Comment on the Paper "Absolute Motion Determined from Michelson-Type Experiments in Optical Media" by V. P. Dmitriyev

Adrian Sfarti

387 Soda Hall, UC Berkeley, USA

Reprint requests to A. S.; E-mail: egas@pacbell.net

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Alternative explanations to the Michelson–Morley experiment exist and continue to be produced. In the current paper, we will correct a recently published paper concerning a reenactment of the famous experiment. The author of the paper in cause claims the presence of a non-null result though he did not run any experiment himself. Dmitriyev bases his paper on a paper by Demjanov that has already been retracted by the journal where he originally published (V. V. Demjanov, Phys. Lett. A **374**, 1110 (2010)). Our paper is organized as follows: in the background section we will give the correct expressions for the relativistic light speed in arbitrary media *as opposed* to the *incorrect* ones given in V. P. Dmitriyev, Z. Naturforsch. **66a**, 228 (2011). We will follow by explaining the correct equations of the Michelson–Morley experiment in a refractive medium with $n > 1$, and we will outline the errors in V. P. Dmitriyev, Z. Naturforsch. **66a**, 228 (2011). The non-mainstream claims of detecting 'absolute motion' are refuted by both theoretical and experimental data.

Key words: Michelson–Morley Experiment; Fizeau Equations; Refractive Index.
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1. Background

Using the special relativity formula for speed composition, we get the speed of light propagating in a moving medium as follows: let the refraction index be n then the speed of light in the medium is c/n, if the speed of the moving medium with respect to Cosmic Microwave Background Radiation (CMBR) is v then the light speed with respect to CMBR is

$$c_{||+} = \frac{\frac{c}{n} + v}{1 + \frac{vc/n}{c^2}} \tag{1}$$

when c/n and v have the same direction and sense, and

$$c_{||-} = \frac{\frac{c}{n} - v}{1 - \frac{vc/n}{c^2}} \tag{2}$$

when c/n and v have opposite senses. The author of [1] starts from the approximate Fresnel formula $c \approx \frac{c}{n} \pm v(1 - \frac{1}{n^2})$, and this is the beginning of a long stretch of errors. For example, later on in his paper the author of [1] completely misses the case when v and c/n are orthogonal, so

$$c_{\perp} = \frac{\frac{c}{n}}{\gamma}, \tag{3}$$

where

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}.$$

This miss will have serious implications throughout his paper.

In the following, we will use the notation $c_0 = c/n$. Expressions (1) – (3) become

$$c_{||\pm} = \frac{c_0 \pm v}{1 \pm \frac{vc_0}{c^2}}, \tag{4}$$

$$c_{\perp} = \frac{c_0}{\gamma}. \tag{5}$$

We will attach two reference systems, S_1 to the horizontal arm of the interferometer and S_2 to the vertical arm.

In S_1 the components of the light speed are

$$u_{x(1)} = c_0, \quad u_{y(1)} = 0. \tag{6}$$

It follows that in a frame attached to CMBR

$$u'_{x(1)} = \frac{c_0 + v}{1 + \frac{c_0 v}{c^2}} = c_{||+}, \tag{7}$$

$$u'_{y(1)} = 0. \tag{8}$$

In S_2 the situation is rotated 90 degrees and therefore

$$u_{y(2)} = c_0, \quad u_{x(2)} = 0 \tag{9}$$

such that in CMBR

$$u'_{x(2)} = v, \quad u'_{y(2)} = c_0/\gamma. \tag{10}$$

We have established the correct basis for explaining the Michelson–Morley experiment in a refractive medium.

2. The Correct Equations for the Michelson–Morley Experiment in a Medium with $n > 1$

From Figure 1, we derive the well known equations for the Michelson–Morley experiment. All computations are done from the perspective of the CMBR frame of reference. The light path along the horizontal arm of the interferometer are

$$c_{||+}t_{AB} = L_{||} + vt_{AB}, \tag{11}$$

$$c_{||-}t_{BA} = L_{||} - vt_{BA}. \tag{12}$$

Due to length contraction, it is

$$L_{||} = L/\gamma, \tag{13}$$

where L is the proper length of the interferometer arm.

