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**Report Sheet for Experiment 13: Measuring speed of light**

Abstract

In this experiment, the concept of infraction between media and total internal refraction is applied in a fiber optic wires to calculate the speed of light. Fiber optic with different lengths were used to measure the difference in time light use to enter and pass through each wire. Speed of light is calculated from the difference in both wires’ length and the corresponding time difference. Experiment shows that the calculated speed of light is 3.32x108 m/s, a 10.76% higher than the theoretical value. This error is more likely to come from the imprecise and rough scale of the time of the oscilloscope rather than the uncareful measurement of the fiber optic wires’ lengths. It is suggested that more trials with longer fiber optics is recommended in future experiments.

Introduction and Theoretical Background

When light moves in other medium except vacuum, the speed of light is changed. The speed of light in any optical material is determined by refractive index (n)  where c = 3 x 108 m/s, is the speed of light in the vacuum and v is the speed of light in the interested medium.

Furthermore, when light moves between media with different refractive index, the ray bends from the incident ray referred to the normal line which can be described by Snell’s law as follow:

At a special case, when the refracted angle is perfectly 90 Degrees, the incident angle is called the critical angle. The occurred total reflection can be used to send information as light pulses through fiber optics lines its structure is a core with higher refractive index within a cladding material with lower value. With the length of path difference and time dilation are observed from the oscilloscope, the speed of light can be determined.

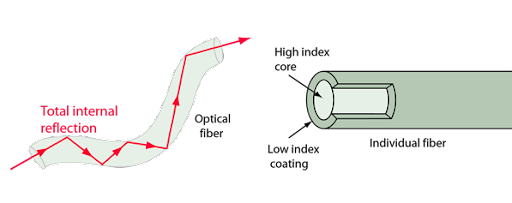


Figure 1 depicts the Fiber Optic wire components and its total reflection

Methods

1. Set the equipment as shown in the figure 2
2. Connect the transmitter device with the power supply change check the reference signals
3. Connect short fiber optic and observer the reference and delay pulse shape
4. Change to long fiber optic and repeat step 3
5. Measure the time dilation and calculate the path difference

A picture containing text, electronics, adapter

Description automatically generated

Figure 2 depicts the experiment set-up

Results

A screenshot of a computer

Description automatically generated with medium confidenceA screenshot of a computer

Description automatically generated with medium confidence

Figure 3 depicts the wave from the oscilloscope of (a) reference(yellow) and with short fiber optic(blue) and (b) reference(yellow) and with long fiber optic(blue)

|  |  |
| --- | --- |
| data | value |
| infractive index | 1.495 |
| Short fiber optic length (m) | 0.215 |
| Diameter of long fiber optic (m) | 0.175 |
| Number of windings in long fiber optic | 29.5 |
| path difference (m) | 16.00 |
| time difference (s) | 7.20E-08 |
| calculated speed (m/s) | 3.32E+08 |
| c (m/s) | 3.00E+08 |
| %error (%) | 10.76 |

Table 1 summarizes parameters used in the experiments

The calculation of information shown in Table 1 can be demonstrated as follows:

* Length of long fiber optic = = 16.218 m
* Path difference = 16.218 – 0.215 = 16.003 m
* Calculated speed = (16.003 m)/ (7.2x10-8 s) = 3.32x108 m/s
* %error = = 10.76%

Discussion

According to the experiment, the calculated speed of light is 3.32x108 m/s, a 10.76% higher than the theoretical value. The error might be contributed from two sources: the inaccurate length measurement, and the resolution of the oscilloscope. First, the use of average diameter is too rough and will lead to imprecise value of speed. For example, a 0.05 m change in the length(which is might be the smallest scale on the measurement device) will cause the error from 10.76% to 10.42%. On the second issue, the discrete scale on the display might not be small enough to precisely measure the time difference. For instance, of a given 4 nanosecond time resolution given in the data file, the error will dramatically shift to 4.94% by using the time dilation of 68 nanosecond instead. This can be primarily solved by using longer fiber optics abd repeat few more trials. Both expected data if the measurement values are shifted by 1 scale of each device(ruler/oscilloscope) is summarized in below.

|  |  |  |  |
| --- | --- | --- | --- |
| data | Experimental | Length Issue | Time issue |
| infractive index | 1.495 | 1.495 | 1.495 |
| path difference (m) | 16.00 | 15.95 | 16.00 |
| time difference (s) | 7.20E-08 | 7.20E-08 | 7.60E-08 |
| calculated speed (m/s) | 3.32E+08 | 3.31E+08 | 3.15E+08 |
| c (m/s) | 3.00E+08 | 3.00E+08 | 3.00E+08 |
| %error | 10.76 | 10.42 | 4.94 |

Table 2 summarizes expected results if the measured values were to be changed by 1 scale of measurement

Conclusion

In conclusion, the concept of infraction between media and total internal refraction is applied in a fiber optic wires to calculate the speed of light. Fiber optic with different lengths were used to measure the difference in time light use to enter and pass through each wire. Speed of light is calculated from the difference in both wires’ length and the corresponding time difference. Experiment shows that the calculated speed of light is 3.32x108 m/s, a 10.76% higher than the theoretical value. This error is more likely to come from the imprecise and rough scale of the time of the oscilloscope rather than the uncareful measurement of the fiber optic wires’ lengths. It is suggested that more trials with longer fiber optics is recommended in future experiments.

Reference

1. Lab manual titled “**Ch10.** **Measuring the earths magnetic field”**from Department of Physics on KLMS
2. Fiber Optics. (n.d.). Retrieved November 29, 2021, from http://hyperphysics.phy-astr.gsu.edu/hbase/optmod/fibopt.html.