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**Transmission line analysis of laser-guided streamers and leaders**[1]

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Plasma Physics Division, NRL. We have developed a 1-D transmission-line model for laser-guided discharges, which can be used to analyze both streamers and leaders over the complete length and duration of the discharge, and which facilitates analytic insight as well as providing a simplified, quickly solvable semi-quantitative simulation capability. It is assumed that the laser designates a specified seed electron density within a long thin channel, which is connected directly to a high-voltage source. In this way, the physical situation differs somewhat from natural lightning, which is driven by a uniform electric field, rather than via connection to a voltage source. The mathematics reduces to a 1-D diffusion equation for the electric field E(z,t), with a diffusion coefficient D(z,t) proportional to the channel conductance, very small ahead of the discharge and rapidly increasing at the discharge head. This equation can be solved directly, or the model can be further reduced by requiring that the discharge propagates in a self-similar fashion at a constant propagation speed u; the diffusion equation then reduces to a first-order O.D.E. in $t' = t - z/u$, which must be solved self-consistently with rate equations that determine $D(t')$. In analyzing streamers (in cold air), we represent the rates as functions of E/n; this simple model yields immediate insights. In analyzing leaders, where the air is heated and excited, we use a complete air chemistry model. The model provides estimates for the minimum propagation speed of negative waves, the minimum level of pre-ionization required for propagation of positive waves, the electric field in the discharge head and body, and the radius and range of leaders, and is especially useful for understanding the streamer-to-leader transition. Work done in collaboration with R. F. Fernsler, S. P. Slinker, D. F. Gordon, and P. Sprangle.

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