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Nonlinear laser pulse and plasma wave evolution in laser wakefield accelerators[1] ERIC ESAREY, C.B. SCHROEDER, B.A. SHADWICK, W.P. LEEMANS, LOASIS Program, LBNL — The evolution of short laser pulses in underdense plasmas is analyzed for arbitrary laser intensity. Some of the new results derived include expressions for the nonlinear group velocity of the laser pulse, the nonlinear phase velocity of the wakefield, the nonlinear frequency shift, and the laser pulse envelope distortion. New scaling laws are presented for the pump depletion length and the electron dephasing length. Analytical results are compared to numerical calculations based on fluid models. In the low laser intensity limit, the depletion length is much longer than the dephasing length, thus implying that some form of phase matching is necessary. In the high intensity limit, the depletion and dephasing lengths are approximately equal, thus allowing for high efficiency coupling of laser energy to the wake and the accelerated particles. Implications for an optimized design of a 1 GeV accelerator stage are discussed.

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