Few-Cycle Pulses in an Optical Parametric Oscillator

P. Kinsler and G.H.C. New.

Blackett Laboratory, Imperial College, Prince Consort Road, London SW7 2BW, United Kingdom.

(email) Dr.Paul.Kinsler@physics.org (ph) +44-20-7594-7520 (fax) +44-20-7594-7714

Optical parametric oscillators (OPOs) based on aperiodically-poled lithium niobate (APPLN) have generated 53 fs idler pulses at 3μm that are nearly transform limited, and contain only five optical cycles[1]; laser pulses with less than three optical cycles have been generated in other contexts[2]. This means the slowly-varying envelope approximations traditionally used to model such processes are no longer valid. Building upon the ideas of Brabec and Krausz[3], we present a comprehensive framework for treating the optical parametric interaction for few-cycle pulses. We apply the theory to an OPO model that includes dispersion, multiple fields and its second-order nonlinearity. We show numerical simulations involving pulses with different numbers of cycles, including idler pulses containing as few as two cycles. The characteristic differences between the results under various levels of approximation are discussed in detail. These demonstrate how the effect of the nonlinearity differs between the many-cycle and few-cycle cases, and how the commonly used slowly varying envelope approximation fails as pulse lengths decrease.

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[3] T. Brabec, F. Krausz, Phys. Rev. Lett. **78**, 3282 (1997).