SECTION 4

Motion and Relativity

THE PROBLEM

A *Spherical-Center-of-Oscillation* naturally sends a *Propagated Outward Flow* of *Medium* uniformly radially outward in all directions from itself at velocity c, the speed of light, as presented in Section 3. The speed of that flow is set by the μ_0 and ε_0 of the *Medium* to the exact value of c by virtue of their controlling the cyclical alternating exchange of the oscillation between the two forms in which it exists.

When the center is not in motion that presents no problem, but with the *Spherical-Center-of-Oscillation* moving in some direction the center's motion and its propagation are in conflict. In the direction of motion the velocity of the center, v, tends to add to the natural value of the speed, c, of propagation of the *Propagated Outward Flow* and in the opposite direction it tends to subtract. But, the speed of the flow is fixed; set at c by μ_0 and ε_0.

That conflict forces an adjustment of the oscillation of the *Spherical-Center-of-Oscillation* to modify its propagation speed of its *Propagated Outward Flow.*

THE Spherical-Center-of-Oscillation at Constant Velocity

The treatment is of the *Spherical-Center-of-Oscillation* at constant velocity because that is the more direct and simple case of motion, and at constant velocity one cannot detect absolute motion. That is, one can say that there is a relative difference of velocity between two systems at constant velocity in one of which the observer is located, but the observer cannot say which system is moving and which, if any, is at rest.

To describe the behavior of the center its propagation will be modeled resolved into three components: forward, rearward, and sideward relative to the direction of the center's velocity, as depicted in Figure 4-1. [In the figure the "up", "down", "left" and "right" are all "sideward".] These orthogonal components represent the propagated wave in all directions. The wave in any particular direction is the "resultant" of that directions' projection on the forward or rearward component (whichever is at a nearer angle) and on the sideward component. (The "resultant" is the hypotenuse of the right triangle having the projection components as its other two sides.)

When a center is at rest [absolute "rest" relative to its propagation] then propagation of waves is the same in all directions at speed $c = \lambda_r \cdot f_r$.

A Center-of-Oscillation at Rest

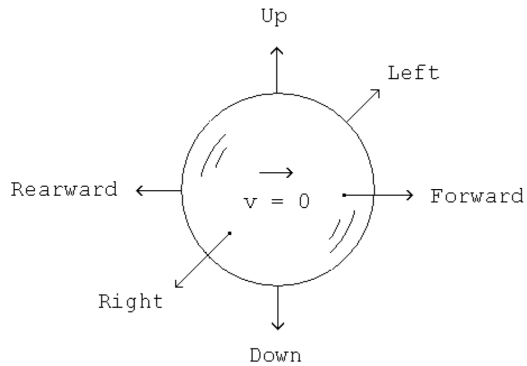


Figure 4-1

As described above under "The Problem" the speed of flow of centers' propagation is fixed at c by the μ_0 and ε_0 of the flowing *Medium*. The center moving at velocity v would find (in the forward direction) its freshly emitted propagation "thrown" forward at speed $[c + v]$ interfering with the flow just ahead of it at speed c and conflicting with the μ_0 and ε_0 of the *Medium*. It finds the propagated wave not moving out of the way at the needed $[c + v]$ in time for the next cycle as set by the at-rest frequency of the center. The result is an imperative to reduce the center frequency ["delay" the next cycle] by the factor $[1 - {}^{v}/_{c}]$. That "interfering" and "conflicting" tends to force on the center a change in its oscillation, a reduction by the factor $[1 - {}^{v}/_{c}]$. That is, with the center moving forward at v,

(4-1) Propagated Speed would become $c \cdot [1 - {}^{v}/_{c}] = (c - v)$

Flow speed = propagated speed + v = $(c - v) + v = c$

In the rearward direction the opposite is the case, an imperative to increase the center frequency by the factor $[1 + {}^{v}/_{c}]$. But, the *Spherical-Center-of-Oscillation* can only oscillate at one specific frequency at a time. It cannot both increase and decrease its oscillation frequency at the same time. It responds by adopting a compromise change in frequency, the geometric mean of the two conflicting factors as in equation *4-2*.

The center's oscillation frequency decreases and its oscillation wavelength correspondingly increases, the product still being c.

