Energetic Electron Dynamics in Air (LA-UR-13-27623)

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The generation and relaxation of conduction electrons newly freed from neutral air is under investigation. The processes considered here are the photoelectron ionization of air, which describes the slowing down of photo- or Compton electrons as they produce new ionization along their paths, and Townsend impact ionization. The time dependent energy distribution of the conduction electrons is of importance because these electrons dominate the conductivity of air. Hence, these conduction electrons regulate the amplitude and frequency of radio waves that propagate, develop, and possibly further ionize the medium that the waves travel through. However, the conduction electrons are often assumed in models to immediately achieve a steady equilibrium state that is based on electron swarm measurements and defined by a local and instantaneous value of E/p.

The previous swarm analysis performed at LANL is being expanded upon using a more general kinetic approach. Using a model developed in the summer of 2012, we have shown that a swarm treatment does not give the correct equilibrium energy for electrons compared against microwave swarm measurements. A verification test of the LANL swarm model has shown that it is in agreement with an analytic estimate of the equilibrium energy discussed by Baum, and Longmire and Longley. However, when validated against data, the swarm model shows significant discrepancy for high values of E/p. This indicates a problem with the swarm treatment, where the electrons are described by a Maxwellian distribution. As such, the swarm equations evolve the mean energy of the group under a given set of ambient conditions that depend on E/p. There are at least two possibilities for the discrepancy. One possibility is that the momentum and energy transfer cross sections used in the early 1970s have uncertainty and require updates. We are presently comparing the momentum and energy transfer cross sections that were used in previous models with the modern cross sections. Furthermore, we discuss our pursuit of a kinetic treatment for the electrons that allows electrons to evolve according to their energy group rather than as the mean of the group. This is especially important in the high energy tail of electron distributions where it is possible for electrons to run away in energy.