The Lorentz Transformation as a Planck Vacuum Phenomenon in a Galilean Coordinate System

William C. Daywitt
National Institute for Standards and Technology (retired), Boulder, Colorado, USA
E-mail: wcdaywitt@earthlink.net

In a seminal Masters' dissertation [1] Pemper derived the relativistic electric and magnetic fields of a uniformly moving charge from the response of some continuum to the perturbation from the charge's Coulomb field. The results seem to imply that the Maxwell equations and the Lorentz transformation are associated with some type of vacuum state. Unbeknownst at the time, Pemper had discovered the Planck vacuum (PV) quasi-continuum [2] and its interaction with the free charge. The importance of this derivation, its obscurity in the literature, and its connection to the PV justifies the following rework of that derivation.

1 Pemper Derivation

When a free, massless, bare charge e_* travels in a straight line at a uniform velocity v its bare Coulomb field e_*/r^2 perturbs (polarizes) the PV [2]. If there were no PV, the bare field would propagate as a frozen pattern with the same velocity and there would be no accompanying magnetic field. The corresponding force perturbing the PV is e_*^2/r^2, where one of the charges e_* in the product e_*^2 belongs to the free charge and the other to the individual Planck particles making up the degenerate negative-energy PV.

This charge-vacuum interaction is described by Pemper [1] as a series ($n = 1, 2, 3, \ldots$) of electric and magnetic fields (*generated by the vacuum*)

$$\nabla \times \mathbf{E}_n = -\frac{1}{c}\frac{\partial \mathbf{B}_n}{\partial t} \tag{1}$$

and

$$\mathbf{B}_{n+1} = \boldsymbol{\beta} \times \mathbf{E}_n \tag{2}$$

that respond in a iterative fashion to the bare charge's Coulomb field, leading to the well-known relativistic electric and magnetic fields that are traditionally ascribed to the charge as a single entity. The serial electric and magnetic fields are $\mathbf{E}_n$ and $\mathbf{B}_n$ and $\boldsymbol{\beta} = \mathbf{v}/c$. The curl equation in (1) is recognized as the Faraday equation and the magnetic field in (2) is due to the free-charge field rotating the induced dipoles within the PV. The series of partial fields is not envisioned as a series in time — the PV response is assumed to happen instantaneously at each field point.

The initial magnetic field in the series is $\mathbf{B}_1 = \boldsymbol{\beta} \times \mathbf{E}_0$, where the bare charge's laboratory-observed Coulomb field is

$$\mathbf{E}_0 = \frac{e\mathbf{r}}{r^3} = \frac{e}{e_*}\frac{e_*\mathbf{r}}{r^3} = \alpha^{1/2}\frac{e_*\mathbf{r}}{r^3}, \tag{3}$$

where α is Planck's constant. The serial electric fields are assumed to be radial; so the final electric field is radial with a magnitude equal to the sum

$$E = E_0 + E_1 + E_2 + E_3 + \ldots, \tag{4}$$

where the E_n are the magnitudes of the $\mathbf{E}_n$s and the final magnetic field is $\boldsymbol{\beta} \times \mathbf{E}$. Assuming that the $E_n = E_n(r, \theta)$, the charge-PV feedback equations (1) and (2) reduce to

$$\frac{\partial E_n}{\partial \theta} = \frac{r}{c}\frac{\partial B_n}{\partial t} \tag{5}$$

and

$$B_{n+1} = \beta E_n \sin\theta \tag{6}$$

in the azimuthal direction about the z-axis.

Calculating the first partial field E_1 in the series begins with (6)

$$B_1 = \beta E_0 \sin\theta \tag{7}$$

and leads to (Appendix A)

$$\dot{B}_1 = \frac{3c\beta^2 E_0 \sin\theta\cos\theta}{r}, \tag{8}$$

where the overhead dot represents a partial differentiation with respect to time. Then from (5)

$$dE_1 = \frac{r\dot{B}_1}{c}\,d\theta = 3\beta^2 E_0 \sin\theta\cos\theta\,d\theta, \tag{9}$$

which integrates over the limits $(0, \theta)$ to

$$E_1 = \frac{3\beta^2 E_0 \sin^2\theta}{2} - \lambda_1 E_0, \tag{10}$$

where the reference field $E_1(\theta = 0) = -\lambda_1 E_0$ with λ_1 a constant to be determined.