(4-2)

$$f_v = f_r \cdot \left[1 - \frac{v^2}{c^2}\right]^{1/2} \qquad \text{[Center frequency decreases]}$$

$$\lambda_v = \lambda_r \cdot \frac{1}{\left[1 - \frac{v^2}{c^2}\right]^{1/2}} \qquad \text{[Center wavelength increases]}$$

$$\lambda_v \cdot f_v = \lambda_r \cdot f_r = c \qquad \text{[Wave velocity still at } c\text{]}$$

While the center can oscillate at only one frequency, it can propagate at different wavelengths in different directions. To maintain propagated wave velocity at c in the direction of center motion the wave must be actually propagated forward by the center at

$c-v$ relative to the center itself so that the wave velocity relative to at rest is the propagated velocity, c, plus the center velocity, v, that is $(c-v)+v = c$.

To propagate forward at $[c - v]$ while maintaining the frequency at f_V requires that the wavelength change to a smaller value, λ_{fwd}. Likewise, rearward the wave must be actually propagated by the center at $[c + v]$ relative to the center with a greater wavelength, λ_{rwd}. Those adjusted propagation wavelengths are as follows.

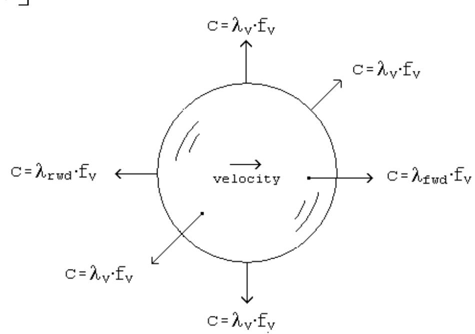
(4-3)

$$\lambda_{fwd} = \frac{c-v}{f_v} = \frac{c\cdot\left[1-\frac{v}{c}\right]}{f_r\cdot\left[1-\frac{v^2}{c^2}\right]^{\frac{1}{2}}} = \lambda_r\cdot\frac{\left[1-\frac{v}{c}\right]^{\frac{1}{2}}}{\left[1+\frac{v}{c}\right]^{\frac{1}{2}}} = \lambda_r\cdot\left[\frac{c-v}{c+v}\right]^{\frac{1}{2}}$$

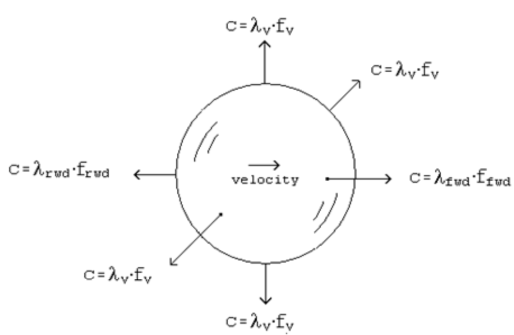
$$f_{fwd} = \frac{c}{\lambda_{fwd}} = f_r\cdot\left[\frac{c+v}{c-v}\right]^{\frac{1}{2}}$$

$$\lambda_{rwd} = \lambda_r\cdot\left[\frac{c+v}{c-v}\right]^{\frac{1}{2}}$$

$$f_{rwd} = f_r\cdot\left[\frac{c-v}{c+v}\right]^{\frac{1}{2}}$$



The Wave as Propagated by the Center at Velocity v (relative to the center)
Figure 4-2



The Above Propagation (as Observed from At-Rest)
Figure 4-3

As the center "sees" it, per the above Figure 4-2, it is oscillating at f_V, with the forward and rearward wavelengths adjusted for the velocity so that the wave travels in each direction at speed **c**. As "at-rest" would "see" it, per Figure 4-3, below, the center appears to propagate different forward and rearward frequencies, f_{fwd} and f_{rwd}.

Thus the field of propagated waves is traveling at c in all directions as observed by the center that is in motion and doing the propagating and as observed from at-rest.

What is "at rest" ? It is the environment of a center not in motion.

THE EFFECT OF VELOCITY ON MASS

Of the total wave traveling outward from the source *Spherical-Center-of-Oscillation*, the only part that interacts with another, encountered, *Spherical-Center-of-Oscillation* is the part intercepted by the encountered center. The *Spherical-Center-of-Oscillation* intercepting the larger portion of incoming wave receives the greater impulse, the greater momentum change. Thus center mass depends on the encountered center's cross-section target for interception of *Propagated Outward Flow* waves. A *Spherical-Center-of-Oscillation* of smaller cross-section is of greater mass.

