Lab Report: Speed of light

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1. Deriving the speed of light from Maxwell‘s equations

The speed of light as a fundamental constant can be derived from Maxwell‘s equations [1]

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}, \quad \nabla \times \mathbf{B} = \mu_{\text{abs}} \epsilon_{\text{abs}} \frac{\partial \mathbf{E}}{\partial t}. \tag{1}$$

where μ_{abs} and ϵ_{abs} are the absolute permeability and permittivity of the medium. They can be related to the relative and vacuum constant for each size like

$$\epsilon_{\text{abs}} = \varepsilon \varepsilon_0, \tag{2}$$

$$\mu_{\text{abs}} = \mu_r \mu_0. \tag{3}$$

In these equations ε_0 is called the vacuum permittivity and ε is a medium-specific *relative permittivity*. In a similar fashion, μ_0 is the vacuum permeability and μ_r the *relative permeability*.

By taking the first time derivative of either equation and plugging the result into the other, one can get a wave equation after the double curl has been reduced to a laplace operator. From the wave equation a speed of light of

$$c = \frac{1}{\sqrt{\varepsilon \varepsilon_0 \mu_0 \mu_r}}. \tag{4}$$

Since ε_0 and μ_0 are physical constants they can be measured and their values are well known to be [2, 3]

$$\varepsilon_0 = 8.854 \times 10^{-12}\,\mathrm{Fm^{-1}}, \quad \mu_0 = 1.256 \times 10^{-6}\,\mathrm{NA^{-2}}. \tag{5}$$

With the relative permeability and relative permittivity of a medium we can define the refractive index

$$n = \sqrt{\varepsilon \mu_r}.$$

n depends, like μ_r, on the frequency of the light because of dispersion.

II. PROCEDURE

III. RESULTS

IV. DISCUSSION

V. CONCLUSION

[1] D. J. Griffiths, *Introduction to electrodynamics; 4th ed.* (Pearson, Boston, MA, 2013) re-published by Cambridge University Press in 2017.
[2] N. I. of Standarts and Technology, Codata value: vacuum magnetic permeability (2022).
[3] N. I. of Standarts and Technology, Codata value: vacuum electric permittivity (2022).

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