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Frequency domain holography of laser wakefield accelerators in the nonlinear bubble regime S.A. YI, S. KALMYKOV, P. DONG, S.A. REED, M. DOWNER, G. SHVETS, Department of Physics, University of Texas at Austin — We present the theoretical basis of frequency domain holography (FDH), a technique for single-shot visualization of laser driven plasma wakes. In FDH, the nonlinear index modulations of the plasma wake are recorded as phase shifts in a co-propagating probe pulse, and interference with a reference allows for the reconstruction of the wake structure. Earlier experimental work [N. H. Matlis *et al.*, Nature Phys. **2**, 749 (2006)] has shown that reconstruction of the probe phase is sufficient for imaging weakly nonlinear periodic wakes. In the highly nonlinear regime, the laser ponderomotive force blows out plasma electrons and forms a density "bubble" that strongly focuses the probe light. We show that imaging the bubble requires full (amplitude and phase) reconstruction of the probe pulse, and find reconstructions of simulated frequency domain holograms in full agreement with direct PIC modeling of the probe pulse. We also assess the sensitivity of the technique to the spectral bandwidth of the probe and reference pulses. In combination with ray-tracing techniques which help evaluate the localized frequency up- and down-shifts of the probe light ("photon acceleration"), FDH appears to be a unique tool for visualization of plasma wakes. This work is supported by the US DOE grants DE-FG02-04ER41321 and DE-FG02-07ER54945.

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