Part I

Special Theory of Time-Asymmetric Relativity [1] [2]

The expanding-universe cosmology is founded on the assumption that Einstein's Relativity is applicable to the entire universe. This cosmology "settles" difficulties not by revealing the relevant theoretical elements missing from Modern Physics but by introducing huge fantastic "realities" (expansion, inflation, horizon, acceleration, dark matter, dark energy, and absurdly ultra-high luminosity of quasars). When applied to much smaller domains, Einstein's Relativity is of a superb quality. Huge fantastic "realities" are characteristics of a simplified theory that is applied outside the domain where it is useful; Einstein's Relativity might thus be a simplification of a more general theory which can be attained by a process of modification. A starting-point for this modification is found in Richard Feynman's lecture "Symmetry in Physical Laws". He discusses there "... a very interesting symmetry which is obviously false, i.e., *reversibility in time*" (Feynman, 1963). This false symmetry should not be present in a universally applicable theory. In this part, it is shown that Einstein's Special Relativity is a simplification of Time-Asymmetric Special Relativity. A universally applicable theory should be founded on Time-Asymmetric Special Relativity, not on its time-symmetric simplification. Relativity's fundamental invariant quantity, the length of a linear element in space-time, is preserved under any definition, invariant-rate *or variant-rate*, of the unit of time (and consequently, under constant *or variant* speed of light). It is fashionable to interpret this fact as evidence that time is a human fiction of no physical significance (Hsu & Hsu, 1994). But the quest for Time-Asymmetric Relativity, the pattern of the fundamental

[1] The time-coordinate reversal operation on this scheme is an asymmetric operation.

[2] A former version of this article appears in *Apeiron*, Vol. 12, No. 3, July 2005.

quantities, and extra-galactic observations yield a different interpretation: *In addition to the familiar invariant-rate time, there flows another kind of time, which, unlike the familiar time, does not flow in step with oscillations. The rate of this time with respect to oscillations undergoes a directionally periodic evolution.* The cosmological red-shift, the cosmological background radiation, glowing nebulas, newborn stars rich in hydrogen and high-energy cosmic rays are observable consequences of the flow of the variant-rate time. Descriptions of physical reality which use only the invariant-rate time are incorrect, even though they are useful in the domain where the consequences of the variant-rate time are negligible.

1. Principle of Time

Mass, length and time are fundamental quantities. It has already been *partially* realized that there are two kinds of mass: inertial mass and gravitational mass; the two kinds of mass are still wrongly described by the same unit, and another significant distinction between them has not been yet recognized. It has also been *partially* realized that there are two kinds of length: length of rigid rods, and length of linear elements in space-time. Time-Asymmetric Relativity is founded on the view that there are two kinds of time: in addition to the familiar invariant-rate time, which describes the w-coordinates of events (their projections on the world-line of the relevant reference frame), *there also flows the variant-rate time*. The flow of the variant-rate time undergoes a *directionally* periodic evolution, a property which justifies the name "**true time**". Consequently, a postulate which is missing in Einstein's Relativity is Principle of Time, which is introduced below together with two reformulated known postulates. Thus, Time-Asymmetric Relativity departs from the customary view by which time is homogeneous and isotropic; time is non-homogeneous and directional due to the directional flow of the variant-rate time and due to its corresponding fundamental parameter, which is the fundamental variant of Nature.

Principle of Time-Asymmetric Relativity

Relativity of physical quantities is due to the invariance of the mathematical principles of Nature, due to the invariance of its universal constants, and due to its fundamental variant.

Principle of Space

With respect to the invariant-rate time the speed of light in vacuum is a universal constant.

Principle of Time

With respect to the variant-rate time the speed of light in vacuum is a directionally periodic function of the common coordinate. [3]

Einstein's principle of relativity can be reformulated:

Principle of Time-Symmetric Relativity

Relativity of physical quantities is due to the invariance of the mathematical principles of Nature and due to the invariance of its universal constants.

The introduction of Principle of Time-Symmetric Relativity and Principle of Space, have superbly explained central observations that cannot be explained by Classical Physics. In the same way, the introduction of Principle of Time-Asymmetric Relativity and Principle of Time, superbly explains central observations that cannot be explained by Modern Physics.

The graph of the variant speed of light versus the common coordinate is a "saw tooth" type: it decreases along very large intervals (order of tens billions invariant-rate years) and increases along shorter intervals. The increasing phase and the decreasing phase are distinguished from each other by definite characteristic slopes such that the time-coordinate reversal operation on that function is an asymmetric operation. The

[3] The common coordinate is the w-coordinate in the center of the gravitational mass of the relevant cosmological system; it is explained in Part II.

variant speed of light is an indispensable part of the non-simplified laws of physics and of the non-simplified description of physical reality. Thus, due to the presence of the variant speed of light, the non-simplified physics is time-asymmetric.

