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Local Lorentz Transformations and the International System of Units (SI)

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ABSTRACT: In this work are collected the modifications in its measurable characteristics suffered by an object flying in space at speed v when it is monitored through measurements of its physical magnitudes by a fixed observer. Such modifications are the now known as Local Lorentz Transformations of physical magnitudes.

KEYWORDS: Special Relativity, Relativistic Mass, Relativistic Energy, Relativistic Momentum and in general Relativistic transformations of physical magnitudes.

IINTRODUCTION

The International System of Units (abbreviated SI from the French as "*Le Système international d'unités*"), currently the world's most widely used system of units, and the National Institute of Standards and Technology publication, *The NIST Reference of Constants, Units and Uncertainty,* will be among the guides to present this work [1], [2]. On the other side, we will be using the results obtained in reference [3], in where it was deduced as first results the length contraction, time dilation (explained and predicted both facts by Lorentz at the beginnings of XX century [4]) and mass increasing, that a fixed observer measures on moving objects.

I LENGTH, TIME, MASS AND ELECTRIC CURRENT INTENSITY

A configuration that will clear the above concepts is the following one: let's suppose we are seeing overhead a spaceship flying at speed v, which indeed is a laboratory with all kind of equipments for doing measurements of physical characteristics on ***stationary objects*** inside this laboratory, which we will refer to it as Lab A. Nevertheless, these measurements are always being done taking as reference a fixed point B at earth. In this sense, a rod whose length at rest is L_0 in Lab A, will be measured by instruments in Lab A, always as L_0, independently of the reference point of measurement, $L_0 = |\mathbf{r}'_M - \mathbf{r}'_N|$, for instance, point B at earth:, where points M and N are stationary points inside Lab A, but points that move relative to reference point B at earth. Let the primed letters apply to magnitudes measured with instruments in Lab A. Additionally, we are at earth at point B in another laboratory, to which we will call Lab B, with all the equipment to measure characteristic quantities of ***movable objects***. In this case, a stationary rod inside Lab A, at the spaceship, which was measured as L_0, now, from Lab B at earth, we will be measuring, taking as before the same

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reference point B of measurements, a dynamic rod's length $L=|\mathbf{r}_M-\mathbf{r}_N|$ which is less than L_0 in a quantity given by $L=\sqrt{1-\frac{v^2}{c^2}}.L_0$ (length contraction). A clock that in Lab A measures a interval of time t_0 between two events, our clock at earth, in Lab B will be measuring, between the same two events, a period t longer than t_0, such that $t=\frac{t_0}{\sqrt{1-\frac{v^2}{c^2}}}$, (time dilation). A body whose stationary mass magnitude given by instruments in the flying lab A, is m_0, becomes being measured at earth in Lab B as a dynamic mass m greater than m_0, i.e.: $m=\frac{m_0}{\left(1-\frac{v^2}{c^2}\right)^{\frac{3}{2}}}$ (Einstein obtained $m=\frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$, an erroneous dynamical value of mass [5]). In the same previously referred work [3] it was shown that the electric charge is invariant to Local Lorentz Transformations, thus, the current intensity I_0, $I_0=I'=\frac{dq'}{dt'}=\frac{dq}{dt.\sqrt{1-\frac{v^2}{c^2}}}$, measured in Lab A, will be measured at earth as $I=\frac{dq}{dt}=\sqrt{1-\frac{v^2}{c^2}}.I_0$.

II TEMPERATURE, AMOUNT OF SUBSTANCE AND LUMINOUS INTENSITY

On the other hand, the characteristic Local Lorentz Transformation for temperature can be obtained from the definition of temperature according to the second law of thermodynamics, which implies that heat does not spontaneously flow from a cold material to a hot material, but it allows heat (energy) to flow from a hot material to a cold material. This can be expressed as a function of the positive tendency of the inverse relationship between the energy dispersal, or thermodynamic Entropy S, and heat Q: $\frac{dQ}{dS}=T$. We know that Entropy is a probabilistic measure of the disorder or energy dispersal of a system. Because of that, it has the characteristics of a number and although it is not dimensionless its invariance under the Local Lorentz Transformations (LLT) is the more suitable assumption to take on, as we will see afterward. Thus, by measuring the variation of Entropy and Heat (energy) of a closed system in the moving Lab A, and taking from [3] the already known LLT of Energy: $dE'=\frac{dE}{\sqrt{1-\frac{v^2}{c^2}}}$ or more specifically: $dQ'=\frac{dQ}{\sqrt{1-\frac{v^2}{c^2}}}$, we have:

$$\frac{dQ'}{dS'}=T'=\frac{\dfrac{dQ}{\sqrt{1-\dfrac{v^2}{c^2}}}}{dS}\qquad\Rightarrow\qquad T'=\frac{T}{\sqrt{1-\dfrac{v^2}{c^2}}};\ \text{For,}\quad T'=T_0\qquad\Rightarrow\qquad T=T_0.\sqrt{1-\frac{v^2}{c^2}}$$

