Fizeau's Experiment as Evidence for Special Relativity

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Einstein's Special Theory of Relativity stands or falls on its ability to explain phenomena that are unexplainable by any other means. No causation is offered for SR, it's regarded as a fundamental property of the universe, observable and verifiable through those phenomena. It follows that if any of those phenomena have other, more mundane, explanations then they can't be considered as demonstrating or confirming SR. If (as can be shown) ***all*** of those phenomena have clear explanations in terms of mechanistic effects then there is ***no*** evidence to support the Special Theory of Relativity.

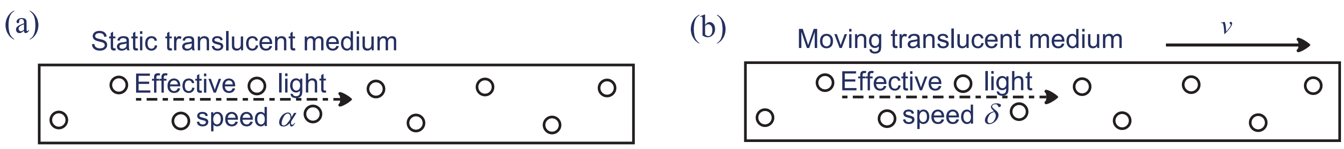
One of the effects regarded by Einstein as highly significant was the speed of light passing along a tube of water running in the same (or opposite) direction. Since the 1800s physicists had puzzled over the fact that in such a situation light travelled faster (or slower) than through still water, but the effect was not simply additive. The French physicist Fizeau had experimentally derived the expression: $\delta = \alpha + v\,(1 - \alpha^2)$, where α and δ are the speed of light through still and moving water respectively and v is the speed of the water, all as fractions of full light speed c (v is negative, of course, if the two motions are in opposite directions).

The science of the time offered no explanation, however Einstein's new Theory covered the situation very effectively. It proposed that light did indeed travel at speed α relative to the water (which is moving at speed v) – but that addition of velocities in a relativistic universe follows a more complex formula. That formula, as derived from the principles of SR, matches very closely the expression derived by Fizeau from the results of his experiments.

It's now known that light travels at its full speed, c, through a translucent medium, but that its passage through that medium is delayed by deflection off the atoms of the medium, giving a component of light flow transverse to its primary direction of motion.[1] The overall direction of flow broadly balances out to give a diffused flow in the original direction.

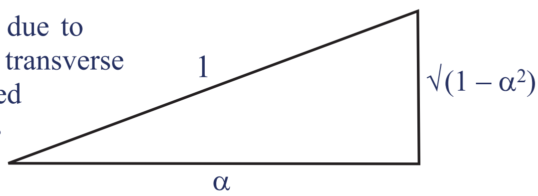
If light is passing through water moving in the same direction then the atoms in the water are 'running away' from the light source; this means that the photons of light will encounter those atoms less frequently and thus incur a smaller 'overhead' of transverse motion component – they will be slowed to a lesser degree.

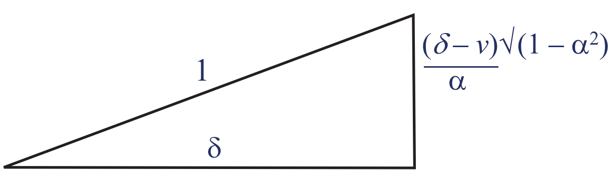
If we simply regard the average transverse component as proportional to frequency of encounters of the light with atoms, the resulting expression turns out to be almost identical to both Fizeau's and Einstein's formulae – midway between the two, in fact. Numerical results match both formulae even for extremely high speeds of water flow – to at least ten, and more often fifteen, places of decimals. This from simple particle considerations, without reference to SR.



Light passing through: (a) a static medium; (b) a medium moving at speed v. The effective speed of the light through the medium in case (a) is α , in case (b) it's δ. From the static observer's perspective the speed by which the light-flow exceeds that of the atoms of the medium will be: α in case (a); $\delta - v$ in case (b). So the frequency of interactions between light and atoms in case (b) will be $\dfrac{\delta - v}{\alpha}$ times the frequency of light-atom interactions in case (a).

Known science tells us that the slowing of light in such a medium is due to interaction between the light and the atoms of the medium, introducing a transverse component into the light-flow. If full light speed is taken as 1 and reduced linear speed as α (both as fractions of full light speed c), then Pythagoras tells us that the transverse component must average $\sqrt{(1 - \alpha^2)}$.





If, as seems logical, the average transverse component varies in proportion to the frequency of light-atom encounters, when the effective light speed is δ that component is $\dfrac{(\delta - v)\sqrt{(1 - \alpha^2)}}{\alpha}$ as shown on the left.

Using Pythagoras' Theorem, this triangle yields a quadratic equation with solution: $\delta = v\,(1 - \alpha^2) + \alpha\sqrt{[1 - v^2(1 - \alpha^2)]}$

If v is significantly less than 1 (*i.e.* light speed), neglecting terms in v^2 gives us: $\delta = \alpha + v\,(1 - \alpha^2)$, which is precisely the formula derived by Fizeau and also corresponds to Einstein's formula to an extremely high degree of accuracy.

We thus have a precise match to all experimental results, with no reference whatever to principles of Special Relativity.

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1. There is also an element of brief absorption by those atoms, followed by re-emission; energy internalised within an atom is regarded mathematically as orthogonal (transverse) to linear motion (check out 'relativistic energy-momentum relation') – so the slowing of light through water is wholly due to a transverse component in the light's motion.