2. The Four-Dimensional Continuum

As a preparation for the time-asymmetric modification of Special Relativity, an oversight regarding fundamental quantities needs to be corrected. Inertial mass and gravitational mass are customarily described by the same unit of mass, and length in space and length in space-time are also customarily described by the same unit of length. This misleading simplification, which contributes indirectly to the current cosmological confusion, is definitely incorrect. Different physical quantities should be described by different units even if they constitute a complementary pair (carry the same "last name"). Mass, length and time are three complementary pairs: inertial mass and gravitational mass, variant length (of rigid rods[4]) and invariant length (of linear element in space-time), variant-rate time and invariant-rate time;[5] they are respectively denoted:

$$[M_{in}] \quad [M_{gr}] \qquad [L_{va}] \quad [L_{iv}] \qquad [T_{vr}] \quad [T_{ir}]$$

Minkowski metric and Lorentz transformations of space-time are essentially correct, but they are expressed in a wrong physical unit—variant length instead of invariant length. In order that the time-asymmetric modification will be done on a healthy ground, this defect should be removed.

In the four-dimensional continuum, all particles move continuously along their world-lines. That motion will be referred to as motion in space-time (motion in 4d). The motion in 4d complements the motion in space

[4] The length of a rigid rod at a certain epoch depends on the reference frame.
[5] In Part IV the complementary companion of the electric charge is introduced.

(motion in 3d, or simply motion). Photons' world-lines identically vanish; consequently, the speed of light in 4d is zero. Photons, like any other particles, move continuously along their world lines, but, along all their existence, photons are at zero invariant distance from their emission events (the crucial cosmological significance of this mathematical fact cannot be realized by Time-Symmetric Relativity). The invariant length of an infinitesimal interval on a massive particle's world-line equals numerically to the variant distance traveled during this interval by light relative to this particle in its empty space vicinity; the equality is numerical but the units are different.

Let w_{iL}, x_{iL}, y_{iL}, z_{iL} be the four coordinates, expressed in invariant length units, of an inertial frame. For a correct description of the motion of a massive particle along its w-axis (its world-line) an additional universal constant, c_{iL}, should be introduced; it is the speed in 4d of massive matter in its own reference frame with respect to the invariant-rate time, in short **the constant speed of matter**. The numerical value of c_{iL} equals to the numerical value of the constant speed of light, c_{vL}, and its physical units are invariant length over invariant-rate time.

$$c_{iL} = \frac{[L_{iv}]}{[L_{va}]} c_{vL} \tag{I.1}$$

For an infinitesimal flow of invariant-rate time dt_{ir} experienced by a particle the corresponding propagation of that particle along its world-line is:

$$dw_{iL} = c_{iL} dt_{ir} \tag{I.2}$$

The faster the motion in space of a particle, the slower is its motion in space-time. Let v_{vL} denotes the speed in space of a particle then its speed in space-time is:

$$\nu_{iL} = \sqrt{1 - \frac{\nu_{vL}^{2}}{c_{vL}^{2}}} \quad c_{iL}$$

Or more elegantly:

$$\beta_{vL}^{2} + \beta_{iL}^{2} = 1 \tag{I.3}$$

Where β_{vL} and β_{iL} are correspondingly, the fractional velocity in space and the fractional velocity in space-time of a particle.

Along one invariant-rate second which elapses in the reference frame of a particle, that particle is propagated $299{,}792.5 \pm 0.1$ invariant kilometers along its world-line. Note that the last sentence makes no sense when the distance is expressed in variant kilometers. Also distances along the three spatial axes in space-time, which practically are measured along axes in space, should be translated to invariant length units—all the coordinates of a physical continuum should be described by the same physical unit (the translation relations are given bellow in formulas I.5). Intervals which, in principle, can be traveled by particles are called time-like intervals and are of real invariant lengths. Intervals which, in principle, cannot be traveled by any observable particle are called space-like intervals and are of imaginary invariant lengths. The spatial coordinates axes in the four dimensional continuum are not the same as the spatial coordinates in the three dimensional space. The spatial axes in space-time are constituted of events which are simultaneous to the origin event and are oriented in three mutually orthogonal spatial directions; they cannot be represented by rigid rods. No particle can travel along the spatial axes in space-time. Thus, every interval on the spatial axes of a 4d frame is a space-like interval; therefore, the three spatial coordinates of any event are of imaginary values. Every interval on the w-axis is a time-like interval; it is traveled by the particle which "owns" the reference frame. Therefore, the w-coordinate of any event is real.

