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If the Speed of Light is Constant, Then Light is a Wave

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Abstract: In this short note we mathematically prove that if we assume that the speed of light is constant, then light propagates as a wave.

Introduction: In another paper, "What is the Matter With De Broglie Waves?" we derived the De Broglie equations for 'wavelength' λ and 'frequency' ν using the 'prime physis' quantity η and the definitions of energy, $E = \dfrac{\partial \eta}{\partial t}$ and momentum $p_x = \dfrac{\partial \eta}{\partial x}$ in terms of η. We showed that,

$$\lambda = \frac{h}{\partial \eta / \partial x}$$

$$\nu = \frac{\partial \eta / \partial t}{h}$$

and $$\lambda \nu = \frac{dx}{dt} = \text{v}$$, the velocity of 'propagation of η '

Assume that $\lambda \nu = c$, a constant. Then $D_t(\lambda \nu) = 0$ and also $D_x(\lambda \nu) = 0$. Using the above, we have

$$D_t(\lambda \nu) = \frac{\dfrac{\partial^2 \eta}{\partial t \partial t} \cdot \dfrac{\partial \eta}{\partial x} - \dfrac{\partial^2 \eta}{\partial t \partial x} \cdot \dfrac{\partial \eta}{\partial t}}{\left(\dfrac{\partial \eta}{\partial x}\right)^2} = 0$$

and $$D_x(\lambda \nu) = \frac{\dfrac{\partial^2 \eta}{\partial x \partial t} \cdot \dfrac{\partial \eta}{\partial x} - \dfrac{\partial^2 \eta}{\partial x \partial x} \cdot \dfrac{\partial \eta}{\partial t}}{\left(\dfrac{\partial \eta}{\partial x}\right)^2} = 0$$

Thus,

$$\frac{\partial^2 \eta}{\partial t^2} \cdot \frac{\partial \eta}{\partial x} = \frac{\partial \eta}{\partial t} \cdot \frac{\partial^2 \eta}{\partial t \partial x}$$

and $$\frac{\partial^2 \eta}{\partial x \partial t} \cdot \frac{\partial \eta}{\partial x} = \frac{\partial \eta}{\partial t} \cdot \frac{\partial^2 \eta}{\partial x^2}$$

Dividing these by $\frac{\partial \eta}{\partial x}$ and using our assumption that $\frac{dx}{dt} = c$, we get

$$\frac{\partial^2 \eta}{\partial t^2} = c \frac{\partial^2 \eta}{\partial t \partial x} \quad \text{and} \quad \frac{\partial^2 \eta}{\partial x \partial t} = c \frac{\partial^2 \eta}{\partial x^2}$$

Combining these, we get

$$\textit{The Wave Equation:} \frac{\partial^2 \eta}{\partial t^2} = c^2 \frac{\partial^2 \eta}{\partial x^2}$$

Thus, if the speed of 'propagation of η ' is constant, then η must satisfy the wave equation.

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