An Absolute Space Interpretation (with Non-Zero Photon Mass) of the Non-Null Results of Michelson-Morley and Similar Experiments: An Extension of Vigier s Proposal

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It is argued that the small ether drifts first observed by Michelson and Morley may be compatible with either an extension of Newtonian Mechanics, or with Vigier s interpretation of relativity in absolute space, provided that a small photon rest mass (of the order of 10^{-35} *gr. for yellow light) be introduced.*

Introduction

In his very interesting paper Vigier [1] proposes to take at face value the results of the famous experiment of Michelson and Morley (M-M), and the subsequent repetitions by Miller. He then argues that in a relativistic interpretation with absolute space [2], such results imply the existence of a non-zero mass for the photon.. However, this interpretation of the special theory of relativity (STR) has been already criticized by Galeczki [3]. The purpose of this note is two-fold: (a) To argue that Vigier s proposal for a massive photon is also consistent with a theory of motion in absolute space involving Galilean-Newtonian transformations, previously proposed by this author [4]. And, (b) To interpret the results from the modern M-M type experiments as evidence for photon mass.

M-M type Experiments and Absolute Space

To the best of our knowledge, the only experimental evidence against the existence of preferred frames (or absolute space, or ether) is the *claimed* null result of M-M experiment and similar such experiments. If we believe that absolute space is a nice trait for nature to have, there are at least three possible lines of attack:

(1) To make the null result of M-M consistent with absolute space and simultaneity. This is the line of thinking behind the Fitzgerald-Lorentz contraction. For other possibilities see Larson [5].

(2) To identify weaknesses in the M-M-type experiment. One of the most thorough criticisms was made by Hicks [6] shortly after M-M performed their experiment. On page 36, he concluded that instead of giving a null result, the numerical data published in their paper [M-M] show a distinct evidence of an effect of the kind to be expected (*i.e.* ether drift). With the exception of Miller s reference [7,8], Hicks s paper has been consistently ignored. For instance, in his two-volume work, Whittaker [9] references Hicks work in a footnote (vol. I, page 391, footnote 2), without quoting his negative conclusion.
There is no doubt that most of the experimental weaknesses in the original M-M experiment were removed in the repeated experiments by Miller [7,8] and Joos [10], and in the modern versions of the experiment [11-13]. However, the criticisms regarding the data reduction process, and the interpretation of the empirical data are still completely valid. This matter is analysed in detail elsewhere [14] (for the original M-M experiment, and for the Kennedy-Thorndike experiment [12]), and the conclusion is reached that such experiments are compatible with the existence of absolute space. It is also argued therein that criticisms [15] directed towards Miller s work [7,8] are unjustified. A similar conclusion is reached by Hayden [16] in his analysis of the effect of Earth s rotation on M-M-type experiments. Regarding the accurate experiment of Brillet and Hall [13], Hayden says (page 365): The authors [Brillet and Hall] have handled their data in a manner such that the effects that may arise from the Earth s rotation are ignored.

(3) To interpret the experimental error associated with the claimed null results of the M-M-type experiment as a real entity, not experimental artifact. That is, the experiments are interpreted as giving a non-null result. This is the possibility explored by Vigier [1], and in this note.

Massive Photons in Absolute Space

The dependence of mass on velocity is typically considered as a trait of STR. However, the present author has found [4] that if Newton s first law is cast in terms of the first law of thermodynamics as conservation of inertial energy $I(V)$, then

$$I(V)=I(0)\left(1-B^2\right)^{-½}=I(0)\left(1-\frac{V^2}{k^2}\right)^{-½} \qquad (1)$$

where V is speed of the particle in a preferred frame S_0, $I(0)$ is inertial energy at rest in the same frame, and k^2 is the constant of conversion from mass to energy, numerically equal to the conventional c^2. Eq. (1) does not depend on Lorentz transformations; hence, the old Galilean-Newtonian velocity transformations apply.

Let us specialize eq. (1) to massive photons. Since the energy of a photon is associated with its momentum, it is possible to identify $I(V)$ with de Broglie s expression $I(V)=h\nu$ and $I(0)$ with the rest mass $I(0)=m_\gamma k^2$ and then eq. (1) leads to

$$I(V)=h\nu=m_\gamma k^2\left(1-\frac{V^2}{k^2}\right)^{-½}, \qquad (2)$$

which is similar to Vigier s eq. (1), but is not liable to the same criticisms (addressed to the STR interpreted as valid in preferred frames). From eq. (2) one gets the speed of massive photons in the preferred frame as

$$V(\nu)=k\left[1-\left(\frac{m_\gamma k^2}{h\nu}\right)^2\right]^{-½}. \qquad (3)$$

where we introduced Vigier s photon rest mass ratio as

$$R(\nu)\equiv\frac{m_\gamma k^2}{h\nu}=\left(1-\frac{V^2}{k^2}\right)^{½}. \qquad (3a)$$

An observer located in an inertial frame moving at velocity v relative to S_0, and making angle α with the photon s trajectory, sees a photon with speed $V^*(\nu)$ given by a conventional vector addition:

$$V^{*2}=V^2+v^2+2Vv\cos\alpha . \qquad (4)$$

Of course, our eq. (4) is different from Vigier s relativistic eq. (3).

