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Steady-State Model for Laser-Guided Lightning-Like Discharges¹ M. LAMPE, R. FERNSLER, S. SLINKER, D. GORDON, P. SPRANGLE, Plasma Physics Division, Naval Research Laboratory — We have developed a reduced model for laser-guided discharges, which can be solved efficiently over the complete length and duration of the discharge, and also provides analytic insights. We assume the laser pre-pulse designates a long thin channel with given low conductivity, and that current flows entirely in this channel. Maxwell's equations can be reduced to a diffusion equation for $E_z(z,t)$, 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. By specifying that the discharge propagates at a constant speed u, the diffusion equation is further reduced to a first-order O.D.E. in $\tau \equiv t-z/u$, which must be solved self-consistently with rate equations that determine $D(\tau)$. The required driving voltage pulse $V(\tau)$ is an output of the calculation. Even in absence of deionization processes, we show the discharge propagates only if T_e is large enough throughout the channel to drive continuing ionization. If the channel is narrow enough, this can occur at sustainable levels of E_z due to saturation of the N₂ vibrational energy sink.

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Martin Lampe Plasma Physics Division, Naval Research Laboratory

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