From (11)–(13), we obtain

$$t_{||} = t_{AB} + t_{BA} = \frac{L}{\gamma}\left(\frac{1}{c_{||+} - v} + \frac{1}{c_{||-} + v}\right) = \frac{2L\gamma}{c_0}. \tag{14}$$

As it can be seen, the formula for $t_{||}$ is *independent* of the refraction index, a well known result [2]. By contrast, Dmitriyev [1] obtains the incorrect expression

$$t_{||} \approx \frac{2nL}{c_0}\left(1 + \frac{v^2}{2c^2}\right)\left(1 + \frac{v^2}{c^2}\left(\frac{\Delta n^2}{n}\right)\right). \tag{Dmitriyev.2}$$

This error is a direct consequence of employing the approximate formula

$$c_{||\pm} \approx \frac{c}{n} \pm v\left(1 - \frac{1}{n^2}\right) \tag{Dmitriyev.1}$$

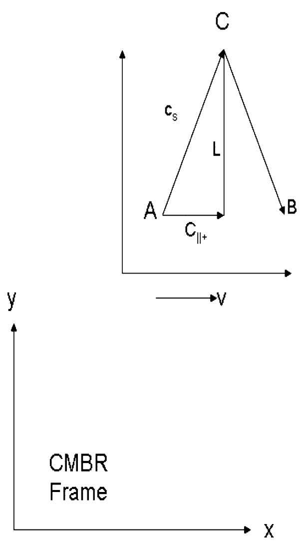

Fig. 1. Michelson–Morley Experiment.

instead of the exact formula (1). Returning to the correct derivation, we obtain for the slanted path of light

$$t_S = t_{AC} + t_{CB}, \tag{15}$$

$$(c_S t_{AC})^2 = (L_\perp)^2 + (vt_{AC})^2 = L^2 + (vt_{AC})^2, \tag{16}$$

$$(c_S t_{CB})^2 = L^2 + (vt_{CB})^2, \tag{17}$$

$$t_{AC} = t_{CB} = \frac{L}{\sqrt{c_s^2 - v^2}}. \tag{18}$$

Since

$$c_S^2 = u'^2_{x(2)} + u'^2_{y(2)}, \tag{19}$$

where, according to the speed transformations

$$u'_{x(2)} = v, \quad u'_{y(2)} = c_0/\gamma, \tag{20}$$

it is

$$c_S^2 - v^2 = \frac{c_0^2}{\gamma^2}, \tag{21}$$

$$t_\perp = t_S = 2t_{AC} = \frac{2L\gamma}{c_0}. \tag{22}$$

As it can be seen from the above detailed proof, $t_\perp$ is independent of the refraction index. The path differential is

$$\Delta t = t_\perp - t_{||} = 0, \tag{23}$$

exactly as in the case of the vacuum experiments. By contrast, Dmitriyev obtains the wrong expression due to an incorrect evaluation of the light speed along the transverse direction,

$$t_\perp \approx \frac{2nL}{c_0}\left(1 - \frac{v^2}{c^2}\left(\frac{n^2}{2} - 1\right)\right), \tag{Dmitriyev.5}$$

resulting into a non-null total time differential

$$\Delta t = t_\perp - t_{||} = \frac{v^2}{c^2}\frac{L}{c\sqrt{\varepsilon}}\Delta\varepsilon(1 - \Delta\varepsilon). \tag{Dmitriyev.6}$$

The above error stems from not understanding the correct composition of speeds for the slanted path. Indeed, the derivation used in (Dmitriyev.5) uses the wrong light speed formula along the slanted path. The errors in (Dmitriyev.2) and (Dmitriyev.5) result into predicting a non-null result for the experiment culminating with the claim of 'detection of absolute motion'.

The presence of the refractive material cancels out when the equations of special relativity is applied correctly. The theoretical result from (23) agrees very well with the experimental result from [3] that is a repetition of the Michelson–Morley experiment with the optical paths in perspex ($n = 1.49$) and a laser-based optics sensitive to ~ 0.00003 fringe. The authors report a null result with an upper limit on V_{aether} of 6.64 km/s.

Now that we explained the errors in the theory of the experiment, let's turn our attention to the experimental data. The author [1] has not run any experiment himself but claims that in 1968 – 1971 Demjanov [4] has run such an experiment. A quick examination of Demjanov's experimental data shows a total absence of error analysis. In fact, there are no error bars whatsoever, so there is no way of separating the actual signal from the background noise. By contrast, all preceding authors [3, 5] have done a very serious error analysis and concluded correctly that the experiment produces a null result.

3. Discussion

It is worthy of mention to set up an asymmetric experiment having only one of the interferometer's legs in a highly refractive material. An example is [5], using a triangle interferometer with one leg in glass. They set an upper limit on the anisotropy of 0.025 m/s. This is about one-millionth of the earth's orbital velocity and about 1/10 000 of its rotational velocity. Indeed, if we revisit (23) in this particular case, we obtain

$$\Delta t = \frac{2L\gamma}{c}(n_1 - n_2). \tag{24}$$

Comparing with $\Delta t' = \gamma \Delta t$, we obtain

$$\Delta t' = \frac{2L}{c}(n_1 - n_2). \tag{25}$$

Formula (25) allows for immediate calculation of v from the fringe shift. As shown in [2, 5], the method allows for setting very tight limits on the speed v.

4. Conclusion

We have shown that the correct usage of relativistic equations restores the order in the interpretation of the Michelson–Morley experiment executed in a refractive medium. The non-mainstream claims made by the author are refuted.

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