# EE119 Homework 11: Lasers and Diffraction

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Due Friday, April 24, 2009

1. We have discussed some of the very common lasers in class. There are many other lasers, which we have not covered in the lecture. In this problem, you should do some library (or internet) research on the following lasers. You should describe their special characteristics, how they operate, and typical operating wavelengths. Include diagrams to get more points and state some common applications to get more points.

   (a) Liquid lasers (dye lasers)

   (b) Excimer lasers

   (c) Plasma X-ray lasers

   (d) Free electron lasers

   (e) VCSEL (Vertical Cavity Surface Emitting Lasers)

2. Give short (a few sentences) answers to the following questions:

   (a) Why is there no lasing from the Helium atoms in a HeNe laser?

   (b) If you could achieve lasing from all the transitions in Neon simultaneously in a single cavity, which transition would yield the longest collimation length? Give the wavelength of the transition, the energy levels involved, and explain your answer.

3. Find an expression for the intensity distribution in the Fraunhofer diffraction pattern of the aperture shown in Figure 1. Assume unit-amplitude, normally incident plane-wave illumination. The aperture is curcular and has a circular central obstruction. (Hint: Use the result given below for the simple circular aperture and then use superposition.) Outer radius is $R_1$ and inner radius is $R_2$.

$$E(r) = e^{jkr} e^{jk\frac{r^2}{2z}} \frac{A}{jz\lambda} \left[ 2 \frac{J_1(kwr/z)}{kwr/z} \right]$$

   Where $J_1$ is the Bessel function of order 1, k is a wavevector and w is the size of the circular pupil (same notations as those used in class). A table of Bessel functions is on p.470 of Hecht (section 10.2.5) Electric field of the Fraunhofer diffraction pattern from a circular aperture:

4. (Hecht 10.7) A single slit in an opaque screen 0.10 mm wide is illuminated (in air) by plane waves from a krypton ion laser ($\lambda_0 = 461.9$ nm). If the observing screen is 1.0 m away, determine whether or not the resulting diffraction pattern will be of the far-field variety and then compute the angular width of the central maximum.

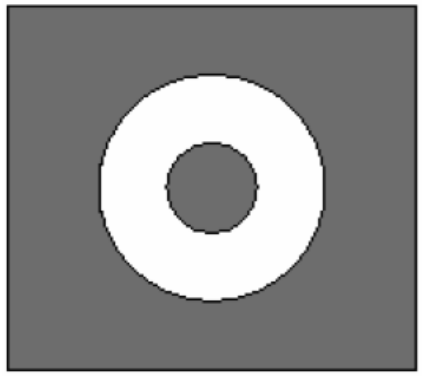

Figure 1: Circular aperture

5. (Hecht 10.11) Two long slits 0.10 mm wide, separated by 0.20 mm, in an opaque screen are illuminated by light with a wavelength of 500 nm. If the plane of observation is 2.5 m away, will the pattern correspond to Fraunhofer or Fresnel diffraction? How many Youngs fringes will be seen within the central bright band?

6. Do problems 10.17-10.21 in Hecht. These problems require you to identify the type of aperture that gives rise to the diffraction pattern shown in the pictures. The answers to these questions are in the back of the book, which means that you should get all of them right. Make sure you understand why the answer is correct. Your grade on this problem will depend on the accuracy and completeness of your explanations.