

Astronomical Telescopes and Instruments 2018:  
Exercises on Physical Optics  
(Due on 2 October 2018 at 13:30)

M.A. Kenworth

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## 1 Double-Pinhole Interferometer

- a. Derive the angular intensity pattern  $I(\theta)$  for two small pinholes separated by a distance  $d$ , where  $\theta$  is the angle measured from the normal of the midpoint of the line between the two pinholes. Assume that the pinholes are illuminated by a distant point source and that  $I(0) = I_0$ . Also assume monochromatic light with wavelength  $\lambda$ , and assume that you are in the Fraunhofer limit (i.e. the distance to the fringes is  $\gg d$ ).
- b. What is the angular separation between adjacent fringe peaks?
- c. The Sun is 150 million km away and is 1.4 million km in diameter. How close do the pinholes have to be before you'll see Young's fringes with the Sun? Assume a narrowband filter with  $\lambda_0 = 0.5\mu\text{m}$ .
- d. Sirius is a nearby star, nearly 25 apparent magnitudes fainter than the Sun. *Estimate* the maximum separation of the pinholes using only this fact.

## 2 Coherence Length

- a. The typical time for a dipole electronic transition in an atom is  $10^{-8}$  seconds. What is the coherence length?
- b. The typical coherence time for a gas laser is  $10^{-4}$  seconds. How big an interferometer can I build and still see fringes?

## 3 Far-field Diffraction Pattern of Circular Aperture

Write down the angular far-field diffraction pattern  $I(\theta)$  for a circular aperture radius  $a$  and wavelength  $\lambda$  and verify that the peak intensity  $I_1$  of the first ring in the Airy pattern for far-field diffraction at a circular aperture is such that  $I_1/I(0) = 0.0175$ .

*Hint:* A useful approximation for the first Bessel function is

$$J_1(u) = \frac{u}{2} \left[ 1 - \frac{1}{1!2!}(u/2)^2 + \frac{1}{2!3!}(u/2)^4 - \frac{1}{3!4!}(u/2)^6 + \dots \right]$$