Let's do some controls. The gas ideal law, which indicates that the product of the pressure and volume of a gas is directly proportional to the temperature: $P.V=n.R.T$, where P is pressure, V is volume, T is temperature, ***n* is the number of moles (dimensionless)** of gas and R is the gas constant. Pressure is defined as force divided by area, and force is invariant to LLT [3}. So,

$$P'.V'=n'.R'.T'\quad\Rightarrow\quad\frac{\dfrac{F}{A}}{1-\dfrac{v^2}{c^2}}.\frac{V}{\left(1-\dfrac{v^2}{c^2}\right)^{\frac{3}{2}}}=n.R.T';\ T'=T_0=\frac{\dfrac{P.V}{n.R}}{\sqrt{1-\dfrac{v^2}{c^2}}}=\frac{T}{\sqrt{1-\dfrac{v^2}{c^2}}}\qquad\Rightarrow\qquad T=T_0.\sqrt{1-\frac{v^2}{c^2}}$$

In semiconductors, the difference of potential V between a p-n junction depends on the absolute Temperature as: $V=\dfrac{kT}{q}$, where q is the electron's charge and k the Boltzmann's constant. We know from [3] that electrical charge is invariant and voltage LLT is given by $V'=V_0=\dfrac{V}{\sqrt{1-\dfrac{v^2}{c^2}}}$. Thus, if a voltage V_0 is measured in the Lab A in the spaceship, we measure at earth $V=V_0.\sqrt{1-\dfrac{v^2}{c^2}}$. So, by using the already known LLT of Temperature, we will obtain consistently that:

$$V'=\frac{k'.T'}{q'}=\frac{k.\dfrac{T}{\sqrt{1-\dfrac{v^2}{c^2}}}}{q}=\frac{\dfrac{k.T}{q}}{\sqrt{1-\dfrac{v^2}{c^2}}}=\frac{V}{\sqrt{1-\dfrac{v^2}{c^2}}}.$$

With these controls we can check that the heat capacity is an invariant quantity under LLT. In fact:

$$C'=\frac{\Delta T'}{\Delta Q'}=\frac{\dfrac{\Delta T}{\sqrt{1-\dfrac{v^2}{c^2}}}}{\dfrac{\Delta Q}{\sqrt{1-\dfrac{v^2}{c^2}}}}=C$$

Let's try to obtain the transformation of the luminous Intensity in order to complete the LLT of all the SI base units.

From [1] we obtain the definition of the luminous Intensity unit: “One candela (cd) is defined as the luminous intensity of a monochromatic 540 THz light source that has a radiant intensity of 1/683 watts per steradian”. From this very first definition we can observe that the candela unit has the unit of [watt/steradian] and the steradian is a dimensionless quantity because it comes from dividing an area of one squared meter by the squared of a one-meter-radius, and by this same reason (their factors cancel out), also the steradian is an LLT invariant quantity. Therefore, this unit has the dimension of power (watt).

By using again reference [3] we obtain that $P' = \frac{dE'}{dt'} = \frac{\frac{dE}{\sqrt{1-\frac{v^2}{c^2}}}}{dt.\sqrt{1-\frac{v^2}{c^2}}} = \frac{P}{\left(1-\frac{v^2}{c^2}\right)}$, thus, the LLT of the luminous intensity becomes:

$$I_v' = I_{v0} = \frac{I_v}{\left(1-\frac{v^2}{c^2}\right)} \quad \Rightarrow \quad I_v = I_{v0}.\left(1-\frac{v^2}{c^2}\right)$$

Thus, a luminous intensity I_{v0} measured in the Lab A in the spaceship, will be measured in Lab B at earth as $I_v = I_{v0}.\sqrt{1-\frac{v^2}{c^2}}$. A resume of base SI units and their LLT is presented in following table:

TABLE 1

SI base units and their Local Lorentz Transformations (LLT)

