Physics 136, Caltech: Applications of Classical Physics — Fall Term, 2006
Assignment 8

Reading

Chapter 8 of Blanford and Thorne. A nice brief paper explaining the intensity correlation interferometry discovered by Hanbury Brown and Twiss is *Purcell*, Nature **178,** 1449 (1956).

Problems (due in class, 1pm Wednesday November 22)

Numbers refer to exercises in Blanford and Thorne, as posted on website.

A. *Rayleigh theory of lenses*

Instead of Abbe's theory of thin lenses concentrating on the light field at the back focal plane of the lens, Rayleigh developed a theory for the resolution of lenses in terms of superimposed Airy diffraction patterns on the image plane from each point source on the source plane.

(a) Use the point spread functions of Section 7.5.2 to calculate the light field on the image plane from a point source at lateral displacement $\mathbf{x}_S$ for a *finite* lens aperture of diameter D. (This is just the point spread function P_{IS}). You should find that the integral of $\mathbf{x}_L$ over the finite lens aperture is the same as in calculating the Airy pattern for the Fraunhofer diffraction of a circular aperture.

(b) How would you construct the intensity distribution on the image plane from an extended object on the source plane (i) with coherent illumination, (ii) with incoherent illumination. (Note that we assumed coherent illumination in the Abbe theory.)

B. *Longitudinal coherence of light from a sodium lamp*

The orange light from a sodium lamp consists of two lines at wavelengths 589.0nm and 589.6nm. The shorter wavelength line has twice the intensity of the longer wavelength line. The lines are Doppler broadened so that they are Gaussians with full width at half maximum intensity 10^{-3}nm. The sodium lamp is used as the source for a Micehlson interferometer with end-mirrors carefully aligned perpendicular to the beams. Calculate and sketch the visibility of the interference pattern in the output beam as a function of the displacement of one mirror from the position giving equal path lengths for the two beams.

C. Do either of

1. Exercise 8.7 *Complex random processes*

or

2. Exercise 8.9 *Reciprocity relations for locally planar optical device*

D. Do either

1. Exercise 8.5 *Cosmic microwave background radiation*

or

2. Exercise 8.11 *Antireflection coating*