Based on the above considerations, it can be shown that the metric of the four-dimensional continuum is actually a Cartesian metric. Let

$(dw_{iL},\ \ dx_{iL},\ \ dy_{iL},\ \ dz_{iL})$ be an infinitesimal linear element in space-time. The squared length of this linear element is the *sum* of the squares of its four components:

$$ds_{iL}^2 = dw_{iL}^2 + dx_{iL}^2 + dy_{iL}^2 + dz_{iL}^2 \tag{I.4}$$

The following relations hold true:

$$dw_{iL} = dw_{vL}\frac{c_{iL}}{c_{vL}} \quad dx_{iL} = idx_{vL}\frac{c_{iL}}{c_{vL}} \quad dy_{iL} = idy_{vL}\frac{c_{iL}}{c_{vL}} \quad dz_{iL} = idz_{vL}\frac{c_{iL}}{c_{vL}} \tag{I.5}$$

Where the suffix "vL" means: "expressed in variant length units".

Expressing (1.4) in variant length units we get:

$$dw_{iL}^2 + dx_{iL}^2 + dy_{iL}^2 + dz_{iL}^2 = [dw_{vL}^2 - dx_{vL}^2 - dy_{vL}^2 - dz_{vL}^2]\frac{{c_{iL}}^2}{{c_{vL}}^2} \tag{I.6}$$

Equation (1.6) shows how the Cartesian metric of space-time is converted to the Minkowski hyperbolic metric when space-time is described in variant length units.

Let us consider two inertial frames:

$\mathrm{K}(w_{iL},\ \ x_{iL},\ \ y_{iL},\ \ z_{iL}),\qquad \mathrm{K}'(w'_{iL},\ \ x'_{iL},\ \ y'_{iL},\ \ z'_{iL})$

K′ moves with respect to K at a uniform velocity $\beta c_{vL}\hat{x}$. Simultaneously to the common origin event the corresponding Y-axes and the corresponding Z-axes coincide. The transformation, from K to K′, of the four coordinates expressed in invariant length units is then:

$$
\begin{aligned}
w'_{iL} &= \gamma(+w_{iL} + i\beta x_{iL}) \\
x'_{iL} &= \gamma(-i\beta w_{iL} + x_{iL}) \\
y'_{iL} &= y_{iL} \quad z'_{iL} = z_{iL}
\end{aligned}
\tag{I.7}
$$

Or in matrix representation:
$$
\begin{pmatrix} \gamma & i\beta\gamma & 0 & 0 \\ -i\beta\gamma & \gamma & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}
$$

Where $\gamma = (1-\beta^2)^{-\frac{1}{2}}$

Transformation I.7 is the non-simplified origin of the familiar Lorentz transformation. Under this non-simplified transformation any linear element of space-time is invariant:

$$
dw'^{\,2}_{iL} + dx'^{\,2}_{iL} + dy'^{\,2}_{iL} + dz'^{\,2}_{iL} = dw_{iL}^{\,2} + dx_{iL}^{\,2} + dy_{iL}^{\,2} + dz_{iL}^{\,2} \tag{I.8}
$$

The familiar Lorenz transformation, which preserves the hyperbolic linear element, is obtained from (1.7) by expressing the four coordinates of space-time in variant length units (see relations 1.5), and then dividing the first equation by $\frac{c_{iL}}{c_{vL}}$ and the second, the third and the fourth equations by $i\frac{c_{iL}}{c_{vL}}$:

$$
\begin{aligned}
w'_{vL} &= \gamma(+w_{vL} - \beta x_{vL}) \\
x'_{vL} &= \gamma(-\beta w_{vL} + x_{vL}) \\
y'_{vL} &= y_{vL} \quad z'_{vL} = z_{vL}
\end{aligned}
\tag{I.9}
$$

$$\begin{pmatrix} \gamma & -\beta\gamma & 0 & 0 \\ -\beta\gamma & \gamma & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

3. Time-Asymmetric Kinematics

The correct description of the four-dimensional continuum requires the exclusive usage of invariant length. The kinematics and the dynamics of moving bodies, however, necessarily require the usage of variant length and the usage of time. This necessity is the reason that variant length and time are used also for simplified descriptions of the four-dimensional continuum. From here on, variant length and time are used unless it is explicitly indicated differently.

Time-asymmetric observations require uses of quadruple-display devices; each device consists of:

1. A SI chronometer displaying the elapsing invariant-rate time, τ , in SI invariant-rate seconds. It is measured since an arbitrarily chosen zero event. The SI homogeneous time, which is the most accurately defined invariant-rate time, is displayed in accordance with:

$$d\tau = \frac{dN}{N_{SI}} \tag{I.10}$$

N denotes the number of counted cycles of the resonance vibration of the cesium-133 atom (cycles of the radiation corresponding to the transition between two hyperfine levels of the ground state of that atom), $N_{SI} \equiv 9{,}192{,}631{,}770$ cycles (of the same radiation) per SI invariant-rate second (Jerrard, 1992).

