Transport Coefficients of Higher-Order for Electrons and Positrons in Neutral Gases and Nonpolar Liquids

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Transport coefficients of third and higher order have been systematically ignored in the traditional interpretations of the swarm experiments, as these experiments are usually performed under conditions in which the contribution of these transport coefficients is not significant. However, it has been shown that the third order transport coefficients (TOTC) are necessary for the conversion of hydrodynamic transport coefficients into transport data which are measured in the steady state Townsend and arrival time spectra experiments. In addition, the TOTC are required for a better representation of the spatial distribution of the swarm, as they describe the asymmetric deviation of the profiles of the number density of charged particles from a perfect Gaussian. Furthermore, if TOTC could be measured and calculated with a sufficient accuracy, this would enable the improvement of the swarm procedure for determining the complete sets of cross sections, as an additional transport coefficient could be included in this procedure.

We have investigated the third order transport coefficients for electrons and positrons in rare gases, as well as for electrons in homogenous atomic liquids. The structure of the third order transport coefficient tensor has been determined by employing the group projector technique, for all configurations of electric and magnetic fields [1]. In addition, the physical interpretation of the third order transport coefficients has been carefully analyzed.

Calculations of the TOTC and transport coefficients of lower order (e.g., drift velocity and diffusion tensor) have been performed in a wide range of the reduced electric fields (E/n_0) by employing Monte Carlo simulations and a multi term method for solving the Boltzmann equation. Both computer codes which are used in this study have been thoroughly tested [2,3]. Among many important points a strong correlation has been found between the E/n_0 profiles of the longitudinal component of the TOTC tensor and longitudinal diffusion. In addition, the TOTC for electrons and positrons in molecular gases have been compared. It has been found that the difference between the TOTC for electrons and positrons can be attributed to the corresponding differences in the rate coefficients for the inelastic collisions. In our study of the electron transport in atomic liquids, the structure induced negative differential conductivity has been thoroughly investigated by analyzing spatially resolved transport data and electron energy distribution functions [4]. Moreover, the influence of various representations of the inelastic energy losses in the liquid phase on the calculated values of the transport coefficients and the first Townsend coefficient has been studied [4].

References

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