Magnitude	Unit	Symb.	Scient. Not.	Fixed System	Moving System
Distance ***r***	meter	m	m	$r = \sqrt{1-\frac{v^2}{c^2}}.r_0$	$r' = r_0$
Mass ***m***	kilogram	kg	kg	$m = \frac{m_0}{\left(1-\frac{v^2}{c^2}\right)^{\frac{3}{2}}}$	$m' = m_0$
Time ***t***	second	s	s	$t = \frac{t_0}{\sqrt{1-\frac{v^2}{c^2}}}$	$t' = t_0$
Electric Current $I = \frac{dq}{dt}$	Amper	A	A	$I = \sqrt{1-\frac{v^2}{c^2}}.I_0$	$I' = I_0$
Thermodynamic Temperature ***T***	°Kelvin	K	K	$T = \sqrt{1-\frac{v^2}{c^2}}.T_0$	$T' = T_0$

Amount of Substance ***n***	mole	mol	[mol]	$n = n_0$	$n' = n_0$
Luminous Intensity $I_v(l)$ (visible)	candela	cd	*cd*	$I_v = \left(1 - \frac{v^2}{c^2}\right).I_{v0}$	$I'_v = I_{v0}$

It is important to observe that in [3] was obtained that electric charge is invariant to LLT, namely it has the same value as moving as at rest. In this way it is easy to deduce the LLT of the electric current intensity is the inverse of that of the LLT of time, taking the value presented in Table 1. In this sense, **the characteristic factors** of the Lorentz local transformations that magnitudes take when objects move, have the dimensionality property. Thus, it is easy to obtain and to check directly the complete transformation of a magnitude by applying the corresponding LLT of the SI basic units to its dimension expressed in scientific notation.

When a physical law is expressed through some constant and the constant has its own dimension, in order to complete the dimension of the magnitude measured by sucht physical law, it will mean that when the object is moving, this "constant" will be measured from earth as it were another magnitude that is also can be modified by the LLT of the units involved in its dimension. For example, in the cases of the Plank constant, the Boltzmann constant, the gravitational constant, the electric permittivity, the magnetic permeability, etc. Namely, such "constants" with dimensions also absorb the changes due the motion of the object to which we are doing measurements from earth.

III KINEMATIC SI DERIVED UNITS

Derived units and their LLT factors are defined in terms of the seven SI base quantities via definitions of magnitudes coming from worldwide accepted mathematical-physical equations or laws.

TABLE 2

Kinematic SI derived units and their Local Lorentz Transformations (LLT)

Magnitude	Unit	Symb.	Scient not.	Fixed System	Moving System
Length ***L***	meter	m	*m*	$L = \sqrt{1 - \frac{v^2}{c^2}}.L_0$	$L' = L_0$
Area ***A***	square meter	m^2	m^2	$A = A_0 \cdot \left(1 - \frac{v^2}{c^2}\right)$	$A' = A_0$
Volume ***V***	cubic meter	m^3	m^3	$V = \left(1 - \frac{v^2}{c^2}\right)^{\frac{3}{2}}.V_0$	$V' = V_0$
Plane angle $\theta = s/R$	radian	*rad*	[ ]	$\theta = \theta_0$	$\theta' = \theta_0$
Solid angle $\Omega = A/R^2$	steradian	*sr*	[ ]	$\theta = \theta_0$	$\theta' = \theta_0$

Velocity ***v***	$\frac{\text{meter}}{\text{second}}$	$\frac{m}{s}$	$m.s^{-1}$	$v=\left(1-\frac{v^2}{c^2}\right).v_0$	$v'=v_0$
Frequency ***f***	$\text{hertz}=\frac{\text{cycles}}{\text{sec}}$	Hz	s^{-1}	$f=\sqrt{1-\frac{v^2}{c^2}}.f_0$	$f'=f_0$
Angular Velocity ***ω***	$\frac{\text{radian}}{\text{second}}$	$\frac{rad}{s}$	s^{-1}	$\omega=\sqrt{1-\frac{v^2}{c^2}}.\omega_0$	$\omega'=\omega_0$
Acceleration ***a***	$\frac{\text{meter}}{\text{second}^2}$	$\frac{m}{s^2}$	$m.s^{-2}$	$a=\left(1-\frac{v^2}{c^2}\right)^{\frac{3}{2}}.a_0$	$a'=a_0$
Angular Acceleration ***α***	$\frac{\text{radian}}{\text{second}^2}$	$\frac{rad}{s^2}$	s^{-2}	$\alpha=\sqrt{1-\frac{v^2}{c^2}}\alpha._0$	$\alpha'=\alpha_0$

