Problem Set 8

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1. For $\lambda = 600\,\mathrm{nm}$ and $\Delta\lambda = 10\,\mathrm{nm}$, the coherence length and time is given by

$$\Delta\ell_c = \frac{\lambda^2}{\Delta\lambda} = 36\,\mu\mathrm{m}$$
$$\Delta t_c = \Delta\ell_c/c = 120\,\mathrm{fs}$$

2. Using the notes in-class and since we're dealing with a small angle,

$$\begin{aligned} \ell_t &= \lambda/\theta_s \\ &= \frac{600\,\mathrm{nm}}{(0.5\,\mathrm{deg} \times \pi/180\,\mathrm{deg})} \\ &= 68.8\,\mu\mathrm{m} \end{aligned}$$

3. In this problem, we're trying to find the separation s, which can be found treating them as two incoherent sources,

$$\begin{aligned} \ell_t &= \frac{\lambda}{\theta_s} \approx \frac{\lambda r}{s} \\ s &= \frac{\lambda r}{\ell_t} = \frac{589\,\mathrm{nm} \times \left(2\,\mathrm{m} \times 1 \times 10^9\,\mathrm{nm/m}\right)}{1\,\mathrm{mm} \times 1 \times 10^6\,\mathrm{mm/nm}} \\ &= 1.2\,\mathrm{mm} \end{aligned}$$

4. The envelope square wave has a frequency of $40\,\mathrm{MHz}$, so for each period, it's able to pass $12.5\,\mathrm{ns}$ of light. This corresponds to a coherence length of $3.75\,\mathrm{m}$. From the notes in class,

$$\begin{aligned} \ell_c &= \frac{\lambda^2}{\Delta\lambda} \\ \Delta\lambda &= \frac{\lambda^2}{\ell_c} = \frac{(488\,\mathrm{nm})^2}{3.75\,\mathrm{m}} \\ &= 6.35 \times 10^{-5}\,\mathrm{nm} \end{aligned}$$

5. For the frequency spectrum

$$I(\omega) = \frac{A}{(\omega - \omega_0)^2 + b^2}$$

the width $\Delta\omega$ is found by the FWHM. The maximum is found at $\omega = \omega_0$ as $I_{\max} = A/b^2$. At half-max, $\omega = \omega_0 \pm b$, so the full width is $\Delta\omega = 2b$, or $\Delta\nu = b/\pi$.

From the relation from in-class,

$$\langle \tau_0 \rangle = \frac{1}{\Delta\nu} = \frac{\pi}{b}$$