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Simulation of Resistive Plate Chamber in Streamer Mode Operation

Simulation of a streamer initiation inside the gas gap of a trigger Resistive Plate Chamber (RPC) with gas mixture C2F4H2/i-C4H10/SF6 96.7/3/0.3 has been performed by simultaneous numerical solution of transport equations together with Poisson equation for electrons, negative and positive ions. The numerical solution is according to a finite difference scheme. The model can predict well spatial and temporal development of avalanche mode, saturated avalanche and finally streamer mode of RPC operation, under the influence of space charge field. In addition, this approach predicts development of the streamer signal inside the gap as a result of space charge distortion. The consequences of simulation in demonstrating the transition of avalanche to saturated avalanche and saturated avalanche to streamer in addition to prediction of the existence of a pre-cursor signal before the breakdown are all in good agreement with experimental results.

Summary (Additional text describing your work. Can be pasted here or give an URL to a PDF document):

Resistive plate chamber (RPC) is a gaseous parallel plate detector, which is extensively used in many high energy physics experiments. In order to understand the physics of RPC and different processes happening inside its gas gap, due to passage of an ionizing particle, several models have been proposed to describe the avalanche development inside the RPC gap, when the produced signal is not so strong. However, the simulation of RPC in streamer mode operation, when the signal is strong, suffers from the lack of extensive investigations. In this work, we have presented the results of a simulation of an RPC including description of the avalanche mode operation, transition from the avalanche mode to the streamer mode and finally the streamer mode operation. The simulation is based on simultaneous numerical solution of the transport equations as one of the widely used methods to study parallel plate chambers.

We numerically solved transport equations together with Poisson equation to include space charge field. Transport equations are first-order partial differential equations. In this approach, the equations are discretized in time and space and they are solved numerically using Lax finite difference scheme to get the spatial and temporal development of electrons, positive and negative ions. The variation of the space charge field during the development of streamer signal is also investigated. The simulation can well produce three modes of operation of RPC, which are avalanche, saturated avalanche and streamer mode. It has been shown by the model that the avalanche mode of RPC follows Townsend mechanism in which the densities of electrons and ions grow exponentially. In the saturated avalanche mode the particle densities are slightly distorted because of the space charge field. In the streamer mode operation, the total electric field is very high so that the effect of attachment coefficient and therefore production of new negative ions are almost negligible. Therefore, the number density of electrons and positive ions coincide with each other. The simulation results show that in the time of development of the steamer signal, the space charge field along the gap becomes almost equal to the external field. This can be an indication of the Raether limit for the streamer initiation to breakdown. In addition, the existence of a pre-cursor signal to breakdown under the influence of space charge field is predicted. The results obtained by the simulation are in good agreement with available experimental data.

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