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Electron transport and streamer propagation in gases and nonpolar liquids and their applications in modelling of particle detectors

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In this work, we discuss the physics of resistive plate chambers (RPCs), including the electron transport and streamer propagation in the gas filled gaps, and signal induction in the system of electrodes. RPCs are used for timing and triggering purposes in many high-energy physics experiments at CERN, including ATLAS, ALICE and CMS. Using the pulsed-Townsend measurements and calculations of the electron drift velocity, longitudinal diffusion coefficient and effective ionization coefficient in pure $C_2H_2F_4$ and its mixtures with Ar, we propose a complete and consistent set of cross sections for electron scattering in $C_2H_2F_4$. Electron transport coefficients, required as an input in fluid-equation based models, are calculated from numerical multi term solutions of Boltzmann's equation and Monte Carlo simulations in a variety of RPC gas mixtures, as a function of the reduced electric field. We have developed a 1.5D classical fluid model with photoionization to investigate the streamer development in various RPCs at CERN and elsewhere. Among many important points, it is found that the electron absorption on the anode has a large influence on the space charge effects and positive streamer formation. The classical fluid model is extended by considering the model in which the source term in the equation of continuity is expanded in terms of the powers of the number density gradient operator. The expansion coefficients are calculated over a wide range of the reduced electric fields using a Monte Carlo simulation technique. Both fluid models are developed to demonstrate how the nature of transport data affects the results of an RPC modelling. Transport of electrons and propagation of streamers, are also considered in liquid noble gases. Solutions of Boltzmann's equation and Monte Carlo method for electrons in dilute neutral gases, are extended and generalized to consider the transport processes of electrons in liquid Ar and liquid Xe by accounting for the coherent and other liquid scattering effects. We focus on the way in which electron transport coef?cients and streamer properties are in?uenced by a representation of the inelastic energy losses, highlighting the need for a correct representation of elementary scattering processes in modeling of liquid discharges. The present work has been done in collaboration with D. Bosnjakovic, I. Simonovic, Z.Lj. Petrovic and R.D. White.