With the oscillation frequency corresponding to the rest mass of the particle it represents per Equations *3-6*, the development so far of decreasing oscillation frequency, equation *4-2*, demonstrates a decrease in rest mass due to the *Spherical-Center-of-Oscillation's* velocity. That is more properly referred to as a decrease in that part of the mass effect due to the overall frequency of oscillation of the center, to be referred to as "mass in rest form", m_r' in equation *4-4*.

(4-4)
$$m'_r = m_r \cdot \frac{f_v}{f_r} = m_r \cdot \left[1 - \frac{v^2}{c^2}\right]^{\frac{1}{2}}$$

However, overall the total mass increases because the effects so far have reduced the cross-section target for interception of *Propagated Outward Flow*.

From the forward or the rearward point of view the center's cross-section is the area of the circle of radius λ_V, the sideward direction. Per equation *4-2*.

(4-5)
$$\lambda_v = \lambda_r \cdot \frac{1}{\left[1 - \frac{v^2}{c^2}\right]^{\frac{1}{2}}}$$

Relative to the center's rest mass, m_r, the overall mass at velocity, m_V, is

(4-6)
$$m_v = m'_r \cdot \left[\frac{\lambda_v}{\lambda_r}\right]^2 = m_r \cdot \left[1 - \frac{v^2}{c^2}\right]^{\frac{1}{2}} \cdot \left[\frac{1}{\left[1 - \frac{v^2}{c^2}\right]^{\frac{1}{2}}}\right]^2$$

$$m_v = m_r \cdot \frac{1}{\left[1 - \frac{v^2}{c^2}\right]^{\frac{1}{2}}}$$

From the sideward point of view the cross-section is no longer a circle, however. In the forward direction the at-rest circle's radius has become λ_{fwd} instead of λ_v and in the rearward direction λ_{rwd} instead of λ_v.

(4-7)

$$\lambda_{fwd} = \frac{c - v}{f_v} = \frac{c \cdot \left[1 - \frac{v}{c}\right]}{f_v} = \frac{\left[1 - \frac{v}{c}\right]}{\lambda_v} \qquad \text{therefore} \qquad \frac{\lambda_{fwd}}{\lambda_v} = \left[1 - \frac{v}{c}\right]$$

(4-8)

$$\lambda_{rwd} = \frac{c + v}{f_v} = \frac{c \cdot \left[1 + \frac{v}{c}\right]}{f_v} = \frac{\left[1 + \frac{v}{c}\right]}{\lambda_v} \qquad \text{therefore} \qquad \frac{\lambda_{rwd}}{\lambda_v} = \left[1 + \frac{v}{c}\right]$$

The product of the change factors, Equations *4-7* and *4-8*, is $[1 - v^2/c^2]$, a reduction of cross-section, the same amount of increase in mass as equation *4-6*.

THE LORENTZ CONTRACTIONS, LENGTH AND TIME

Logic requires of the overall universe that in all frames of reference at constant velocities relative to each other [*i.e.* inertial frames]:

- The equations describing the laws of physics have the same form, and
- The universal constants appearing in those equations be the same,

This is called the Principle of Invariance, and means that the speed of light, *c*, a universal constant, is the same in all inertial frames, which appears to conflict with our instinctive assumption that the speed of light should vary with the speed of the light's source.

That logic combined with experiments showing that the speed of light actually is the same independent of whatever inertial frame, required the development of the Lorentz Transformations to account for the constancy of the speed of light. The transformations are coordinate transformations between two inertial frames. The Lorentz contractions are the related change in the fundamental quantities: mass, length, and time.

The Lorentz Contractions

The Lorentz Contractions are as follows.

(4-9)

$$L = L_r \cdot \left[1 - \frac{v^2}{c^2}\right]^{\frac{1}{2}}$$

[Observed Length in the Direction of motion shortens.]

$$f = f_r \cdot \left[1 - \frac{v^2}{c^2}\right]^{\frac{1}{2}}$$

[Observed frequency slows.]

$$t = t_r \cdot \frac{1}{\left[1 - \frac{v^2}{c^2}\right]^{\frac{1}{2}}}$$

[Observed time periods length, Time passes more slowly.]

(4-9 continued)

$$m = m_r \cdot \frac{1}{\left[1 - \frac{v^2}{c^2}\right]^{\frac{1}{2}}}$$ [Observed mass increases.]