The second iteration for the electric field begins with

$$B_2 = \beta E_1 \sin\theta = \frac{3\beta^3 E_0 \sin^3\theta}{2} - \lambda_1 B_1 \tag{11}$$

and yields (Appendix A)

$$\dot{B}_2 = \frac{15c\beta^4 E_0 \sin^3\theta\cos\theta}{2r} - \lambda_1 \dot{B}_1\,. \tag{12}$$

Equation (5) then leads to

$$dE_2 = \frac{r\dot{B}_2}{c}\,d\theta = \left(\frac{15\beta^4 E_0 \sin^3\theta\cos\theta}{2} - \frac{\lambda_1 r\dot{B}_1}{c}\right)d\theta, \quad (13)$$

which integrates to

$$E_2 = \frac{15\beta^4 E_0 \sin^4\theta}{8} - \lambda_1\frac{3\beta^2 E_0 \sin^2\theta}{2} - \lambda_2 E_0, \quad (14)$$

where again $E_2(\theta = 0) = -\lambda_2 E_0$.

The third iteration proceeds as before and results in (Appendix A)

$$\dot{B}_3 = \frac{3\cdot 5\cdot 7c\beta^6 E_0 \sin^5\theta\cos\theta}{8r} - \lambda_1\frac{3\cdot 5c\beta^4 E_0 \sin^3\theta\cos\theta}{2r} - \lambda_2\frac{3c\beta^2 E_0\sin\theta\cos\theta}{r} \quad (15)$$

and

$$E_3 = \frac{3\cdot 5\cdot 7\beta^6 E_0 \sin^6\theta}{6\cdot 8} - \lambda_1\frac{3\cdot 5\beta^4 E_0\sin^4\theta}{2\cdot 4} - \lambda_2\frac{3\beta E_0\sin^2\theta}{2} - \lambda_3 E_0 \quad (16)$$

for the third partial field.

Inserting (10), (14), and (16) (plus the remaining infinity of partial fields) into (4) gives

$$\begin{aligned} E &= E_0 + \frac{3\beta^2 E_0\sin^2\theta}{2} + \frac{3\cdot 5\beta^4 E_0\sin^4\theta}{8} + \frac{3\cdot 5\cdot 7\beta^6 E_0 \sin^6\theta}{48} + \ldots \\ &\quad -\lambda_1\left(E_0 + \frac{3\beta^2 E_0\sin^2\theta}{2} + \frac{3\cdot 5\beta^4 E_0\sin^4\theta}{8} + \ldots\right) \\ &\quad -\lambda_2\left(E_0 + \frac{3\beta E_0\sin^2\theta}{2} + \ldots\right) - \lambda_3(E_0 + \ldots) + \ldots \\ &= E_0\left(1 + \frac{3\beta^2\sin^2\theta}{2} + \frac{3\cdot 5\beta^4\sin^4\theta}{2\cdot 4} + \frac{3\cdot 5\cdot 7\beta^6\sin^6\theta}{2\cdot 4\cdot 6} + \ldots\right)(1-\lambda), \end{aligned} \quad (17)$$

where

$$\lambda \equiv \sum_{n=1}^{\infty}\lambda_n \quad (18)$$

is a constant. The sum after the final equal sign in (17) is recognized as the function $(1 - \beta^2\sin^2\theta)^{-3/2}$; so E can be expressed as

$$E = \frac{(1-\lambda)E_0}{(1-\beta^2\sin^2\theta)^{3/2}}\,. \quad (19)$$

Finally, the constant λ can be evaluated from Gauss' law and the conservation of bare charge e_*:

$$\int \mathbf{D}\cdot d\mathbf{S} = 4\pi e_* \longrightarrow \int \mathbf{E}\cdot d\mathbf{S} = 4\pi e, \quad (20)$$

where $\mathbf{D} = (e_*/e)\mathbf{E}$ is used to arrive at the second integral. Inserting (19) into (20) and integrating yields

$$\lambda = \beta^2, \quad (21)$$

which, inserted back into (19), gives the relativistic electric field of a uniformly moving charge. That this field is the same as that derived from the Lorentz transformed Coulomb field is shown in Appendix B.

2 Conclusions and Comments

The calculations of the previous section suggest that the Lorentz transformation owes its existence to interactions between free-space particles and the negative-energy PV. Free space is defined here as "the classical void + the zero-point electromagnetic vacuum" [3].