2. A display of the time-coordinate in invariant meters. w_{iL} is measured from the same zero event. This quantity is displayed in accordance with:

$$dw_{iL} = c_{iL} d\tau \tag{I.11}$$

Where c_{iL} denotes the constant speed of matter.

3. A display of the variant speed of light, $\mathrm{v}_{(w)}$ (in variant meters per variant-rate second). According to the gravitational part of Periodic Physics which is introduced in Part II, the gravitational potential depends on the variant speed of light. Light is continuously at zero invariant distance from its emission event and it preserves the gravitational potential of that event (in the reference frame of the absorbing matter). By applying the theory of macro gravitation on the extra-galactic observations, the evolution of the variant speed of light during the observable past can be evaluated.[6] The third display shows, therefore, an extrapolation of the function that is obtained from the extra galactic observations.

4. A display of the variant-rate time, t, in variant-rate seconds. The time-asymmetric magnitude of an infinitesimal time-interval equals to the invariant distance traveled by the device during that time-interval divided by the value of the variant speed of matter in that interval:

$$dt = \frac{dw_{iL}}{\mathrm{v}_{iL}} \tag{I.12}$$

The quantity V_{iL}^{-1} can be called **time-density**, the time-density along world-lines evolves continuously. Equation (I.12) demonstrates that a correct description of the evolution of the variant speed of light is essentially the same thing as a correct description of the flow of the

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6 The expanding-universe model results from the application of Einstein's General Relativity outside the domain where it is useful; it is shown in Part II that the expansion of the universe is required neither for explaining the extra-galactic observations nor for explaining the fact that the universe has not collapsed and does not seem to be in a process of collapse.

variant-rate time and vice versa. Let $N_{(w)}$, the number of cycles (of the radiation mentioned above) per variant-rate second, be a correct description of the flow of the true time (it is convenient to define $N_{(0)} = N_{SI}$), then

$$\mathrm{v}_{(w)} = \frac{N_{(w)}}{N_{SI}} c \tag{I.13}$$

After an unlimited number of identical quadruple-display devices are prepared, a local inertial frame[7] will be chosen whose Cartesian system of coordinates is calibrated according to the SI definition of the length-unit. The devices will be distributed within this system such that all the SI chronometers are mutually synchronized according to Einstein's definition of synchronization (Einstein, 1952). Since there is a one-to-one mapping between each of the quantities w_{iL}, t, $\mathrm{v}_{(w)}$ and τ, then all the other displays will also be synchronized. The above system can be regarded as two inertial frames which share a common system of spatial coordinates: one frame provides an approximate description of the flow of the variant-rate time, and will be called the "time-asymmetric frame"; the other frame provides the customary description of the flow of the invariant-rate time, and will be called the "time-symmetric frame".

The magnitude of a squared linear element between two infinitesimally close events with respect to the time-asymmetric frame is $\mathrm{v}^2 dt^2 - dr^2$,[8] where dt and dr are the variant-rate time interval and the spatial interval, respectively, and v is the quasi-constant value of the variant speed of light assigned by this frame to the infinitesimal region under consideration. The same squared interval with respect to the time-symmetric frame is $c^2 d\tau^2 - d\sigma^2$, where $d\tau$ and $d\sigma$ are the invariant-rate time interval and the spatial interval, respectively. Due to the absence of relative motion, and since all the variant-rate chronometers, like all the SI chronometers, are synchronized, there is complete agreement between the two frames with respect to simultaneity. Events are simultaneous with respect to one frame if and only if they are simultaneous with respect to

7 In an inertial frame a free particle moves at uniform velocity.

8 Variant length is applied here, thus the metric is hyperbolic.

the other. And since both frames share a common system of spatial coordinates, there is also complete agreement about spatial intervals, therefore

$$dr = d\sigma \tag{I.14}$$

The quantities $\mathrm{v}dt$ and $cd\tau$ are the radius of the light sphere emitted at the first event simultaneously to the second event with respect to the time-asymmetric frame and the time-symmetric frame, respectively. This physical reality is described in both frames by equal quantities, thus

$$\mathrm{v}dt = cd\tau \tag{I.15}$$

From (I.14) and (I.15) we get

$$\mathrm{v}^2\, dt^2 - dr^2 = c^2 d\tau^2 - d\sigma^2 \tag{I.16}$$

A linear element evaluated in a time-asymmetric inertial frame is preserved in a moving-together time-symmetric frame.

