatially resolved model of the steady-state distribution of metastable particles is developed; and techniques are described for the analysis of data comprising multi-exponential decays plus noise.

"Nec dubitamus multa esse quae et nos praeterierint; homines enim sumus et occupati officiis." Pliny, Preface, *Historia Naturalis*.

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Table of Contents.

Tables.