Estimates for the Rest Mass of Photons

Let us assume with Vigier that the experimental error and/or accuracy ΔV quoted in the various M-M-type experiments is a manifestation of a true photon speed in the observer s frame. Then,

$$c_\nu^*=c\pm\Delta V \text{ (Vigier s relativistic model)} \qquad (5a)$$

$$V^*=c\pm\Delta V \text{ (absolute space inertial model)} \qquad (5b)$$

Let us consider three groups of solutions for the observer s velocity: (1) $v=300\text{km s}^{-1}$, $\beta=10^{-3}$ (resulting from observations of background radiation), (2) $v=30\text{km s}^{-1}$, $\beta=10^{-4}$ (Earth s orbital speed as in M-M experiment), and (3) $v=0\text{km s}^{-1}$, $\beta=0$ (observer at rest in the preferred frame). For such small values, Vigier s eq. 4 reduces to

$$c_\nu^*=c_\nu^o\pm v\beta . \qquad (6a)$$

As pointed out by Vigier, eq. (6a) implies that the expected ether drift v is lowered by a factor β. In the absolute space case, our eq. (4) leads to

$$V=-v\cos\alpha+\left(V^{*2}-v^2\sin^2\alpha\right)^{-½} \qquad (6b)$$

For the special case of small v, it reduces to

$$V=V^*-v\cos\alpha \qquad (6c)$$

Substituting eqs. (5) into eqs. (6) we get

$$c_\nu^o=c\pm\Delta V\mp v\beta , \qquad (7a)$$

$$V=c\pm\Delta V-v\cos\alpha . \qquad (7b)$$

Substitution of eq. (7a) into Vigier s eq. (1), and eq. (7b) into our eq. (2) allows determination of photon rest mass as

$$m_\gamma c^2=h\nu R(\nu), \qquad (8)$$

$$R(\nu)=\left(1-\frac{V_0^2}{c^2}\right)^{½} \qquad (9)$$

where V_0 is given by eq. (7a) in Vigier s relativistic model, and by eq. (7b) in our absolute space inertial model.

As a numerical example, consider the case of collinear motion of observer and photon ($-v\beta$ in eq. 7a, and $\cos\alpha=1$ in eq. 7b), calculated for various values of $-\Delta V$. Tables 1 and 2 summarize the result of the exercise for some of the best known M-M-type experiments. It may be seen that $R(\nu)$ is about one order of magnitude larger for the inertial model.

Conclusion

It was argued that both relativistic and absolute space models may be used to interpret the results of the M-M-type experiments as non-null observations, leading to a non-zero frequency-dependent rest mass for the photon. The rest mass is frequency-dependent, which implies that each photon has a different core.

Consider a yellow light photon (as in the M-M ex-

Table 1. Photon rest mass ratio for Vigier s relativistic model (eqs. 7a and 9)

		Photon rest mass ratio $R(\nu)$		
Experiment	ΔV, km s 1	b = 10 3	b = 10 4	b = 0
M-M [7,8]	8.0	7.4×10 3	7.3×10 3	7.3×10 3
Kennedy [12]	1.0	2.9×10 3	2.6×10 3	2.6×10 3
Cole [17]	0.3	2.0×10 3	1.4×10 3	1.4×10 3
Perfectly null	0	1.4×10 3	1.4×10 4	0

Table 2. Photon rest mass ratio for the the absolute space inertial model (eqs. 7b and 9)

		Photon rest mass ratio $R(\nu)$		
Experiment	ΔV, km s 1	b = 10 3	b = 10 4	b = 0
M-M [7,8]	8.0	4.5×10 2	1.6×10 2	7.3×10 3
Kennedy [12]	1.0	4.5×10 2	1.4×10 2	2.6×10 3
Cole [17]	0.3	4.5×10 2	1.4×10 2	1.4×10 3
Perfectly null	0	4.5×10 2	1.4×10 2	0

periment) with energy $h\nu$ around 2.18 eV. If the Earth moves through the preferred frame at a speed of 300 km/s, then for yellow light Vigier s model predicts a rest mass of the order of 10^{35} g, whereas our model predicts a mass an order of magnitude higher, 10^{34} g. If the only relevant motion is Earth s orbital velocity, then both models predict a photon rest mass in the same range of 10^{35} g.

Even a perfectly null M-M-type experiment, could be consistent with a frequency-dependent non-zero rest mass. Hence, new experiments, based on completely different concepts, are required to test our predictions.

The connection between the two models discussed here and the four-dimensional symmetries discussed by Hsu [18] is deferred for future work. Such analysis may help clarify the possible origin of the large photon mass found herein.

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