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The Fresnel Formula Applied to Empty Space

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Abstract

Scalar field theories require the refractive index of empty space to diverge from unity. First-order divergence is analyzed using the Fresnel formula. There is no divergence for an observer in linear motion with the space frame.

Lindén (1972) has noted that the most serious objection to scalar theories of gravitation is the inability to predict light deflection correctly. Lindén also notes "It is a simple matter to show that the speed of light must be proportional to 1 minus twice the magnitude of Newtonian potential in order that an application of Fermat's principle should give a result agreeing with the prediction of general relativity."

Linden goes on to show that a test for the hypothesis that the speed of light is variable in dependence upon the gravitational field requires measurement of a variation of $\frac{2}{3}$ parts in 10^9 in the course of the earth's annual motion, whereas modern technology allows such measurement only to 1 part in 10^8.

The concept that the free space medium may have, as it were, an index of refraction will be taken as a serious proposition. Rather than addressing the effects of a gravitational field upon the refractive index, however, we will analyze the first-order consequences of this proposition upon the null result of the Michelson-Morley experiment.

If an element of free space is assigned an index of refraction n that departs from unity then we may wonder whether the Fresnel formula as applied to the speed of light in moving media may also be applied to a free space in which there is "movement." This introduces the notion that space may have its own structure but that when this structure is moving the element of space to which it belongs has no overall momentum. Making an analogy with matter, the light propagation velocity c_1 as seen by an observer relatively at rest may be proportional to $\sqrt{P/\rho}$, where P is a pressure modulus and ρ is mass density. n is then c/c_1. Thus n^2 is proportional to density. For zero overall momentum any movement of structure seen by the observer will be balanced by counter flow of something associated with space. Thus for density ρ we may find that $\rho(1 - k)$ moves at velocity v with the structure and ρk moves at velocity u, where

$$uk + v(1 - k) = 0$$

Evidently, since $n = 1$ when $k = 0$

$$n^2 = 1 - k$$

From these two equations we have

$$v = u(1 - 1/n^2)$$

Now it was Fresnel's achievement to show that the effect of matter moving at velocity u was to augment the speed of light relative to the observer at rest by exactly this amount, n being the refractive index in the presence of the disturbing medium. It is then most interesting to note that in the absence of matter this same formula leads to the startlingly simple result that light merely travels at a velocity augmented by the velocity v of the structure. Relative to this space structure the speed of light is constant. This is exactly the result found by Michelson and Morley.

If future technology verifies that the speed of light does vary in free space and so gives impetus to scalar theories of gravitation one facet of the above result is worth pursuing. It is noteworthy that linear momentum of the space medium is conserved and is zero, but if rotation is considered the structured space medium could exhibit an angular momentum exchange with matter. This is because uniformity of the density ρ is a fundamental consideration and linear motion could not occur without a reverse flow. For rotation of a spherical segment of space there is a conserved density even without counterflow. Much depends upon the magnitude of the density. If it is finite then this raises the question of whether a planet may exchange angular momentum with the space it occupies and so contribute to the perihelion anomaly.

Furthermore, cosmologically the exchange of energy between a star during its formation and the space medium could be of special significance, and we additionally have an approach to understanding the finite nature of the angular momentum of the solar system. These considerations are beyond the scope of this paper and will be reported separately.

Reference

Lindén, T. L. J. (1972). *International Journal of Theoretical Physics*, **5**, 359–368.