Optics 505
Final Exam

May 14, 1998

1) Two plane waves are interfered at an angle of +10 degrees and –10 degrees with respect to the normal to the observation plane. The mean wavelength is 500 nm and the wavelength spread is 5 nm. Assume a uniform distribution across the 5 nm wavelength spread. The optical paths for the two interfering beams are matched at the center of the interference pattern.

   a) (5 Pts) What is the spacing of the interference fringes?

   b) (5 Pts) What is the linear distance in the observation plane (measured perpendicular to the fringes) between the first two zeroes of fringe visibility?

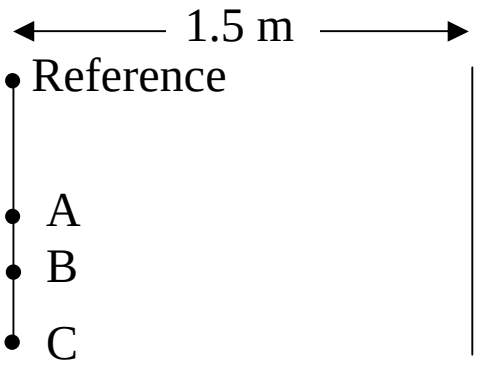
   c) (5 Pts) How does the number of fringes between these two zeroes depend upon the angle between the two interfering beams?

2) A hologram is made of the three point sources located along a straight line as shown below. Assume we have a linear recording material.

   a) (5 Pts) Sketch the image produced by so called "self interference" if points A and B are separated 1 cm and B and C are separated 1.5 cm.

   b) (10 Pts) What is the minimum distance between the reference point source and object A such that the primary image does not overlap the "self interference" image.

   c) (5 Pts) Assume condition b is satisfied and for the reconstruction process the illumination point source is placed 3 meters from the hologram. Sketch the conjugate image showing its position relative to the illuminating source.



3) (10 Pts) What wavefront error is present in an optical system that has an OTF given by

$$OTF[\nu_x] = (\text{Aberration Free MTF})\, e^{i2\pi(\nu x/\nu oo)}$$

where ν_{oo} is a constant?

4) Two telescopes are used to image a star too small to be resolved by either system. One telescope has a circular diameter d = 10 cm and a 150 cm focal length, while the second has a square aperture of width w = 10 cm and a 100 cm focal length. Assume a wavelength of λ = 500 nm.

   a) (5 Pts) Give the distance from central maximum to first zero in the image for both telescopes.

   b) (10 Pts) Give the relative on-axis irradiance for the two telescopes.

   c) (5 Pts) Give the incoherent MTF cutoff frequency for both telescopes. (Do not limit yourself to spatial frequencies along the x and y axes)

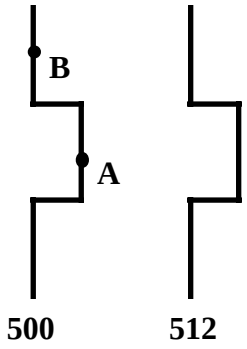
5) a) (5 Pts) A transmission grating having 16,000 lines per inch is 2.5 inches wide. What is the resolving power in the third order if we are operating in the green at a wavelength of about 550 nm? Calculate the minimum resolvable wavelength difference in the second order.

   b) (10 Pts) A diffraction grating has its third and fourth-order spectra overlapping. What wavelength in the third order coincides with the 490 nm line in the fourth order?

6) A FECO interferometer is used to test a nearly flat mirror.

   a) (5 Pts) Sketch the setup showing all important components.

   b) (5 Pts) What is the approximate surface height difference between point A and point B?



7) (10 Pts) Using the Lloyd's mirror arrangement shown below, interference fringes are observed on a screen a distance L = 1 m from the source. Assume the reflectance of the mirror is unity. The source consists of two equally bright point sources incoherent with respect to each other having an average wavelength of 500 nm. If Y_o = 1 cm and the source separation, Δy, is 1 mm, what is the smallest value of Y in the observation plane for zero contrast of the interference fringes.