IV DYNAMIC SI DERIVED UNITS

TABLE 3

Dynamic SI derived units and their Local Lorentz Transformations (LLT)

Magnitude	Unit	Symb.	Scient. Not.	Fixed System	Moving System
Force ***F***	Newton	N	$m.kg.s^{-2}$	$F=F_0$	$F'=F_0$
Energy, Work, Heat ***E***	Joule	J	$m^2.kg.s^{-2}$	$E=\sqrt{1-\frac{v^2}{c^2}}.E_0$	$E'=E_0$
Power ***W=E/t***	Watt	W	$m^2.kg.s^{-3}$	$W=\left(1-\frac{v^2}{c^2}\right).W_0$	$W'=W_0$
Torque ***τ = r x F***	Newton.meter	$N.m$	$m^2.kg.s^{-2}$	$\tau=\sqrt{1-\frac{v^2}{c^2}}.\tau_0$	$\tau'=\tau_0$
Linear Momentum ***p = m.v***	Newton.second	$N.s$	$m.Kg.s^{-1}$	$p=\frac{p_0}{\sqrt{1-\frac{v^2}{c^2}}}$	$p'=p_0$
Angular Momentum ***L = r x p***	Newt.met.sec	$N.m.s$	$m^2.kg.s^{-1}$	$L=L_0$	$L'=L_0$
Pressure ***P=F/A***	Pascal	Pa	$m^{-1}.kg.s^{-2}$	$P=\frac{P_0}{\left(1-\frac{v^2}{c^2}\right)}$	$P'=P_0$

Gravitational Field or Gravity ***g=F/m***	$\frac{\text{Newton}}{\text{kg}}$	$\frac{\text{N}}{\text{kg}}$	$m.s^{-2}$	$g=\left(1-\frac{v^2}{c^2}\right)^{\frac{3}{2}}.g_0$	$g'=g_0$
Gravtational constant ***G = g.r²/M***	$\frac{\text{Newton.meter}^2}{\text{Kg}^2}$	$\frac{\text{N.m}^2}{kg^2}$	$m^3.kg^{-1}.s^{-2}$	$G=\left(1-\frac{v^2}{c^2}\right)^4.G_0$	$G'=G_0$

V ELECTROMAGNETIC SI DERIVED UNITS

TABLE 4

Electromagnetic SI derived units and their Local Lorentz Transformations (LLT)

Magnitude	**Unit**	**Symb.**	**Scient. Not.**	**Fixed System**	**Moving System**
Electric Charge ***q***	Coulomb	C	$A.s$	$q=q_0$	$q'=q_0$
Voltaje ***V=W/I***	Volt	V	$m^2.kg.s^{-3}.A^{-1}$	$V=\sqrt{1-\frac{v^2}{c^2}}.V_0$	$V'=V_0$
Current ***I***	Amper	A	A	$I=\sqrt{1-\frac{v^2}{c^2}}.I_0$	$I'=I_0$
Resistance ***R = V/I***	Ohm	Ω	$m^2.kg.s^{-3}.A^{-2}$	$R=R_0$	$R'=R_0$
Capacitance ***C = q/V***	Farad	F	$m^{-2}.kg^{-1}.s^4.A^2$	$C=\frac{C_0}{\sqrt{1-\frac{v^2}{c^2}}}$	$C'=C_0$
Electric Field ε ***=F/q***	$\frac{\text{Newton}}{\text{Coulomb}}$	$\frac{N}{C}$	$m.kg.s^{-3}.A^{-1}$	$\varepsilon=\varepsilon_0$	$\varepsilon'=\varepsilon_0$
Magnetic Field (***B ~ F/q.v)***	Tesla	T	$kg.s^{-2}.A^{-1}$	$B=\frac{B_0}{\left(1-\frac{v^2}{c^2}\right)}$	$B'=B_0$
Magnetic Flux Φ	Weber	Wb	$m^2.kg.s^{-2}.A^{-1}$	$\Phi=\Phi_0$	$\Phi'=\Phi_0$
Mutual Inductance ***M = -V/(dI/dt)***	Henry	M	$m^2.kg.s^{-2}.A^{-2}$	$M=\frac{M_0}{\sqrt{1-\frac{v^2}{c^2}}}$	$M'=M_0$
Magnetic Permeability	$\frac{\text{Henry}}{\text{meter}}$	μ	$m.kg.s^{-2}.A^{-2}$	$\mu=\frac{\mu_0}{\left(1-\frac{v^2}{c^2}\right)}$	$\mu'=\mu_0$

