Fundamentals of Electric Theory and Circuits

by

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The speed and wavelength of light waves in glass and prisms.

White light is incident on a prism. The light is a mixture of it's constituent colours red…….violet of frequency, wavelength and speed $f_{\text{red(free space)}}$, $\lambda_{\text{red(free space)}}$, c……..$f_{\text{violet(free space)}}$, $\lambda_{\text{violet(free space)}}$,$c$.

The frequency, speed and wavelength of the constituent colours inside the prism whose crests (of the sinewaves) advance with speed v and the frequency, speed and wavelength of the constituent colours on emerging from it are indicated in the table.

Table

Incident light	**A mixture of** $f_{\text{red(free space)}}$, $\lambda_{\text{red(free space)}}$, c……..$f_{\text{violet(free space)}}$, $\lambda_{\text{violet(free space)}}$,$c$
Inside the prism	**Splits into sinewaves (of constituent colours) whose crests advance with speed (called phase-speed) *v**. (See** https://brucesherwood.net/?p=95) $f_{\text{red(free space)}}$, $\lambda_{\text{red(inside prism)}} < \lambda_{\text{red(free space)}}$, $v_{\text{(red)}} < c$ • • • • $f_{\text{violet(free space)}}$, $\lambda_{\text{violet(inside prism)}} < \lambda_{\text{violet(free space)}}$, $v_{\text{(violet)}} < c$
On emerging from prism	**Remains split into constituent colours** $f_{\text{red(free space)}}$, $\lambda_{\text{red(free space)}} > \lambda_{\text{red(inside prism)}}$, c • •

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$f_{\text{violet(free space)}}$, $\lambda_{\text{violet(free space)}} > \lambda_{\text{violet(inside prism)}}$, c

* *'v'* is the speed with which a *wave crest* of a steady-state sine wave advances in the glass. This is the so-called "phase speed", which in glass is smaller than 3×10^8 m/s.

Prof. Sherwood describes the slowing down of light in glass thus

In a microscopic but otherwise classical analysis, the electric field in electromagnetic radiation accelerates electrons held by springs in the atoms of a piece of glass, and these accelerated electrons re-radiate in all directions. The observed light is the superposition of the electric (and magnetic) fields of the incoming light and the re-radiation. Full quantitative analysis from a microscopic point of view requires a kind of self-consistent calculation, because the re-radiation from accelerated electrons contributes to the net electric field driving the electrons. Feynman deals with the low-density limit in which re-radiation of re-radiation is negligible, but this is adequate to understand the essential aspects of the phenomena. In the backward direction we normally call the re-radiation "reflection," but this labeling obscures the fact that this is new light radiated by all the atoms in the glass, not old light that has magically "bounced off" the front surface due to some unknown mechanism. The microscopic analysis of "reflection" is exactly the same as the analysis of x-ray diffraction, but because the inter-atomic spacing is small compared to the wavelength of visible light, the "reflected" light has just one, zeroth-order interference maximum in the "reflection" direction (n = 0 in the Bragg "reflection" condition).

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However, the apparent "slower speed" is the result of the superposition of two radiative electric fields, the incoming radiation and the re-radiation, both of which travel at the normal speed of light *c*. If taken too seriously, it is a violation of the superposition principle to say that the speed of light is affected by the presence of matter. The incoming radiation was produced by some accelerated charges, and the field that those charges produced is unaffected by the presence of other charges anywhere in the universe, and this field propagates at speed *c*. In particular, incoming radiation passes through glass unchanged, but downstream we observe the superposition of this unchanged radiation with re-radiation from the accelerated electrons in the glass. The leading edge of radiation may travel at a speed smaller than *c*, but only through the superposition of the contributions of accelerated charges that make radiative fields that propagate at speed *c*.

Read the full article here https://brucesherwood.net/wp-content/uploads/2017/06/Refraction.pdf.

The speed of propagation of light '*c*' is everywhere and always 3×10^8 m/s.