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Relativistic soliton-like collisionless ionization wave[1] ALEXEY AREFIEV, Institute for Fusion Studies, The University of Texas at Austin, MATTHEW MCCORMICK, HERNAN QUEVEDO, ROGER BENGTSON, TODD DITMIRE, Center for High Energy Density Science, The University of Texas at Austin — It has been observed in recent experiments with laser-irradiated gas jets that a plasma filament produced by the laser and containing energetic electrons can launch a relativistic ionization wave into ambient gas [Phys. Rev. Lett. 112, 045002 (2014)]. Here we present a self-consistent theory that explains how a collisionless ionization wave can propagate in a self-sustaining regime. A population of hot electrons necessarily generates a sheath electric field at the plasma boundary. This field penetrates the ambient gas, ionizing the gas atoms and thus causing the plasma boundary to expand. We show that the motion of the newly generated electrons can form a potential well adjacent to the plasma boundary. The outwards motion of the well causes a bunch of energetic electrons to become trapped, while allowing the newly generated electrons to escape into the plasma without retaining much energy. The resulting soliton-like ionizing field structure propagates outwards with a bunch of hot electrons that maintain a strong sheath field despite significant plasma expansion. We also present 1D and 2D particle-in-cell simulations that illustrate the described mechanism.

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