Microwave Optics II

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1 Abstract

In previous experiments, the wavelength of microwave light has been calculated from a standing wave pattern. In this experiment, it is conformed that the light that has a wavelength of a few centimeters shows diffraction and interference phenomena as other spectrums of electromagnetic waves.

2 Theory

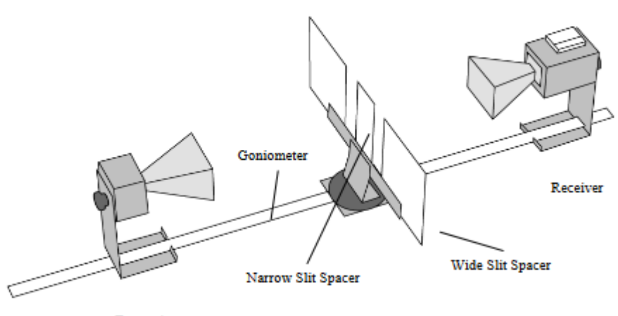
In the previous diffraction experiment report[1] it has been shown that the intensity at a point P on the observing screen to be

$$I = 4I_0(\frac{\sin\beta}{\beta})^2 \cos\alpha^2 \tag{1}$$

Where $\beta = \frac{1}{2}kb\sin\theta$ and $\alpha = \frac{1}{2}ka\sin\theta$. And from this equation it is already proven that the maximum intensity values occur whenever

$$d\sin\theta = (n+1)\frac{\lambda}{2} \tag{2}$$

Main components of this experiments are the microwave transmitter unit and a microwave receiver unit and they placed horizontally. For the first part of the experiment, between two of them two plates are placed to create two wide slits in order to create diffraction (see the figure below).



In the second part of the experiment, a wooden plate that serves as a partial reflector is placed in front of the transmitter unit and the receiver is placed behind the transmitter to prevent the interference effect of the transmitter. In this part, the amplitude of the transmitted light is divided by the wooden reflector and reflected back. The second half of the light propagates further and is reflected from the metal reflector. By changing the position of the wooden reflector, the optical path difference between the waves, the interference pattern is observed. This is basically the same principle of the Michelson Interferemonter, which was investigated before this experiment[2]. The irradiance of the interference of two light sources, in this case, can be expressed as follows

$$I = I_1 + I_2 + \epsilon v(\vec{E_1}\vec{E_2}) \cos \Delta\phi \tag{3}$$

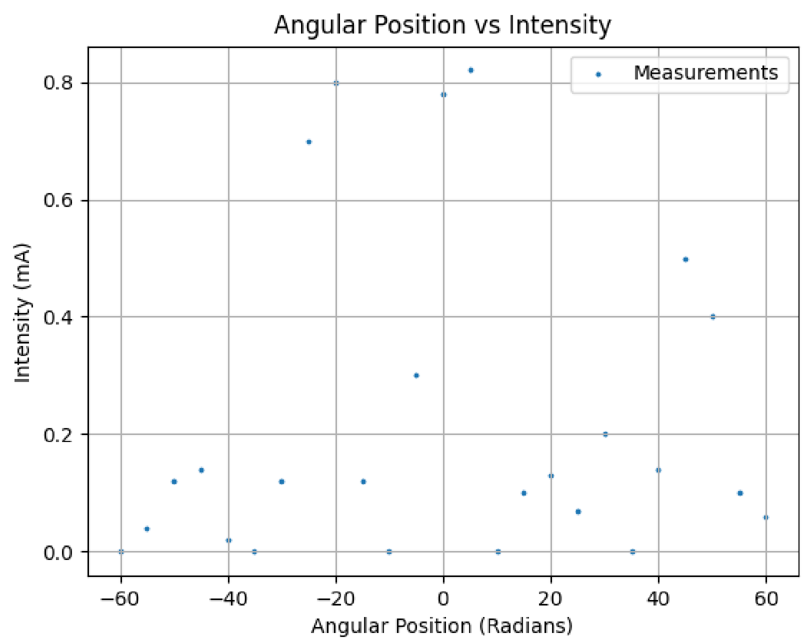
$$\Delta\phi = 2\pi \frac{d}{\lambda/n} = 2\frac{d}{\lambda} \tag{4}$$

Where $\Delta\phi$ is the phase difference between the light sources, d is the travel distance of the mirror with respect to its original position.

3 Results

3.1 Part A

Angle	Clockwise Intensity Readings (mA)	Counterclockwise Intensity Reading (mA)
0°	0.78	0.78
5°	0.82	0.3
10°	0	0
15°	0.1	0.12
20°	0.38	0.8
25°	0.22	0.7
30°	0.2	0.12
35°	0	0
40°	0.14	0.02
45°	0.5	0.14
50°	0.4	0.12
55°	0.1	0.04
60°	0.06	0



The expected minima and maxima from the eq.2 is the following: $28.68°, 46.05°$

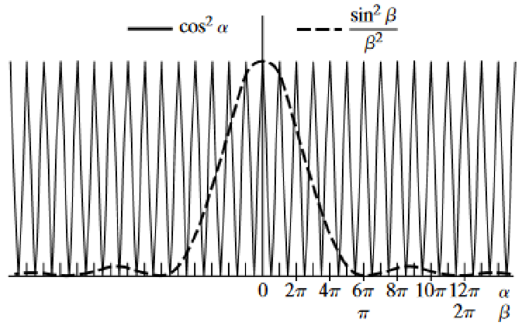
3.2 Part B

Reflector Position(cm)	96.9	98.3	99.7	101.1	102.6	104.1

The distance between maximum intensities are on average $\bar{y} = 1.4cm$ and the wavelength of the light that transmitter emits is $\lambda = 2.88cm$. This is nearly half of the wavelength and it is what has been expected by the optical path difference equation (eq.3).

4 Discussion

From the formula for intensity at a point for double-slit diffraction (eq.1), one can see that the sinc function in the equation decreases quickly as angular position advances, this can be seen from the figure below. Deriving this equation a few assumptions were made such as *far-field* diffraction and the small-angle approximation. These assumptions do not affect the results since the uncertainties are high relative to the assumptions. In part A the results were in agreement with two expected maximum values. In part B the results are on average half of the wavelength. So in both parts, the results were in agreement with the equations that have been driven in the last two reports.



5 References

1-Andırınlıoğlu,Serdar (2021), Diffraction and Grating Experiment Report
2- Hecht, Eugene (2002). Optics. Addison-Wesley. ISBN 978-0-321-18878-6.