Time and frequency are reciprocals of each other and the above equation *4-2* decrease in center frequency with velocity validates the f and t Lorentz Transforms. [The increasing λ_r to λ_v of that equation is compensating for the frequency decrease to keep the sideward propagation speed at c. Sideward is not the direction of v so the Lorentz Contraction does not apply to that λ.]

The equation *4-6* overall increase in center mass with velocity validates the mass, m, Lorentz Transform. Remaining to be validated is the length, L contraction. The λ_{fwd} and λ_{rwd} contraction Equations *4-7* and *4-8* are a center length contraction in the velocity direction, a Lorentz Contraction.

On the macroscopic scale it is necessary to investigate two centers and the distance between them in order to develop a velocity-caused contraction of length in matter. In bulk matter composed of multiple particles, atoms and their components, the spacing of the atoms depends on the balance of the various electrostatic forces acting as a result of the centers-of-oscillation, protons and electrons, of which the matter atoms are composed.

Considering just two *Spherical-Centers-of-Oscillation* at rest in a fixed position relative to each other, the effect of their moving jointly at velocity v in the direction of the line joining them should be a Lorentz Contraction to closer spacing of the two centers by the Lorentz Contraction factor.

The position of each of the two centers is the balance of all of the forces acting on the centers, an equilibrium position. If the velocity is to change the distance between the two centers then the force acting between the two centers must change so that a new closer equilibrium spacing exists and determines the new distance between the two centers. For the centers to need to be closer in order to re-establish equilibrium the effective charge of each of the centers must be decreased by the velocity.

In other words, for the Coulomb force between the two centers

(3-21)
$$F = \frac{Q_1 \cdot Q_2}{4\pi \cdot R^2}$$

to be unchanged even though R is reduced by the Lorentz Contraction by the factor

(4-10)
$$\frac{R_{vel}}{R_{rst}} = \left[1 - \frac{v^2}{c^2}\right]^{\frac{1}{2}}$$

so that R^2 is changed by the factor

$$\frac{R^2_{vel}}{R^2_{rst}} = \left[1 - \frac{v^2}{c^2}\right]$$

then $Q_1 \cdot Q_2$ must be so reduced by the same factor as is R^2.

But, that is exactly the case. It has already been shown by equation 4-3 that the forward wave propagation speed is reduced by the factor $[1-{}^{v}/c]$ to $c' = c-v$ and that the rearward wave propagation speed is analogously changed by the factor $[1+{}^{v}/c]$ to c’’ = c+v.

The charge, Q enters into Coulomb’s Law as the amount of *Propagated Outward Flow* actually propagated [how many multiples of the fundamental basic charge] times its speed, c, [see Appendix C, “Derivation of Coulomb’s Law”, equation C-16 so that the charge, Q, of the trailing center “looking“ forward is reduced by the reduction of its c to $c' = c - v$, a factor of $[1-{}^{v}/c]$.

Similarly the charge, Q, of the leading center “looking“ backward is increased by the increase of its c to $c'' = c + v$, a factor of $[1+{}^{v}/c]$.

Therefore, $Q_1 \cdot Q_2$ is modified by the product of the two factors which is $[1 - {}^{v^2}/{}_{c^2}]$, which matches the Lorentz Contraction of R^2 and therefore of R and validates the length, L, Lorentz Contraction.

The Velocity-Caused Impulse Increment

There is, however, another component to the interaction. While, in the forward direction, the source *Spherical-Center-of-Oscillation* propagates the wave at $c'= c-v$, the wave actually travels at velocity c because the center itself is traveling forward at v yielding the overall wave velocity as $c'+v = (c-v)+v = c$. The forward wave, the force it can deliver reduced by its propagation at $c-v$, is thus also "thrown forward" by the center's velocity. This adds another component of force, of potential impulse per wave times the wave repetition rate, the force that the wave can deliver to an encountered center.

In fact, without the wave having that additional component of force, and the consequent reaction back on the center in that same additional amount, the center would not experience equal reaction back on it in all directions from its propagated wave. The magnitude of this "force component" due to the center's velocity is $[{}^{v}/{}_{c}] \cdot F_r$, where F_r is the force that the wave would deliver if at rest and which it does always deliver to the sides: up, down, right and left.

The situation is analogous for the rearward wave otherwise the reaction back on the center by the rearward propagated wave would be $[{}^{v}/{}_{c}] \cdot F_r$ greater than the rest case. Without these "force components" the center would be self-accelerated in the forward direction by a force of $2 \cdot [{}^{v}/{}_{c}] \cdot F_r$ (the forward and rearward effects combined), clearly not the case.

