PROBLEM SET 5

(Due Tues., Nov. 13, 2001)

1. Write a program to calculate point spread functions (PSFs) for aberrated circular pupils. (Write your own code using MATLAB or Mathematica, or similar. Do not use SPLAT or another canned imaging program.) Plot results for the following aberrations. Be sure to include an appropriate transverse scaling of the image.

   a) Unaberrated.

   b) Defocus: $A_d\rho^2$, with $A_d = 0.5\lambda$, and 1λ.

   c) Astigmatism: $A_a\rho^2\cos^2\theta$, with $A_a = 2\lambda$. Calculate the focused image, then add 1λ of defocus.

   d) Coma: $A_c\rho^3\cos\theta$, with $A_c = 2\lambda$. Calculate the focused image, then add 1λ of defocus.

   e) Choose one or two of the high order Zernike terms (n ~ 30) with 1λ of amplitude.

2. Write another program to calculate modulation transfer functions (MTFs) for aberrated circular pupils. Plot results for the following aberrations. For symmetric aberrations, a simple radial plot suffices. For asymmetric aberrations, plot results along both the $\theta = 0$, and $\theta = \pi/2$ directions:

   a) Unaberrated.

   b) Defocus: $A_d\rho^2$, with $A_d = 1\lambda$.

   c) Astigmatism: $A_a\rho^2\cos^2\theta$, with $A_a = 2\lambda$.

   d) Coma: $A_c\rho^3\cos\theta$, with $A_c = 2\lambda$.

3. Consider an object consisting of 2 points, separated by 1.5 times the Rayleigh resolution along the $\theta = 0$ direction. Calculate the image formed by a system with a circular pupil under two illumination conditions : case A - sources are mutually coherent with $\pi/2$ relative phase difference; case B- sources are mutually incoherent. (Same rules as Problem 1 - use your own code, not a canned program.) For both illumination cases, plot the image assuming the pupil has the following aberrations:

   a) Unaberrated.

   b) Defocus: $A_d\rho^2$, with $A_d = 0.5\lambda$.

   c) Astigmatism: $A_a\rho^2\cos^2\theta$, with $A_a = 0.5\lambda$.

   d) Coma: $A_c\rho^3\cos\theta$, with $A_c = 0.5\lambda$.