The fact that the bare charge is massless makes the Pemper derivation significantly less involved and more straightforward than the related case for the massive point charge (Dirac electron). Nevertheless, the uniform motion of the Dirac electron too exhibits electron-PV effects. When a bare charge is injected into free space (presumably from the PV) it very quickly ($\sim 10^{-30}$ sec) develops a mass from being driven by the random fields of the electromagnetic vacuum. The corresponding electron-PV connection is easily recognized in the Lorentz-covariant Dirac equation [4, p. 90], [5]:

$$\left(ic\hbar\gamma^\mu\partial_\mu - mc^2\right)\psi = 0 \longrightarrow \left(ie_*^2\gamma^\mu\partial_\mu - mc^2\right)\psi = 0, \quad (22)$$

where the PV relation $c\hbar = e_*^2$ is used to arrive at the equation on the right. A nonrelativistic expression for the electron mass is given by Puthoff [3, 6]

$$m = \frac{2}{3}\frac{\left\langle \dot{r}^2\right\rangle^{1/2}}{c}\,m_*, \quad (23)$$

where $\dot{\mathbf{r}}$ represents the random excursions of the zero-point-driven bare charge about its center of (random) motion at $\mathbf{r} = 0$ and m_* is the Planck mass.

The massive point charge perturbs the PV with the two-fold force [5]

$$\frac{e_*^2}{r^2} - \frac{mc^2}{r}, \quad (24)$$

where the first and second terms are the polarization and curvature* forces respectively. It is the interaction of this composite force with the PV that is responsible for the Dirac equation as evidenced by the e_*^2 and mc^2 in (22) and (24). Thus

*Using the PV relations $G = e_*^2/m_*^2$ and $e_*^2 = r_* m_* c^2$ in the curvature force leads to $mc^2/r = mm_*G/rr_*$ and shows the direct gravitational interaction between the electron mass and the Planck particle masses within the PV.

both the Pemper derivation and the Dirac equation argue compellingly for the existence of the Planck vacuum state and its place in the physical scheme of things. It is noted in passing that the force in (24) vanishes at the electron's Compton radius $r_c = e_*^2/mc^2$.

Appendix A: Galilean Coordinate System

The laboratory system in which the charge propagates is considered to be a Galilean reference system. In that system (x, y, z) represents the radius vector from the system origin to any field point (considered in the calculations to be fixed). The position of the charge traveling at a constant rate v along the positive z-axis is $(0, 0, vt)$; so at time $t = 0$ the charge crosses the origin. Since the field point is fixed, the vector in the x-y plane

$$\mathbf{b} = b\,\widehat{\mathbf{b}} \equiv \mathbf{x} + \mathbf{y} \tag{A1}$$

is constant. The radius vector from the position of the charge to the field point is then

$$\mathbf{r} = (x, y, z - vt)\,. \tag{A2}$$

Combining (A1) and (A2) gives

$$r = \left[b^2 + (z - vt)^2\right]^{1/2} \tag{A3}$$

for the magnitude of that vector.

If θ is the angle between the radius $\mathbf{r}$ and the positive z-axis, it is easy to show from (A1)—(A3) that

$$r \sin\theta = b \tag{A4}$$

and

$$r \cos\theta = z - vt \tag{A5}$$

and from (A3)—(A5) that

$$\dot{r} = -v \cos\theta \tag{A6}$$

and

$$r\dot{\theta} = v \sin\theta, \tag{A7}$$

where the overhead dot represents a partial derivative with respect to time.

From (7) the initial magnetic field in the charge-PV interaction is

$$B_1 = \beta E_0 \sin\theta = \beta \cdot \frac{e}{r^2} \cdot \frac{b}{r} = \frac{\beta e b}{[b^2 + (z - vt)^2]^{3/2}} \tag{A8}$$

whose time differential leads to

$$\dot{B}_1 = \frac{3c\beta^2 E_0 \sin\theta \cos\theta}{r} \tag{A9}$$

in a straightforward manner.
From (11) in the text

$$B_2 = \beta E_1 \sin\theta = \frac{3\beta^3 e b^3}{2\,[b^2 + (z - vt)^2]^{5/2}} - \lambda_1 B_1, \tag{A10}$$

which leads to

$$\dot{B}_2 = \frac{15c\beta^4 E_o \sin^3\theta \cos\theta}{2r} - \lambda_1 \dot{B}_1\,. \tag{A11}$$