Returning to the case of two *Spherical-Centers-of-Oscillation* traveling in the direction of an imaginary line joining them, when the forward wave of the trailing center encounters the rear of the leading center the $+[{}^{v}/{}_{c}] \cdot F_r$ positive "force component" of the forward wave and the $-[{}^{v}/{}_{c}] \cdot F_r$ negative "force component" of the rear of the encountered leading center cancel out leaving the net action due to the encounter as presented above before considering the "force component due to center velocity or momentum" aspect.

The situation is the same with the rearward propagated wave of the leading center encountering the front of the trailing center. The net effect on the interaction is null, but the phenomena are still there.

Particle Kinetics

Kinetic energy, *KE*, is defined as the work done by the force, *f*, acting on the particle or object of mass, *m*, over the distance that the force acts, *s*. This quantity is calculated by integrating the action over differential distances. It was done using the Lorentz Contraction for mass originally by Einstein as follows

(4-10)

$$KE = \int_0^s f\cdot ds \qquad \text{[Per above definition]}$$

$$= \int_0^s \frac{d(m\cdot v)}{dt}\cdot ds \qquad \text{[Newton's 2nd law, } f = m\cdot a = m\cdot dv/dt\text{]}$$

$$= \int_0^{(m\cdot v)} \frac{ds}{dt}\cdot d(m\cdot v) \qquad \text{[Rearrangement of form]}$$

$$= \int_0^{(m\cdot v)} v\cdot d(m\cdot v) \qquad \text{[}v = ds/dt\text{]}$$

But, now the mass, *m*, increases with velocity per equation *4-9*, Therefore:

$$KE = \int_0^v v\cdot d\left[\frac{m_r\cdot v}{\left[1 - \frac{v^2}{c^2}\right]^{½}}\right] \qquad \text{[m is } m_r \text{ Lorentz contracted by v. } m_r \text{ is rest mass]}$$

$$= \frac{m_r\cdot v^2}{\left[1 - \frac{v^2}{c^2}\right]^{½}} - m_r\cdot\int_0^v \frac{v\cdot dv}{\left[1 - \frac{v^2}{c^2}\right]^{½}} \qquad \text{[Integration by parts]}$$

(4-11)

$$KE = \frac{m_r\cdot v^2}{\left[1 - \frac{v^2}{c^2}\right]^{½}} + m_r\cdot c^2\cdot\left[1 - \frac{v^2}{c^2}\right]^{½} - m_r\cdot c^2 \qquad \text{[Integration of 2nd term]}$$

$$= \frac{m_r \cdot v^2 + m_r \cdot c^2 \cdot \left[1 - \frac{v^2}{c^2}\right]}{\left[1 - \frac{v^2}{c^2}\right]^{1/2}} - m_r \cdot c^2$$ [Place 2nd term over 1st term denominator]

$$= \frac{m_r \cdot v^2 + m_r \cdot c^2 - m_r \cdot v^2}{\left[1 - \frac{v^2}{c^2}\right]^{1/2}} - m_r \cdot c^2$$ [Expand term with brackets]

$$KE = \frac{m_r \cdot c^2}{\left[1 - \frac{v^2}{c^2}\right]^{1/2}} - m_r \cdot c^2$$ [Simplify]

$$= m_v \cdot c^2 - m_r \cdot c^2$$ [m_v is total mass at $v > 0$
m_r is total mass at $v = 0$
$m_v = m_r$ Lorentz transformed]

This result states that:

{Kinetic Energy} = {Total Energy} - {Rest Energy}

or

{Total Energy} = {Kinetic Energy} + {Rest Energy}

The appearance in this result that the energies are the product of the masses times c^2, the speed of light squared, was the origination of that concept, the famous Einstein's $E = m \cdot c^2$. The concept falls out naturally from applying the Lorentz transforms to the classical definition of kinetic energy. It is somewhat surprising that Einstein was the first to do that inasmuch as it was Lorentz who developed the Lorentz transforms and the Lorentz contractions.

Alternative Treatment of the Same Derivation

If in the above original derivation one proceeds differently from the first line of equation *4-11* on, as below, a slightly different result is obtained.

