Optics 505

Final Exam

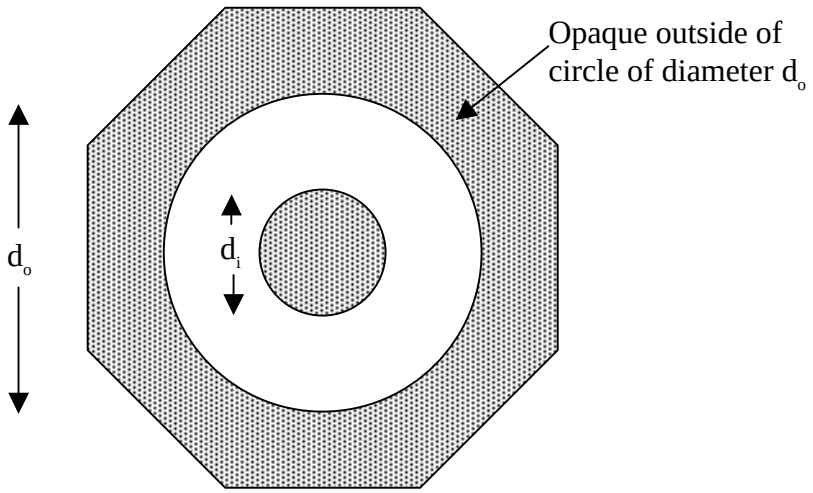
May 13, 1997

2 hour, closed book, no notes, in class, exam

1) (15 Pts) A 633 nm wavelength linearly polarized source is used with a Young's two-pinhole interferometer. The same amount of light is transmitted through each pinhole. A 17.58 micron thick quartz plate is placed over one pinhole where the axes of the quartz plate are at 45 degrees relative to the direction of polarization of the incident light. The indices of refraction for quartz are n_o=1.544 and n_e=1.553. If when the quartz plate is removed the fringe contrast is unity, what is the fringe contrast with the quartz plate in place?

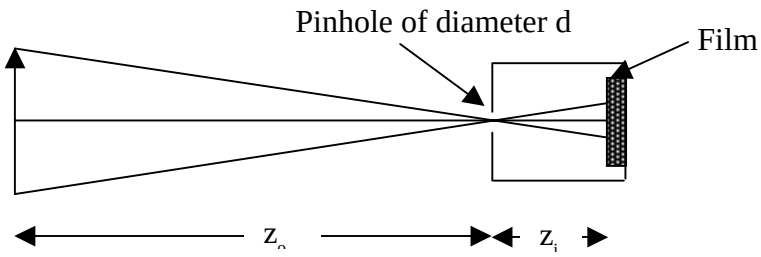
2) (10 Pts) A 1 mm diameter pinhole is placed immediately in front of a spatially incoherent source of average wavelength 550 nm. The light passed by the pinhole is to be used in a diffraction experiment, for which it is desired to illuminate a distant 2 mm diameter aperture coherently. Calculate the minimum distance between the pinhole source and the diffracting aperture. State any assumptions being made.

3) a) (15 Pts) Find an expression for the irradiance distribution in the Fraunhofer diffraction pattern of the aperture shown below. Assume unit-amplitude, normally incident plane-wave illumination of wavelength λ. The diffraction pattern is observed in the focal plane of a lens having focal length f. The aperture is circular and has a circular central obscuration of diameter d_i. The region outside the diameter d_o circular region is opaque.

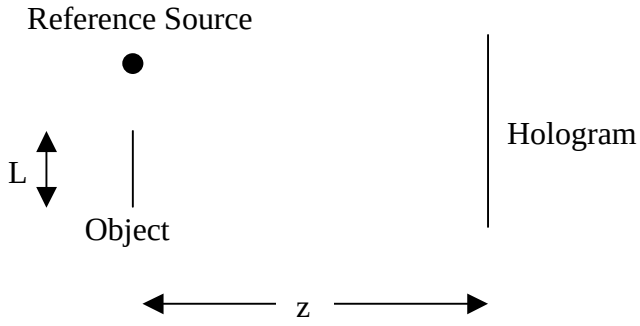


b) (10 Pts) Repeat part a for the situation where the inner circular aperture of diameter d_i is transparent, but introduces a 180 degree phase change to the light transmitted through it.

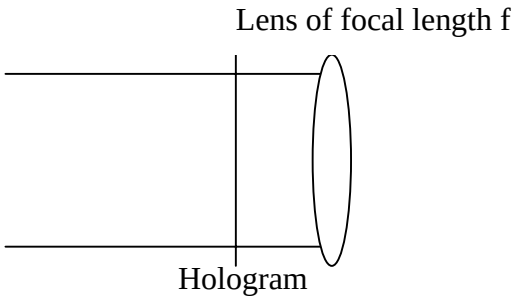
4) Consider the pinhole camera shown below. Assume the object is incoherent and nearly monochromatic, the distance z_o from the object is so large that it can be treated as infinite, and the pinhole is circular with diameter d.
   a) (10 Pts) Under the assumption that the pinhole is large enough to allow a purely geometrical-optics estimation of the point-spread function, find the optical transfer function of this camera. If we define the "cutoff frequency" of the camera to be the frequency where the first zero of the OTF occurs, what is the cutoff frequency under the above geometrical-optics approximation?
   b) (10 Pts) Again calculate the cutoff frequency, but this time assuming that the pinhole is so small that Fraunhofer diffraction by the pinhole governs the shape of the point-spread function.
   c) (5 Pts) Considering the above, estimate the optimum size of the pinhole in terms of the various parameters of the system.



5) A hologram is made by interfering light from a point source and light from a diffuse transparency of width L as shown below. The distance from the object to the recording plane is z. Assume a linear recording process. The reconstruction wavelength is the same as the recording wavelength. The images are obtained by illuminating the hologram with a plane wave, followed by a positive lens of focal length f.
   a) (10 Pts) What are the positions of the two first-order images relative to the lens?
   b) (5 Pts) What is the transverse magnification of the two first-order images?
   c) (10 Pts) How far from the center of the object transparency should the reference point source be placed in order to assure no overlap of the zero-order light with the first-order images?



Hologram Recording



Hologram Reconstruction