A linear element evaluated in a time-asymmetric inertial frame is preserved in all the time-asymmetric frames that move at uniform motion relative to that frame. This fact is the actual mathematical content of the Principle of Relativity (the true velocity of a free particle is proportional to the variant speed of light; the term uniform in this context refers to the fractional magnitude of the velocity). To any of those time-asymmetric frames, a frame can be attached in which the speed of light is an arbitrary smooth function of the time-coordinate. This operation leaves the linear element preserved. This is true because equation (I.16) is valid also when the constant speed of light is replaced with other arbitrary smooth descriptions of the speed of light. A linear element is, therefore, preserved in all systems that rest or move at uniform motion with respect to a time-asymmetric inertial frame under any constant or smooth definition of the variant speed of light. This crucial fact is guaranteed by the following transformation

$$
\begin{aligned}
d\tau &= \frac{\mathrm{v}}{\mathrm{v}'}\gamma\left(dt - \beta\frac{dx}{\mathrm{v}}\right) \\
d\xi &= \gamma\left(dx - \beta\mathrm{v}\,dt\right) \\
d\eta &= dy \quad , \quad d\zeta = dz
\end{aligned}
\tag{I.17}
$$

Where $\qquad 0 \le \beta < 1 \quad , \quad \gamma \equiv \left(1-\beta^2\right)^{-\frac{1}{2}} \quad , \quad 0 < \mathrm{v}, \mathrm{v}' < \infty$

Transformation (I.17) deals with two frames: a time-asymmetric inertial frame, frame **1,** and another inertial frame, frame **2**. In Frame **1** the true description of the variant speed of light v is applied, while frame **2** assigns to space-time some arbitrary description of the variant speed of light v', which is a gradually evolving or a constant function of its time-coordinate. Frame **2,** whose Cartesian coordinates are parallel to the corresponding coordinates of frame **1,** moves with respect to the latter at a uniform velocity $\beta\mathrm{v}\,\hat{x}$, where $\hat{x}$ is the unit vector in the positive direction of the X-axis. At the common zero event, the origins of the two frames coincide. The differential four-vector under consideration is $\left(dt, dx, dy, dz\right)$ with respect to frame **1** and $\left(d\tau, d\xi, d\eta, d\zeta\right)$ with respect to frame **2**.

Let us consider an infinitesimally small element on the world-line of a moving point-like body. From (I.14) and (I.15) it follows that for frames moving together the ratio between the speed of a body and the variant speed of light is invariant under any gradually evolving (or constant) definition of the variant speed of light. Consequently, by symmetry considerations, since the velocity of **2** as viewed from **1** is $\beta\mathrm{v}\,\hat{x}$, the velocity of **1** as viewed from **2** is $-\beta\mathrm{v}'\,\hat{\xi}$. From here, the inverse transformation follows:

$$
\begin{aligned}
dt &= \frac{\mathrm{v}'}{\mathrm{v}}\gamma\left(d\tau + \beta\frac{d\xi}{\mathrm{v}'}\right) \\
dx &= \gamma\left(d\xi + \beta\mathrm{v}'\,d\tau\right) \\
dy &= d\eta \quad , \quad dz = d\zeta
\end{aligned}
\tag{I.17$'$}
$$

Transformation (I.17) guarantees the preservation of a linear infinitesimal interval (expressed in variant length units) not only under uniform motion, but also under any gradually evolving (or constant) arbitrary definition of the variant speed of light.

$$v'^2\, d\tau^2 - d\xi^2 - d\eta^2 - d\zeta^2 = v^2\, dt^2 - dx^2 - dy^2 - dz^2 \tag{I.18}$$

Equation (I.18) demonstrates that the metric of space-time is invariant under arbitrary substitutions of the variant speed of light. This is the ultimate reason for the success of the Time-Symmetric Special Relativity, which substitutes the variant speed of light with the universal constant speed of light. The metric of space-time does not depend on the true description of the flow of the variant-rate time. Consequently the flow of the variant-rate time can be observed only where the non-homogeneity of time has observable consequences. In the domain where such consequences are absent, the customary, invariant-rate, description of the flow of time is useful despite its limited applicability. Equation (I.18) raises an interesting possibility. It is possible that for different systems the evolution of the variant speed of light in the same region is different. This possibility cannot *a priori* be dismissed. We shall see in Part II that it will help to explain certain observations which otherwise have no satisfying explanation.

4. Time-Asymmetric Electrodynamics

The time-asymmetric laws of physics can systematically be derived from their familiar time-symmetric simplifications. A time-asymmetric law should hold true where the time-asymmetric description of physical reality is applied. This is the case when the law satisfies the following two requirements:

1. It reduces exactly to the corresponding time-symmetric law when the variant speed of light is substituted by the constant speed of light.