Electric Permittivity	$\frac{\text{Farad}}{\text{meter}}$	$\in$	$m^{-3}.kg^{-1}.s^{4}.A^{2}$	$\in=\frac{\in_0}{\left(1-\frac{v^2}{c^2}\right)}$	$\in'=\in_0$
Electric Displacement **D = ϵ.ε**	$\frac{\text{Farad}}{\text{meter}}.\frac{\text{Newton}}{\text{Coulomb}}$	D	$m^{-2}.A.s$	$D=D_0$	$D'=D_0$

VI PHOTOMETRY SI DERIVED UNITS

TABLE 5

Photometric SI derived units and their Local Lorentz Transformations (LLT)

Magnitude	Unit	Symb.	Scient. Not.	Fixed System	Moving System
Luminous Intensity ***I_v***	candela	I_V	cd	$I_v=\left(1-\frac{v^2}{c^2}\right).I_{v0}$	$I'_v=I_{v0}$
Luminous Flux ***F_v***	lumen	F_V	$cd.sr$	$F_V=\left(1-\frac{v^2}{c^2}\right).F_{V0}$	$F_V'=F_{V0}$
Luminous Energy ***Q***	lumen second	Q_V	$lm.s$	$Q_V=\sqrt{1-\frac{v^2}{c^2}}.Q_{V0}$	$Q_V'=Q_{V0}$
Luminance ***L_v***	$\frac{\text{candela}}{\text{meter}^2}$	L_V	$\frac{cd}{m^2}$	$L_V=L_{V0}$	$L_V'=L_{V0}$
Illuminance ***E_v***	$lux=\frac{\text{lumen}}{\text{meter}^2}$	E_V	lx	$E_V=E_{V0}$	$E_V'=E_{V0}$
Emitance ***M_v***	$lux=\frac{\text{lumen}}{\text{meter}^2}$	M_V	lx	$M_V=M_{V0}$	$M_V'=M_{V0}$

VII RADIOMETRY SI DERIVED UNITS

TABLE 6

Radiometry SI derived units and their Local Lorentz Transformations (LLT)

Magnitude	Unit	Symb.	Scient. Not.	Fixed System	Moving System
Radiant Intensity ***I***	$\frac{\text{watt}}{\text{steradian}}$	I	$W.sr^{-1}$	$I=\left(1-\frac{v^2}{c^2}\right).I_0$	$I'_v = I_0$
Radiant Flux ***Φ***	watt	Φ	W	$\Phi=\left(1-\frac{v^2}{c^2}\right).\Phi_0$	$\Phi'=\Phi_0$

Radiant Energy ***Q***	joule	Q	J	$Q=\sqrt{1-\frac{v^2}{c^2}}.Q_0$	$Q'=Q_0$
Radiance ***L***	$\frac{\text{watt}}{\text{steradian.meter}^2}$	L	$W.sr^{-1}m^{-2}$	$L=L_0$	$L'=L_0$
Irradiance ***E***	$\frac{\text{watt}}{\text{meter}^2}$	E	$W.m^{-2}$	$E=E_0$	$E'=E_0$
Radiant exitance, Radiant emitance	$\frac{\text{watt}}{\text{meter}^2}$	M	$W.m^{-2}$	$M=M_0$	$M'=M_0$
Radiosity	$\frac{\text{watt}}{\text{meter}^2}$	J_λ	$W.m^{-2}$	$J_\lambda=J_{\lambda 0}$	$J_\lambda'=J_{\lambda 0}$
Spectral radiance	$\frac{\text{watt}}{\text{steradian.meter}^3}$	L_λ	$W.sr^{-1}m^{-3}$	$L_\lambda=\frac{L_{\lambda 0}}{\sqrt{1-\frac{v^2}{c^2}}}$	$L_\lambda'=L_{\lambda 0}$
Spectral irradiance	$\frac{\text{watt}}{\text{steradian.meter}^3}$	E_V	$W.sr^{-1}m^{-3}$	$E_\lambda=\frac{E_{\lambda 0}}{\sqrt{1-\frac{v^2}{c^2}}}$	$E_V'=E_{V0}$

VIII OTHER SI DERIVED UNITS

TABLE 7

Other SI derived units and their Local Lorentz Transformations (LLT)

