The Fresnel Bisprism

Abstract

The Fresnel Biprism variation of young’s double slit experiment was used to calculate a value for the wavelength of light emitted by a sodium lamp. This was found to be$7.3839x10^{-7}\pm 1.0688x10^{-8}m$. However the variation of the value attained from the generally accepted values of sodium’s prominent spectral lines; 5.889950$x10^{-7}$ m and 5.895924$x10^{-7}$m, was beyond the margin of error calculated.

Introduction and Theory

This experiment aims to attain a value for the wavelength of light by means of a Fresnel Biprism. This method attains a value for the wavelength of light emitted by a sodium lamp with more accuracy then would be attained via Young’s double slit experiments. The interference pattern in this experiment is created by two virtual images of the same source. This increases the quality of the pattern produced because the glass biprism is not subject to the same degree of physical inconsistency as two parallel slits.

In Young’s slits experiment , the separation of fringes, s, is given by $s=\frac{λD}{d}$, where $λ$ is the wavelength of light used, d is the separation of the parallel slits and D is the distance from the slits to the projected image. For the Fresnel variation, the separation of slits cannot be measured as the interference is produced by two coherent virtual images instead. Instead d is determined by placing a lens between the biprism and the micrometer eyepiece. For the two values of D for which real images of the virtual slits are formed, two values of d; d­1 and d2 , can be measured on the micrometer scale. d is then given by$ d=(d\_{1}d\_{2})^{\frac{1}{2}}$.

Experimental Method

The aim of the experiment was to attain a value for the wavelength of sodium lamp by measuring s, d­1 and d2 in the biprism system.

The sodium lamp was encased in a metal casing and an adjustable slit was placed in front of the lamp along an optical bench. The biprism was placed 0.125m in front of the slit. The edge of the biprism was ensured to be parallel with the slit by rotating the biprism. The eyepiece was placed close to the birprism along the bench and the fringe pattern was located through the eyepiece. The eyepiece was then moved to a distance of 1.1m from the slit.

The lens was placed on the optical bench between the eyepiece and the biprism. A white sheet of paper was used as a screen directly at the eyepiece and it was ensured that there were two positions of the lens along the bench for which sharp images appear on the screen.

The lens was removed from the bench for the measurements of s. The distance across twenty fringes was measured with the eye piece and an average value for s was taken. This was repeated twice more.

The lens was replaced on the bench and moved to the positions for which sharp images were projected into the eyepiece. For both positions of the lens at which a sharp image was projected, the distance between the two virtual images was measured using the eyepiece. The value of d was then calculated from the equation $d=(d\_{1}d\_{2})^{\frac{1}{2}}$.

Results and Analysis

The first value of the separation of fringes,$s\_{1}$, was calculated to be 2.61$x10^{-4}$m. s2 and s3­ were calculated to be 2.84$x10^{-4}$m and 2.835$x10^{-4}$m, respectively. Hence s was calculated to be the average of these three values, 2.7617$x10^{-4}$m.

$d\_{1} and d\_{2}$ were found to be 1$x10^{-3}$m and 8.65$x10^{-3}$m. From the equation $d=(d\_{1}d\_{2})^{\frac{1}{2}}$, d was found to be 2.9412$x10^{-3}$m. D was 1.1m.

All values of distance along the optical bench were subject to an error of ±0.002m and when counting fringes the measurements were subject to a human error of ±1 fringe and 0.1x10-3m.The measurements of $d\_{1} and d\_{2}$ were subject to an error margin of ±0.02 x10-3m.

The margin of error for the first value obtained for s was calculated from the Gauss’ Error laws as follows:

$$∆s\_{1}=\frac{5.22x10^{-3}}{20}\left(\left(\frac{0.1x10^{-3}}{5.22x10^{-3}}\right)^{2}+\left(\frac{1}{20}\right)^{2}\right)=1.3975x10^{-5}m$$

And similarly Δs2 and Δs3­ were calculated and found to be 1.5031$x10^{-5}m$ and $1.055x10^{-5}m, respectively.$ From these values, the error in the final averaged value of s was calculated:

$$Δs=\frac{1}{3}(\left(2.7950x10^{-4}\right)^{2}+\left(3.0062x10^{-4}\right)^{2}+\left(3.0109x10^{-4}\right)^{2})^{\frac{1}{2}}=2.8282 x10^{-6}m$$

The error in d was calculated:

$$∆d=\left(\left(1x10^{-3}\right)\left(8.65x10^{-3}\right)\right)^{\frac{1}{2}}\left(\frac{1}{2}\right)\sqrt{(\frac{0.02x10^{-3}}{1x10^{-3}})^{2}+(\frac{0.02x10^{-3}}{8.65x10^{-3}})^{2}}=2.9607x10^{-5}m$$

Using these margins of error and the previously calculated value of λ, the error in the value λ was calculated:

$$∆λ=7.3839x10^{-7}\sqrt{\left(\frac{2.9607x10^{-5}}{\left(\left(1x10^{-3}\right)\left(8.65x10^{-3}\right)\right)^{\frac{1}{2}}}\right)^{2}+\left(\frac{2.8282 x10^{-6}}{2.7617x10^{-4}}\right)^{2}+\left(\frac{2x10^{-3}}{1.1}\right)^{2}}=1.0688x10^{-8}m$$

Discussion and Conclusions

The value attained for the wavelength of sodium light $7.3839x10^{-7}\pm 1.0688x10^{-8}m$ varied from the accepted value of the most prominent spectral lines 5.889950$x10^{-7}$ m and 5.895924$x10^{-7}$m beyond the margin of error calculated. This could be contributed to human error in measuring the number of fringes in the interference pattern when finding average values of s. It could also have been the result of a systematic error in the recording of results.