Physics 7810 Ultrafast Optics

Homework Set #3

1) It is often desirable to generate a pulse with a "square" temporal shape. There are several possible ways of generating such a pulse. The best solution often depends on the input pulse and the desired length of the square pulse. Both linear and non-linear processes can be used. Examples include nonlinear absorption, self defocusing through a $n_4 I^4$ process followed by spatial filtering, pulse splitting-sequencing by interferometric delay lines, or spectral filtering in a pulse shaper. Compare these methods in terms of energy loss and residual modulation of the "flat" part of the pulse. Assume you initially have 1 mJ Gaussian pulse of 50 fs duration and want to generate a square pulse of (a) 40 fs duration; (b) 150 fs duration; and (c) 900 fs duration.

2) (a) How would one generate at train of identical pulses, each being 180^O out of phase with the previous one? (b) Consider a bandwidth-limited pulse of duration τ_p. Is it possible to generate temporal substructure with transients shorter than τ_p with spectral filtering? Explain.

3) The energy storage time is an important parameter of a gain medium. Consider a one-stage amplifier of 5 mm length transversely pumped by a pulse of 20 ns duration and 5 mJ energy. A (fs) 100 pj pulse is to be amplified. The gain medium consists of a 3-level system (as in the lecture notes). The relaxation time from level 2 to level 1 is assumed to be extremely fast. Calculate and compare the energy amplification achievable in a single-pass configuration for a lifetime of the upper gain level, T_{10}, of (a) 100 ps and (b) 1 ms. For simplification you may assume a rectangular temporal and spatial profile of both the pump and pulse to be amplified. Use a beam size of 50 x 50 μm^2. Assume homogeneous gain and equal cross sections for the absorption and amplification, $\sigma \sim 10^{-17}$ cm^2.