2. It is invariant under a **time-transformation**.

A time-transformation transforms a familiar customary, time-homogeneous, description of physical reality in an inertial frame into a true, time-asymmetric, description in a co-moving true frame. The time transformation of space-time is:

$$dt_{tr} = \frac{c}{\mathrm{v}} dt_{ho}$$
$$dx_{tr} = dx_{ho} \quad , \quad dy_{tr} = dy_{ho} \quad , \quad dz_{tr} = dz_{ho} \tag{I.19}$$

The true description of space is identical to the time-symmetric description of space. The same thing is true regarding the time-coordinate. The true magnitude of an infinitesimal time-interval, however, is inversely proportional to the variant speed of light (proportional to the time-density).

The differential operator $m_{(c,0)} \frac{d}{d\tau}$ will be applied to the four-vector $(t, x, y, z,)_{(t')}$ which describes the world-line of a particle with respect to a true inertial frame. $m_{(c,0)}$ denotes the time-symmetric rest-mass of the particle, and τ denotes the invariant-rate time in an inertial frame which initially moves together with the particle. This operation will result in a contravariant four-vector whose components transform as the components of a space-time four-vector. From (I.17′) it is deduced that $dt = \frac{c}{\mathrm{v}} \gamma d\tau$, where $\beta \mathrm{v}$ is the initial speed of the particle and $\gamma \equiv (1-\beta^2)^{-\frac{1}{2}}$. It therefore follows that $m_{(c,0)} \frac{d}{d\tau} = \frac{c}{\mathrm{v}} m_{(c,0)} \gamma \frac{d}{dt}$ and the contravariant four-vector created is:

$$\left(\frac{c}{\mathrm{v}} m_{(c,0)} \gamma \quad , \quad \frac{c}{\mathrm{v}} m_{(c,0)} \gamma \frac{dx}{dt} \quad , \quad \frac{c}{\mathrm{v}} m_{(c,0)} \gamma \frac{dy}{dt} \quad , \quad \frac{c}{\mathrm{v}} m_{(c,0)} \gamma \frac{dz}{dt} \right) \tag{I.20}$$

Generalizing the concept of relativistic inertial mass we shall define :

$$m_{(\mathrm{v},\beta)} = \frac{c}{\mathrm{v}} m_{(c,0)} \gamma \tag{I.21}$$

$m_{(\mathrm{v},\beta)}$, the time-asymmetric inertial mass, depends not only on the particle itself and on its fractional velocity β, but also on the observer's time-density. We have obtained a momentum-mass (inertial mass) four-vector $(m, \vec{p})$. Note that the physical units of the time-asymmetric description of inertial mass are: $\frac{[T_{vr}]}{[T_{ir}]}[M_{in}]$

Generalizing the concept of total relativistic energy we get:

$$E_{(\mathrm{v},\beta)} = m_{(\mathrm{v},\beta)}\,\mathrm{v}^2 \qquad \text{(I.22)}$$

Our new four-vector can be represented also as a momentum-energy four-Vector: $\left(\frac{E}{\mathrm{v}^2}, \vec{p}\right)$

Let $\left(\frac{H}{\mathrm{v}^2}, p_x, p_y, p_z\right)$ and $\left(\frac{\Omega}{\mathrm{v}'^2}, p_\xi, p_\eta, p_\zeta\right)$ be the momentum-energy four-vectors assigned to a particle by frames **1** and **2** respectively. Being a contravariant four-vector, this vector is transformed like a space-time four-vector and therefore:

$$\begin{aligned} \Omega &= \frac{\mathrm{v}'}{\mathrm{v}}\gamma\left(H - \beta\,\mathrm{v}\,p_x\right) \\ p_\xi &= \gamma\left(p_x - \beta\frac{H}{\mathrm{v}}\right) \\ p_\eta &= p_y \quad , \quad p_\zeta = p_z \end{aligned} \qquad \text{(I.23)}$$

$$\begin{aligned} H &= \frac{\mathrm{v}}{\mathrm{v}'}\gamma\left(\Omega + \beta\,\mathrm{v}'\,p_\xi\right) \\ p_x &= \gamma\left(p_\xi + \beta\frac{\Omega}{\mathrm{v}'}\right) \\ p_y &= p_\eta \quad , \quad p_z = p_\zeta \end{aligned} \qquad \text{(I.23')}$$

From (I.18), the invariant quantity which is preserved under transformation of momentum-energy is:

$$\frac{\Omega^2}{\mathrm{v}'^2} - {p_\xi}^2 - {p_\eta}^2 - {p_\zeta}^2 = \frac{H^2}{\mathrm{v}^2} - {p_x}^2 - {p_y}^2 - {p_z}^2 \qquad \text{(I.24)}$$

Equation (I.24) is multiplied by c^2 to get the following invariant quantity, the particle's squared homogeneous rest-energy:

$$\frac{c^2}{\mathrm{v}^2} E^2 - c^2 \vec{p}^2 = c^4 m_{(c,0)}{}^2 \qquad \text{(I.25)}$$

Where E and $\vec{p}$ denote the particle's total relativistic energy and its linear momentum as viewed from the time-density v^{-1}.

