Response to the Comment by A. Georges on the Author's Paper "Nonlinear Models for Relativity Effects in Electromagnetism, Z. Naturforsch. 64a, 327 (2009)"

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Responses to the comments in A. Georges, Z. Naturforsch. 64a, 872 (2009) on the author's paper are given.

Key words: Covariant Formulation for Electromagnetism; Galilean Invariance; Transverse and Longitudinal Doppler Effects; Fresnel Drag.
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According to the comments by A. Georges [1] on the author's paper [2] the present note is divided into four sections.

1. Invariance with Galilean Transformation

The article [2] does not claim that standard Maxwell's laws are invariant under Galilean transformations. Rather, the article shows that the form of the modified Maxwell's equations ((76), (77) in [2]) remains invariant under Galilean transformations, with the proposed Weber-type formulation (see the line above (74) in [2]). In particular, equation (4) in [1], i. e.,

$$\frac{\mathrm{d}E}{\mathrm{d}t} = \frac{\partial E}{\partial t} + (v\cdot\nabla)E \tag{1}$$

would have the field velocity V_E instead of the frame velocity v according to the proposed approach (see (75) in [2]), i. e.,

$$\frac{\mathrm{d}E}{\mathrm{d}t} = \frac{\partial E}{\partial t} + (V_\mathrm{E}\cdot\nabla)E. \tag{2}$$

The main innovation that enables the form invariance (under Galilean transformations in the Weber-type model) is the association of velocity fields V_E and V_B with electric and magnetic fields E and B, respectively, as in the first line of Section 2.1 of [2]. Although the values of the field velocities (V_E and V_B) are different in different frames, the same form of the modified Maxwell's equations ((76), (77) in [2]) are used in different frames in [2]. Moreover, any electric field E and magnetic field B with field velocities $V_{\mathrm{E,O_1}}$ and $V_{\mathrm{B,O_1}}$ that satisfy the modified Maxwell's equations with respect to an inertial observer O_1 also satisfy the same form of modified Maxwell's equations with field velocities $V_{\mathrm{E,O_2}} = V_{\mathrm{E,O_1}} + v$ and $V_{\mathrm{B,O_2}} = V_{\mathrm{B,O_1}} + v$ with respect to another inertial observer O_2 where v is the velocity of frame 1 with respect to frame 2. For example, see the rationale for the modified Maxwell's equations with the Weber-type approach in (67) – (75) in [2]. Thus, the form of the proposed modified Maxwell's equations (76), (77), under the Weber-type formulation in [2], is co-ordinate invariant.

2. Doppler Effect

The article [2] does not claim that the Doppler equations with the Weber-type approach are the same as the relativistic Doppler equation; however, both approaches predict similar first-order effects seen in experiments.

2.1. Transverse Doppler Effect

The transverse Doppler effect (derived using the Weber-type approach) is exactly the same as the relativistic transverse Doppler effect – see sentence after (92) in [2]. To compare the expressions with the two approaches, it is important to use the same frame in the two approaches. In the context of [2], if frame 1 is the inertial frame associated with a source of light, then the relativistic expression for the Doppler effect should be (instead of (5) in [1])

$$f_2 = f_1 \frac{\sqrt{1-\beta^2}}{1-\beta\cos(\theta_2)}, \tag{3}$$

where f_1 is the frequency in frame 1, f_2 is the frequency in frame 2 (in which frame 1 is moving with velocity v as shown in Figure 8 in [2]), $\beta = v/c$, and θ_2 is the angle between the light propagation direction and the source velocity in frame 2. When $\theta_2 = \pi/2$ the above relativistic Doppler expression reduces to (same as the expression in [3], page 301)

$$f_2 = f_1\sqrt{1-\beta^2} \tag{4}$$

which is the same as in (92) in [2] with the Weber-type approach.Thus, the proposed Weber-type approach predicts exactly the same transverse Doppler effect as with the relativistic approach – and would therefore, exactly match the transverse Doppler effects in experiments.