(4-11)

$$KE = \frac{m_r \cdot v^2}{\left[1 - \frac{v^2}{c^2}\right]^{1/2}} + m_r \cdot c^2 \cdot \left[1 - \frac{v^2}{c^2}\right]^{1/2} - m_r \cdot c^2$$ [Repeated *(4-11)* to start here]

(4-12)

$$KE + m_r \cdot c^2 = \frac{m_r \cdot v^2}{\left[1 - \frac{v^2}{c^2}\right]^{1/2}} + m_r \cdot c^2 \cdot \left[1 - \frac{v^2}{c^2}\right]^{1/2}$$ [Move the right most "$- m_r \cdot c^2$"]

Considering and evaluating the three terms of equation *4-12*:

$$KE + m_r \cdot c^2 = \text{Kinetic plus rest energies}$$
$$= \text{Total Energy}$$
$$= m_v \cdot c^2$$

$$\frac{m_r \cdot v^2}{\left[1 - \frac{v^2}{c^2}\right]^{1/2}} = \text{A relativistically increased energy of motion.}$$
$$= m_v \cdot v^2$$

$$m_r \cdot c^2 \cdot \left[1 - \frac{v^2}{c^2}\right]^{1/2} = \text{A relativistically reduced rest energy.}$$
$$= m_v \cdot c^2 - m_v \cdot v^2$$

the result is that equation *4-12* is equivalent to

$$(4\text{-}13) \quad \begin{bmatrix}\text{Total}\\ \text{Energy}\end{bmatrix} = \begin{bmatrix}\text{Energy in}\\ \text{Kinetic Form}\end{bmatrix} + \begin{bmatrix}\text{Energy in}\\ \text{Rest Form}\end{bmatrix}$$

$$m_v \cdot c^2 = m_v \cdot v^2 + m_v \cdot (c^2 - v^2)$$

and (dividing the above energy equation by c^2 to obtain an equation in mass)

$$(4\text{-}14) \quad \begin{bmatrix}\text{Total}\\ \text{Mass}\end{bmatrix} = \begin{bmatrix}\text{Mass in}\\ \text{Kinetic Form}\end{bmatrix} + \begin{bmatrix}\text{Mass in}\\ \text{Rest Form}\end{bmatrix}$$

$$m_v = m_v \cdot v^2/c^2 + m_v \cdot (1 - v^2/c^2)$$

The m'_r "mass in rest form", of equation *4-4*

$$m'_r = m_r \cdot \left[1 - \frac{v^2}{c^2}\right]^{\frac{1}{2}}$$

equals the m_v of equation *4-6*, below

$$m_v = m_r \cdot \frac{1}{\left[1 - \frac{v^2}{c^2}\right]^{\frac{1}{2}}}$$

multiplied by the $(1 - v^2/c^2)$ as in the bottom of equation *4-14*

$$\left[1 - \frac{v^2}{c^2}\right]$$

Why is the formulation for classical *Kinetic Energy* $KE = ½ \cdot m \cdot v^2$ but *Energy in Kinetic Form* is simply $m \cdot v^2$ without the ½? When dealing with quite small velocities (v very small relative to c) the excursion of total energy above rest energy and the excursion of energy in rest form below rest energy are both essentially linear. In that case the portion above the rest case is essentially half of the total excursion above and below the rest case. The classical kinetic energy is then half, $½ \cdot m \cdot v^2$, the total energy in kinetic form, $m \cdot v^2$, for $[v/c]$ quite small.

THE CENTER OF OSCILLATION “AT REST” AND “IN MOTION

In motion at a constant velocity, v, the *Spherical-Center-of-Oscillation* experiences the asymmetrical distortions of equation $4-3$ and Figures 4-2 and 4-3. The distortions indicate the motion and the motion enhanced energy of the center. At rest, in the absence of motion the center is spherically symmetrical.

Thus the rest mass and rest energy correspond to the spherically symmetrical portion of the center’s oscillation [the only portion if $v = 0$] and they are “mass in rest form” and “energy in rest form”. The overall distorted portion corresponds to the total “mass in kinetic form” and “energy in kinetic form” of the center. Of course the difference of the two is the mass and energy in kinetic form.

- What, then, is the prime frame of reference ?

It is the “rest frame”.

- And, what is the “rest frame” ?

It is the frame in which particles are at rest.

- And, how do particles exhibit their being at rest ?

By their oscillation and their Propagated Outward Flow both being perfectly the same in all directions, that is spherically symmetrical.