The time transformation of momentum-energy is

$$H = \frac{\mathrm{v}}{c} \Omega \qquad \text{(I.26)}$$
$$p_x = p_\xi \quad , \quad p_y = p_\eta \quad , \quad p_z = p_\zeta$$

Under time-transformation, the momentum of a particle is invariant, while its energy is proportional to the variant speed of light. The particle's inertial mass is transformed like time and is, therefore, proportional to the observer's time-density (I.21). The time-symmetric description of space-like quantities is correct, while the time-symmetric description of time-like quantities does not provide a correct description of physical reality. [9] Under the assumption that time is homogeneous, rest-mass and rest-energy are constants, and the law of conservation of energy holds true. Time, however, is non-homogeneous. Rest-masses and rest-energies evolve continuously, and consequently the true energy of a closed system, unlike its customary energy, is not conserved. The continuous directional evolution of rest-masses and rest-energies and the continuous directional evolution of variant-rate time-periods of apparently periodic oscillators are some of the facts which rule out the customary idea that the arrow of time is not present where entropy is not defined. The arrow of time is intrinsically present in the correct description of physical reality from the

[9] The terms space-like and time-like are also used to distinguish between two different kinds of intervals in space-time. It is important to realize that space-like intervals as well as time-like intervals are space-like quantities.

very elementary level, and, as is shown hereafter, it is intrinsically present in the laws of physics from the very elementary level.

Newton's Second Law $\vec{F} \propto \frac{d\vec{p}}{dt}$ is the principal postulate of mechanics. This postulate asserts that the derivative of a particle's momentum with respect to time is proportional to the force exerted on it. This postulate splits to two sub-postulates:

Principle of Time-Symmetric Mechanics
The derivative of the momentum of a particle with respect to the invariant-rate time is proportional to the time-symmetric description of the force exerted on it.

Principle of Time-Asymmetric Mechanics
The derivative of the momentum of a particle with respect to the variant-rate time is proportional to the time-asymmetric description of the force exerted on it.

Under time-transformation, momentum is invariant (I.26) and time is proportional to the time-density (I.19). Defining a unity proportion constant, it follows that:

$$\vec{F}_{(\mathrm{v})} = \frac{\mathrm{v}}{c}\vec{F}_{(c)} \qquad \text{(I.27)}$$

$\vec{\mathrm{F}}_{(\mathrm{c})}$ is a force relative to a time-symmetric inertial observer and $\vec{\mathrm{F}}_{(\mathrm{v})}$ is this same force relative to a moving-together true frame.

Using the notations of the six fundamental physical units, which are introduced in section 2, an example of the difference in physical units between the homogeneous description and the true description, is introduced below. The physical units of the homogeneous description of a force are:

$$[\vec{F}_{(c)}] = \frac{[M_{in}][L_{va}]}{[T_{ir}]^2}$$

While the physical units of the true description of a force are:

$$[\vec{F}_{(\mathrm{v})}] = \frac{[M_{in}][L_{va}]}{[T_{vr}][T_{ir}]}$$

The electric charge of a particle, unlike its rest-mass, is an absolute quantity. This and the manner in which the electromagnetic field is defined in the cgs unit-system and (I.27) lead to the conclusion that in this unit-system, under a time-transformation, the magnitude of the electromagnetic field is proportional to the variant speed of light:

$$\vec{E}_{(\mathrm{v})} = \frac{\mathrm{v}}{c}\vec{E}_{(c)} \tag{I.28}$$

$$\vec{B}_{(\mathrm{v})} = \frac{\mathrm{v}}{c}\vec{B}_{(c)} \tag{I.29}$$

Where $\vec{E}$ denotes the electric field, and $\vec{B}$ denotes the magnetic field. From here, keeping in mind that velocity magnitudes are proportional to v, the following time-asymmetric Lorentz force can be obtained:

$$\vec{F}_{em} = q\left(\vec{E} + \frac{\vec{\upsilon}}{\mathrm{v}} \times \vec{B}\right) \tag{I.30}$$

$\vec{F}_{em}$ denotes the electromagnetic force exerted on a particle whose charge is q which moves in an electromagnetic field at velocity $\vec{\upsilon}$.