2.2. Longitudinal Doppler Effect

In experiments (such as Ives Stilwell [4] and the extension of [5] in [6]) where measurements are made close to the longitudinal direction, with a small angle θ_1 between the light propagation direction and the source velocity in frame 1 (see Figure 8 in [2]), the relativistic expression for the Doppler effect is (as in (5) in [1] with $\theta = \theta_1$)

$$\begin{aligned} f_2 &= f_1 \frac{1+\beta\cos(\theta_1)}{\sqrt{1-\beta^2}} \\ &\approx f_1\left(1+\beta\cos(\theta_1)+\frac{1}{2}\beta^2\right). \end{aligned} \tag{5}$$

With the Weber-type approach, the resulting light velocity c_2 with Galilean addition (see Figure 8 in [2]) is

$$\begin{aligned} c_2^2 &= [v + c\cos(\theta_1)]^2 + [c\sin(\theta_1)]^2 \\ &= c^2 + 2vc\cos(\theta_1) + v^2 \end{aligned} \tag{6}$$

from which the Doppler effect (with the Weber-type approach) can be written in terms of θ_1 as

$$\begin{aligned} f_2 &= f_1\frac{c_2}{c} = f_1\sqrt{1+2\beta\cos(\theta_1)+\beta^2} \\ &\approx f_1\left(1+\beta\cos(\theta_1)+\frac{\sin^2(\theta_1)}{2}\beta^2\right). \end{aligned} \tag{7}$$

Therefore, both, the Weber-type approach in [2] and the relativistic approach, predict the same first-order effects (compare (5) and (7)) in longitudinal-type Doppler experiments with a small angle $\theta_1 \neq 0$.

2.3. Potential Difference in Longitudinal Doppler Effect

While it is experimentally challenging to get θ_1 exactly zero, if such an experiment could be done, then there would be a difference in the predicted results. For example, the Weber-type approach in [2] predicts a Doppler effect of (from (7) with $\theta_1 = 0$)

$$f_2 = f_1(1+\beta) \tag{8}$$

that does not have a nonlinear effect. In contrast, the relativistic Doppler effect in (5) would predict a nonlinear effect when $\theta_1 = 0$. However, even with an infinitesimally small angle θ_1, which would be difficult to avoid in experiments (e. g., see extension of [5] in [6]), the predicted first-order effects of both theories would match exactly, as discussed in Section 2.2 of this reply.

3. Propagation Speed of Light

The proposed Weber-type approach uses the same form of the modified Maxwell equations ((76), (77) in [2]) in different frames O_1, O_2 as discussed in Section 1 of this reply. Therefore, the resulting modified wave equation

$$\nabla^2 E - \frac{1}{c^2}\frac{\mathrm{d}^2 E}{\mathrm{d}t^2} = 0, \tag{9}$$

with the time derivative $\mathrm{d}E/\mathrm{d}t$ defined in (2), also has the same form in both frames O_1, O_2. This modified wave equation does lead to the Galilean addition of velocities (see example in Section 4.2 in [2]). However, the article [2] explicitly shows in Section 4 that classical optics effects such as the null result of the Michelson-Morley experiment, stellar aberration, transverse Doppler and Fresnel drag (that typically cause problems with Galilean addition of velocities) can be predicted with the Weber-type relative-velocity approach.

4. Convection of Light in Moving Media (Fresnel Drag)

The model presented in [2] (equations (93) – (97)) is based on the approach by Michelson and Morley in [7]. The model predicts that the velocity of light in a media moving with velocity v (with respect to a stationary observer) is seen (as by the stationary observer) to increase by (as in (97) in [2])

$$\left(1-\frac{1}{\eta^2}\right)v, \tag{10}$$

where η is the media's coefficient of refraction – this expression exactly matches the relativistic prediction of the classical Fresnel drag seen in experiments, e. g., see (44) in [3].

5. Summary

The main innovation is the association of velocities with fields wherein the force between the field and a particle depends on the relative velocity between the particle and the field. The interesting aspect of this Weber-type model in [2] is that it explains traditional problems in optics such as Fresnel drag, which (in conjunction with the Michelson-Morley experiment) was one of the problems that the Lorentz transformation was trying to resolve. Moreover, the proposed approach matches electromagnetism effects from CRT data (in Section 2.2, see Fig. 1 in [2]), and explains experimental discrepancies in two classical experiments (in Section 3.2 in [2]). Extensions of the approach in [2] (e. g., to integrate with cosmological models) will be needed for evaluating the ability of the approach to explain (or not to explain) other experimental phenomena.

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