Physics 7810 Ultrafast Optics

Homework Set #2

1) Three mode-locked lasers generate pulses of 40 fs duration at the wavelengths of 620, 700 and 780 nm. Under what condition can the output of these lasers be combined to provide a train of much shorter pulses? What are the practical problems to be solved? Assuming perfect technology, how short would the combined pulses be?

2) Derive an evolution equation for the pulse energy in a mode-locked laser ring cavity consisting of the sequence (a) output coupler with reflectivity r – gain – saturable absorber; (b) gain – output coupler – absorber; and (c) absorber – gain – output coupler.

3) Derive the expression for a third-order interferometric correlation:

$$B(\tau) = B_0(\tau) + \mathrm{Re}\left[B_1(\tau)e^{-i\omega_l\tau}\right] + \mathrm{Re}\left[B_2(\tau)e^{-2i\omega_l\tau}\right] + \mathrm{Re}\left[B_3(\tau)e^{-3i\omega_l\tau}\right]$$

where

$$B_0(\tau) = \int \left\{\hat{E}_1^6(t-\tau) + \hat{E}_2^6(t) + 9\hat{E}_1^2(t-\tau)\hat{E}_2^2(t)\left[\hat{E}_1^2(t-\tau) + \hat{E}_2^2(t)\right]\right\}dt$$

$$B_1(\tau) = 6\int \left[\hat{E}_1^4(t-\tau) + \hat{E}_2^4(t) + 3\hat{E}_1^2(t-\tau)\hat{E}_2^2(t)\right]\hat{E}_1(t-\tau)\hat{E}_2(t)e^{i[\varphi_1(t-\tau)-\varphi_2(t)]}dt$$

$$B_2(\tau) = 6\int \left[\hat{E}_1^2(t-\tau) + \hat{E}_2^2(t)\right]\hat{E}_1^2(t-\tau)\hat{E}_2^2(t)e^{2i[\varphi_1(t-\tau)-\varphi_2(t)]}dt$$

$$B_3(\tau) = 2\int \hat{E}_1^3(t-\tau)\hat{E}_2^3(t)e^{3i[\varphi_1(t-\tau)-\varphi_2(t)]}dt$$

and the two pulses are $E_{1,2} = \left(\hat{E}_{1,2}e^{i\omega_l t}e^{i\varphi_{1,2}} + c.c.\right)/2$. For equal pulses, determine the peak to background ratio of the interferometric autocorrelation and the intensity autocorrelation.