Under a time-transformation, the spatial derivative operation is invariant, whereas the time derivative operation is proportional to the variant speed of light. At the same time an electric charge has an absolute value, and consequently the electric charge density is invariant under time-transformation. These facts in combination with the two requirements mentioned in the beginning of this section lead to the following time-asymmetric modification of Maxwell's equations in cgs time-asymmetric units (variant **c**entimeter, inertial **g**ram, and variant-rate **s**econd):

$$
\begin{aligned}
\vec{\nabla} \times \vec{E} &= -\frac{1}{\mathrm{v}} \frac{\partial \vec{\mathrm{B}}}{\partial t} \\
\vec{\nabla} \times \vec{B} &= \frac{1}{\mathrm{v}} \frac{\partial \vec{\mathrm{E}}}{\partial t} + \frac{4\pi\rho}{c} \vec{\upsilon} \\
\vec{\nabla} \cdot \vec{E} &= \frac{\mathrm{v}}{c} 4\pi\rho \\
\vec{\nabla} \cdot \vec{B} &= 0
\end{aligned}
\qquad \text{(I.31)}
$$

Where $\vec{E}$ and $\vec{B}$ denote the electromagnetic field, and ρ and $\vec{\upsilon}$ denote the electric charge density and its velocity, respectively. Each term of equations (I.31) is proportional to the variant speed of light, and this is the reason why they hold true also under the time-symmetric substitution, $\mathrm{v} = c$.

For the SI version of the time-asymmetric modification of Maxwell's equations the universal constants ε_0 and μ_0, which appear in the time-symmetric equations, are replaced by the dependent variants $\varepsilon_{(\mathrm{v})} \equiv \frac{c\varepsilon_0}{\mathrm{v}}$ and $\mu_{(\mathrm{v})} \equiv \frac{c\mu_0}{\mathrm{v}}$, respectively

$$
\begin{aligned}
\vec{\nabla} \times \vec{\mathrm{E}} &= -\frac{\partial \vec{\mathrm{B}}}{\partial t} \\
\vec{\nabla} \times \vec{\mathrm{B}} &= \frac{1}{\mathrm{v}^2} \frac{\partial \vec{\mathrm{E}}}{\partial t} + \frac{c}{\mathrm{v}} \mu_0 \rho \vec{\upsilon} \\
\vec{\nabla} \cdot \vec{\mathrm{E}} &= \frac{\mathrm{v}}{\mathrm{c}\varepsilon_0} \rho \\
\vec{\nabla} \cdot \vec{\mathrm{B}} &= 0
\end{aligned}
\qquad \text{(I.32)}
$$

Due to the definition of the magnetic field in SI units, this vector is invariant under time transformation. Consequently each term of the second and the fourth equations is invariant under time transformation.

5. The Time-Asymmetric Origin of Modern Physics

In the former section a simple method has been used to reveal the time-asymmetric origin of Maxwell's electrodynamics. The time-asymmetric origin of any other partial theory can be revealed by applying the same simple method. Large-scale modern cosmology and modern particle physics are exceptions. These partial theories are spoiled not only by using only one kind of time, and they require additional modifications. The time-asymmetric modification is applicable on any time-symmetric physical law which has been experimentally verified under the time-symmetric description of physical quantities. The process which yields an improved physics in which the arrow of time is intrinsically present at any level is executed along the following algorithm:

1. According to the physical units of the law, determine whether each term of this law is invariant under a time-transformation or proportional to some power of the variant speed of light.

2. Time-transform all the variable quantities which appear in the law (do not touch any fundamental parameter yet).

3. A term that after the time-transformation satisfies requirement 1 appears unaltered in the time-asymmetric law (but here, the time-asymmetric description of physical quantities is required).

4. A term that does not satisfy requirement 1 after the time-transformation should be examined further:

5. If the constant speed of light appears in this term, then in the time-asymmetric origin of this law it is replaced by the variant speed of light.

6. If the constant speed of light does not appear in this term, then in the time-asymmetric origin of this law a factor of $\frac{v}{c}$ rose to an appropriate power appears in this term.

Conclusion

Time-Asymmetric Physics is based on the view that time is a complementary pair. The familiar invariant-rate time, which flows in step with the time-coordinate, is complemented by the variant-rate time. The introduction of the variant-rate time, whose rate with respect to oscillations is directionally periodic, is necessary for the correct description of the governing principles of nature and of physical reality. The introduction of the variant-rate time is in particular crucially necessary for large-scale cosmology, where time-symmetric physics is no more useful but misleading, and the non-homogeneity of time is of predominate observable consequences. The answer to the fundamental question: "Does physical reality governed by time-symmetric laws?" is definitely negative. Physical reality, at all levels, is governed by time-asymmetric laws!

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