ECE 181

DIFFRACTION

I. OBJECTIVES

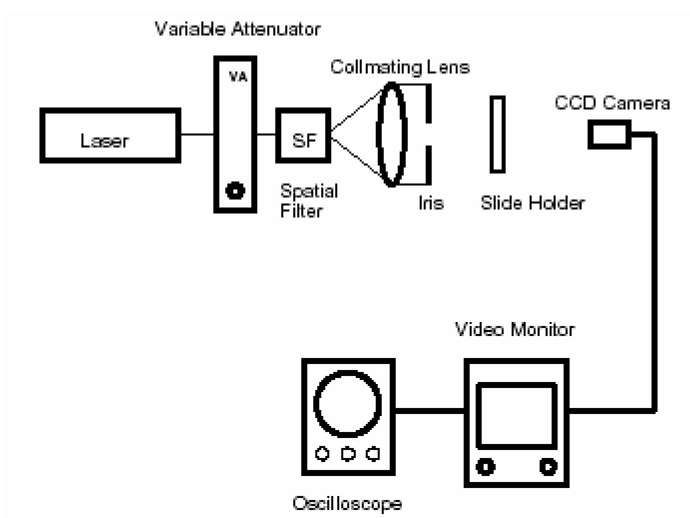
To study free-space diffraction patterns generated by the following input patterns: (a) a single slit, (b) a double slit, (c) a periodic diffraction grating, and (d) a Fresnel zone plate.

II. REFERENCES

B. Saleh and M. Teich, Fundamentals of Photonics, Ch. 4, pp. 111-121, 127-128, 131-134.

III. EXPERIMENTAL SETUP DESCRIPTION

In the Lab you will find an optical system for generation and recording diffraction patterns (see figure below). The system starts with a HeNe laser, followed by a variable attenuator for controlling the intensity sent through the rest of the system. The next component is a spatial filter assembly that expands the laser beam, followed by a collimating lens to form the plane wave used for illuminating the objects. An iris is placed after the lens to control the size of the beam. Next is a slide holder; 35mm format object slides are placed in this mount. (Also variable air slit will be used as an object.)
Further down the optical table is an observation system. A CCD camera and a monitor allow real-time viewing of the optical image. The video output is also connected to an oscilloscope, which displays an intensity cross-section of the diffraction patterns. The camera output has a conversion factor of 6.25μs/mm, and this will be used to quantify physical dimensions of the objects.



IV. EXPERIMENTS

When performing the experiment, always make sure to sketch the optical system in your notebook, labeling all components clearly and make sure to note all of the important measurements and distances.

A. Single slit

(a) Replace the slide holder with variable air-slit unit and place it R=70cm away from the camera.
(b) Adjust the attenuator for best signal strength without camera saturation.
(c) Observe and sketch the diffraction pattern seen on the monitor. A sinc^2 intensity pattern should be displayed on the oscilloscope.
(c) Using the camera's time-distance conversion, measure the distance D between the two minima on either side of the center lobe. Then calculate the diffraction angle θ using $tg\theta = D/2R$.
(d) Calculate the single slit width S using $S = \lambda/\sin\theta$, where $\lambda = 0.633\mu m$.
(e) Repeat measurement and calculation for another slit width.

B. Double slit

(a) Set the attenuator for minimum intensity transmission.
(b) Replace the variable air-slit with the slide holder and place a slide containing a multiple double slits into the slide holder.
(b) The double slit slide contains 5 sets of double slits, with each set having a different separation distance A. The iris must therefore be adjusted so that only *one* double slit set is illuminated at a time.
(c) Place the double slit slide R=70cm away from the camera. Adjust the attenuator for best signal strength without camera saturation. Choose one double slit set. Observe and sketch the diffraction pattern seen on the monitor. A periodic sinusoidal pattern should be displayed on the oscilloscope.
(c) Using the camera's time-distance conversion, measure the period P of the pattern. Calculate the angle θ using $tg\theta = P/2R$.
(d) Calculate the double slit separation A using $A = \lambda/2\sin\theta$
(e) Repeat measurement and find slit separation for another double slit.

C. Diffraction grating

(a) Set the attenuator for minimum intensity transmission.
(b) Set the iris for the smallest beam size possible.
(c) Replace the slits slide with the one-dimensional periodic grating. Place the grating R=70cm away from the camera. Adjust the attenuator for best signal strength without camera saturation.
(d) Observe and sketch the diffraction pattern seen on the monitor. The intensity lobes for the -1, 0, and +1 orders of the grating should be displayed on the oscilloscope.
(e) Measure the distance between the -1 and +1 orders, and calculate the diffraction angle θ.
(f) Calculate the grating period Λ using $\Lambda = \lambda/\sin\theta$.

D. Fresnel Zone Plate

(a) Cap the camera, turn off the video monitoring system and oscilloscope.
(b) Place the slide containing the Fresnel Zone Plate into the slide holder. Adjust the iris size to illuminate the zone plate only.
(d) Using a card, trace the resulting beam propagation along the optical axis, starting from the far end of the optical table and working towards the slide. Locate the primary focal point of the zone plate and record the focal distance F.
(e) Locate the positions F/2, F/3, F/4, and F/5. Are there focal points at all these locations? If there are, compare their intensities to that of the primary focal point.