From $B_3 = \beta E_2 \sin\theta$,

$$\begin{aligned} B_3 &= \frac{15\beta^5 E_0 \sin^5\theta}{8} - \lambda_1 \frac{3\beta^3 E_0 \sin^3\theta}{2} - \lambda_2 \beta E_0 \sin\theta \\ &= \frac{15\beta^5 e b^5}{8\,[b^2 + (z - vt)^2]^{7/2}} - \lambda_1 \frac{3\beta^3 e b^3}{2\,[b^2 + (z - vt)^2]^{5/2}} \\ &\quad -\lambda_2 \frac{\beta e b}{[b^2 + (z - vt)^2]^{3/2}} \end{aligned} \tag{A12}$$

and

$$\begin{aligned} \dot{B}_3 &= \frac{3 \cdot 5 \cdot 7c\beta^6 E_0 \sin^5\theta \cos\theta}{8r} - \lambda_1 \frac{3 \cdot 5c\beta^4 E_0 \sin^3\theta \cos\theta}{2r} \\ &\quad -\lambda_2 \frac{3c\beta^2 E_0 \sin\theta \cos\theta}{r}\,. \end{aligned} \tag{A13}$$

Appendix B: Lorentz Transformed Fields

The Lorentz transformation coefficients $a_{\mu\nu}$ in the coordinate transformation [7, pp. 380–381]

$$\begin{aligned} x'_\mu = a_{\mu\nu} x_\mu &= \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & \gamma & i\beta\gamma \\ 0 & 0 & -i\beta\gamma & \gamma \end{pmatrix} \begin{pmatrix} x \\ y \\ z \\ ict \end{pmatrix} \\ &= \begin{pmatrix} x \\ y \\ \gamma(z - vt) \\ i\gamma(ct - \beta z) \end{pmatrix} \end{aligned} \tag{B1}$$

lead to the Lorentz transformed fields

$$F'_{\mu\nu} = a_{\mu\sigma} a_{\nu\tau} F_{\sigma\tau}, \tag{B2}$$

where the $F'_{\mu\nu}$, etc., are the electromagnetic field tensors. The primed and unprimed parameters refer respectively to the charge-at-rest and laboratory systems, where the charge system travels along the z-axis of the laboratory system with a constant velocity v.

Using the static Coulomb field in the charge system and transforming it to the laboratory system with the inverse of (B2) leads to the magnitude

$$E = \frac{\gamma e \left[b^2 + (z - vt)^2\right]^{1/2}}{[b^2 + \gamma(z - vt)^2]^{3/2}} \tag{B3}$$

for the electric field, where $\gamma = 1/(1 - \beta^2)^{1/2}$. (B3) reduces to (19) in the following way:

$$E = \frac{\gamma e \left[b^2 + (z - vt)^2\right]^{1/2}}{\gamma^3\,[b^2 + (z - vt)^2 - \beta^2 b^2]^{3/2}}$$

$$= \frac{e/\left[b^2 + (z - vt)^2\right]}{\gamma^2 \left[1 - \beta^2 b^2/[b^2 + (z - vt)^2]\right]^{3/2}}$$

$$= \frac{(1 - \beta^2)\, E_0}{\left(1 - \beta^2 \sin^2 \theta\right)^{3/2}} \,. \qquad \text{(B4)}$$

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References

1. Pemper R.R. A classical foundation for electrodynamics. Master Dissertation, Univ. of Texas, El Paso, 1977. Barnes T.G. Physics of the Future – A Classical Unification of Physics, Institute for Creation Research, California, 1983.
2. Daywitt W.C. The Planck vacuum. *Progress in Physics*, 2009, v. 1, 20–26.
3. Daywitt W.C. The Source of the Quantum Vacuum. *Progress in Physics*, 2009, v. 1, 27–32.
4. Gingrich D.M. Practical Quantum Electrodynamics, CRC – The Taylor & Francis Group, Boca Raton, 2006.
5. Daywitt W.C. The Dirac Electron in the Planck Vacuum Theory. *Progress in Physics*, 2010, v. 4, 69–71.
6. Puthoff H.E. Gravity as a zero-point-fluctuation force. *Physical Review A*, 1989, v. 39, no. 5, 2333–2342.
7. Jackson J.D. Classical Electrodynamics. John Wiley & Sons, 1st ed., 2nd printing, New York, 1962.