The magnitude of the electric field at the photosensor is given by the sum of the electric fields of each of the waves,

$$E = E_1 + E_2 + E_3 + E_4 \tag{1}$$

The intensity is proportional to the square modulus of (1)

$$\begin{aligned} |E|^2 &= (E_1 + E_2 + E_3 + E_4)(E_1^* + E_2^* + E_3^* + E_4^*) && (2)\\ &= |E_1|^2 + |E_2|^2 + |E_3|^2 + |E_4|^2 + 2Re(E_1E_2^*) + 2Re(E_1E_3^*) && (3)\\ &\quad +2Re(E_1E_4^*) + 2Re(E_2E_3^*) + 2Re(E_2E_4^*) + 2Re(E_3E_4^*) && (4) \end{aligned}$$

In this particular case, we can write the (time-averaged) electric fields as

$$\begin{aligned} E_1 &= E_{01}e^{ik_1x} && (5)\\ E_2 &= E_{01}e^{ik_1(x+2\Delta x)} && (6)\\ E_3 &= E_{02}e^{ik_2x} && (7)\\ E_4 &= E_{02}e^{ik_2(x+2\Delta x)} && (8) \end{aligned}$$

Substituting into (3), and after performing some trigonometric algebra, we get

$$\begin{aligned} |E|^2 &= 2\left[E_{01}^2 + E_{02}^2 + E_{01}^2\cos(2k_1\Delta x) + E_{02}^2\cos(2k_2\Delta x)\right.\\ &\quad \left.+4E_{01}E_{02}\cos\left(k_1\Delta x\right)\cos\left(k_2\Delta x\right)\cos\left((k_1-k_2)(\Delta x+2x)\right)\right] && (9) \end{aligned}$$

We define $a = \frac{E_{01}}{E_{02}}$, and rewrite this as

$$\begin{aligned} I \propto \frac{1}{2}\left|\frac{E}{E_{02}}\right|^2 &= 1 + a^2 + a\cos(2k_1\Delta x) + \cos(2k_2\Delta x)\\ &\quad +4a\cos\left(k_1\Delta x\right)\cos\left(k_2\Delta x\right)\cos\left((k_1-k_2)(\Delta x+2x)\right) && (10) \end{aligned}$$

The $2x$ factor in the last term is just an offset that does not affect the shape of the curve, so we can set $x = 0$. Rewriting in terms of ν_0, the frequency of the central mode, and $\Delta\nu$, the frequency separation between the modes, we have that

$$\begin{aligned} I &\propto 1 + a^2 + a\cos\left(\frac{4\pi\nu_0\Delta x}{c}\right) + \cos\left(\frac{4\pi(\nu_0+\Delta\nu)\Delta x}{c}\right)\\ &\quad +4a\cos\left(\frac{2\pi\nu_0\Delta x}{c}\right)\cos\left(\frac{2\pi(\nu_0+\Delta\nu)\Delta x}{c}\right)\cos\left(\frac{2\pi\Delta\nu\Delta x}{c}\right) && (11) \end{aligned}$$

For an HeNe laser with nominal wavelength $\lambda_0 = 632.8$ nm, and cavity length $L = 10$ cm, we have that $\nu_0 = 4.74 \times 10^{14}$ Hz and $\Delta\nu = \frac{c}{2L} = 1.50 \times 10^9$ Hz. Figure 1 shows a plot of (10) after normalization, using these values, and $a = 1$.

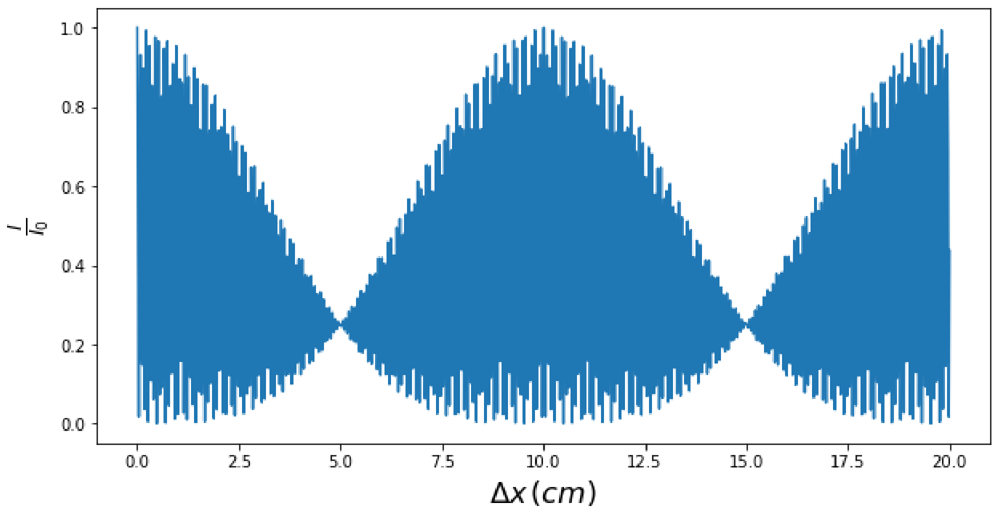

Figure 1: Normalized intensity vs Δx with $\nu_0 = 4.74 \times 10^{14}$ Hz and $\Delta\nu = 1.50 \times 10^9$ Hz.