Magnitude	**Unit**	**Symb.**	**Scient. Not.**	**Fixed System**	**Moving System**
Dynamic viscosity	Pascal second	$Pa.s$	$m^{-1}.kg.s^{-1}$	$D_v=\frac{D_{v0}}{\left(1-\frac{v^2}{c^2}\right)^{\frac{3}{2}}}$	$D'_v=D_{v0}$
Heat Capacity ***C**v*, Entropy ***S***	$\frac{\text{Joule}}{\text{Kelvin}}$	S	$m^2.kg.s^{-2}.K^{-1}$	$S=S_0$	$S'=S_0$
Thermal conductivity	$\frac{\text{Watt}}{\text{meter.Kelvin}}$	$\frac{W}{m.K}$	$m^1.kg.s^{-3}K^{-1}$	$T_C=T_{C0}$	$T_C'=T_{C0}$
Molar energy	$\frac{\text{Joule}}{\text{mole}}$	$\frac{J}{mol}$	$m^2.kg.s^{-2}.mol^{-1}$	$E_M=\sqrt{1-\frac{v^2}{c^2}}.E_{M0}$	$E_M'=E_{M0}$
Molar entropy, molar heat capacity	$\frac{\text{Joule}}{\text{mole.Kelvin}}$	$\frac{J}{mol.K}$	$m^2.kg.s^{-2}.mol^{-1}K^{-1}$	$S_M=S_{M0}$	$S_M'=S_{M0}$

Becquerel ***Bq***	$Bq = \frac{\text{Decays}}{\text{second}}$	$\frac{1}{s}$	s^{-1}	$Bq = \frac{Bq_0}{\left(1 - \frac{v^2}{c^2}\right)}$	$Bq' = Bq_0$
Absorbed dose of ion. radiation	$Gray = \frac{Joule}{kg}$	$\frac{J}{kg}$	$m^2.s^{-2}$	$Gy = \left(1 - \frac{v^2}{c^2}\right)^2 .Gy_0$	$Gy' = Gy_0$

VIII MAXWELL EQUATIONS

It can be shown that Maxwell Equations that holds in any reference system it also can be done under Local Lorentz Transformations. By taking into account that:

$\nabla' = \frac{\partial}{\partial r'} = \frac{\partial}{\frac{\partial r}{\sqrt{1 - \frac{v^2}{c^2}}}} \Rightarrow \nabla' = \sqrt{1 - \frac{v^2}{c^2}}.\nabla$, and that $\nabla' = \nabla_0$:

1) $$\nabla' \times \vec{\boldsymbol{\varepsilon}}' = -\frac{\partial \mathbf{B}'}{\partial t'} \Rightarrow \sqrt{1 - \frac{v^2}{c^2}}\nabla \times \vec{\boldsymbol{\varepsilon}} = -\frac{\partial \mathbf{B}\left(1 - \frac{v^2}{c^2}\right)}{\partial t.\sqrt{1 - \frac{v^2}{c^2}}} \Rightarrow \nabla \times \vec{\boldsymbol{\varepsilon}} = -\frac{\partial \mathbf{B}}{\partial t}$$

2) $$\nabla' \times \mathbf{H}' = \frac{\partial \mathbf{D}'}{\partial t'} + \mathbf{J}' \Rightarrow \sqrt{1 - \frac{v^2}{c^2}}\nabla \times \mathbf{H} = \frac{\partial \mathbf{D}.\left(1 - \frac{v^2}{c^2}\right)}{\partial t.\sqrt{1 - \frac{v^2}{c^2}}} + \mathbf{J}.\sqrt{1 - \frac{v^2}{c^2}} \Rightarrow \nabla \times \mathbf{H} = \frac{\partial \mathbf{D}}{\partial t} + \mathbf{J}$$

3) $$\nabla' \bullet \mathbf{D}' = \rho' = \frac{q'}{V'} \Rightarrow \sqrt{1 - \frac{v^2}{c^2}}\nabla \bullet \mathbf{D}.\left(1 - \frac{v^2}{c^2}\right) = \frac{q}{\frac{V}{\left(1 - \frac{v^2}{c^2}\right)^{\frac{3}{2}}}} \Rightarrow \nabla \bullet \mathbf{D} = \rho$$

4) $$\nabla' \bullet \mathbf{B}' = \mathbf{0} \Rightarrow \nabla \bullet \mathbf{B}.\left(1 - \frac{v^2}{c^2}\right) = \mathbf{0} \Rightarrow \nabla \bullet \mathbf{B} = \mathbf{0}$$

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