Review Problem 3

Suppose we have an incoherent optical system with a circular pupil that operates at a working F-number $F_w/\# = 4$ and has a wavelength of $\lambda = 0.5\mu m$. Answer the following:

(a) What is the cutoff frequency?

The cutoff frequency is given by $\rho_{cutoff} = \frac{1}{\lambda F_w/\#} = 500\frac{cyc}{mm}$

(b) The irradiance of the object for the system is given by

$o(x,y) = \frac{1}{2} + \frac{1}{4}cos(2\pi\xi_o x) + \frac{1}{10}cos(4\pi\xi_o x) + \frac{1}{10}cos(8\pi\xi_o x)$, where $\xi_o = 250\ cyc/mm$. If the system is diffraction limited, what is the irradiance of the image?

The last two terms of the object irradiance are at or above the cutoff frequency so they don't contribute to the image. The second term has a frequency of $\xi_o = 250\ cyc/mm$, *so we need to calculate the value of the diffraction limited OTF at this frequency.*

Let $\beta = \lambda F_w/\#\rho$, *which equals 0.5 when* $\rho = \xi_o$. *The diffraction limited OTF is given by*

$$OTF = \frac{2}{\pi}\left[cos^{-1}\beta - \beta\sqrt{1-\beta^2}\right]$$

when $\beta = 0.5$, *the OTF = 0.391. The image irradiance is*

$$i(x,y) = \frac{1}{2} + \frac{0.391}{4}cos(2\pi\xi_o x)$$

(c) What is the contrast of the final image?

The contrast is

$$\frac{i_{max}(x,y) - i_{min}(x,y)}{i_{max}(x,y) + i_{min}(x,y)} = \frac{\left(\frac{1}{2} + \frac{0.391}{4}\right) - \left(\frac{1}{2} - \frac{0.391}{4}\right)}{\left(\frac{1}{2} + \frac{0.391}{4}\right) + \left(\frac{1}{2} - \frac{0.391}{4}\right)} = 0.1955$$