Therefore, Eq.(71) may be rewritten in the following form:

$$m_g = m_{i0} - \left[\left(\frac{n_r \eta k}{c^2}\right)^2 \frac{T^2}{{m_{i0}}^2}\right] m_{i0} \qquad (72)$$

For electrons at T=300K, we have

$$\left(\frac{n_r \eta k}{c^2}\right)^2 \frac{T^2}{{m_e}^2} \approx 10^{-17}$$

Comparing (72) with (18), we obtain

$$E_{Ki} = \frac{1}{2}\left(\frac{n_r \eta k}{c}\right)^2 \frac{T^2}{m_{i0}}. \qquad (73)$$

The derivative of E_{Ki} with respect to temperature T is

$$\frac{\partial E_{Ki}}{\partial T} = (n_r \eta k/c)^2 (T/m_{i0}) \qquad (74)$$

Thus,

$$T\frac{\partial E_{Ki}}{\partial T} = \frac{(n_r \eta k T)^2}{m_{i0}c^2} \qquad (75)$$

Substitution of $E_{Ki} = E_i - E_{i0}$ into (75) gives

$$T\left(\frac{\partial E_i}{\partial T} + \frac{\partial E_{i0}}{\partial T}\right) = \frac{(n_r \eta k T)^2}{m_{i0}c^2} \qquad (76)$$

By comparing the Eqs.(76) and (73) and considering that $\partial E_{i0}/\partial T = 0$ because E_{i0} does not depend on T, the Eq.(76) reduces to

$$T(\partial E_i/\partial T) = 2E_{Ki} \qquad (77)$$

However, Eq.(18) shows that $2E_{Ki} = E_i - E_g$. Therefore Eq.(77) becomes

$$E_g = E_i - T(\partial E_i/\partial T) \qquad (78)$$

Here, we can identify the energy E_i with the *free-energy* of the system-F and E_g with the *internal energy* of the system-U, thus we can write the Eq.(78) in the following form:

$$U = F - T(\partial F/\partial T) \qquad (79)$$

This is the well-known equation of Thermodynamics. On the other hand, remembering $\partial Q = \partial\tau + \partial U$ (1st principle of Thermodynamics) and

$$F = U - TS \qquad (80)$$

(Helmholtz's function), we can easily obtain from (79), the following equation

$$\partial Q = \partial\tau + T\partial S. \qquad (81)$$

For *isolated systems*, $\partial\tau = 0$, we have

$$\partial Q = T\partial S \qquad (82)$$

which is the well-know *Entropy Differential Equation*.

Let us now consider the Eq.(55) in the *ultra-relativistic case* where the inertial energy of the particle $E_i = M_i c^2$ is much greater than its inertial energy at rest $m_{i0}c^2$. Comparison between (4) and (10) leads to $\Delta p = E_i V/c^2$ which, in the ultra-relativistic case, gives $\Delta p = E_i V/c^2 \cong E_i/c \cong M_i c$. On the other hand, comparison between (55) and (41) shows that $Un_r = \Delta pc$. Thus $Un_r = \Delta pc \cong M_i c^2 >> m_{i0}c^2$. Consequently, Eq.(55) reduces to

$$m_g = m_{i0} - 2Un_r/c^2 \qquad (83)$$

Therefore, the *action* for such particle, in agreement with the Eq.(2), is

$$S = -\int_{t_1}^{t_2} m_g c^2 \sqrt{1 - V^2/c^2}\,dt =$$
$$= \int_{t_1}^{t_2} \left(-m_i + 2Un_r/c^2\right)c^2 \sqrt{1 - V^2/c^2}\,dt =$$
$$= \int_{t_1}^{t_2} \left[-m_i c^2 \sqrt{1 - V^2/c^2} + 2Un_r \sqrt{1 - V^2/c^2}\right]dt. \qquad (84)$$

The integrant function is the *Lagrangean*, i.e.,

$$L = -m_{i0}c^2 \sqrt{1 - V^2/c^2} + 2Un_r \sqrt{1 - V^2/c^2} \qquad (85)$$

Starting from the Lagrangean we can find the Hamiltonian of the particle, by means of the well-known general formula:

$$H = V(\partial L/\partial V) - L.$$

The result is

$$H = \frac{m_{i0}c^2}{\sqrt{1 - V^2/c^2}} + Un_r\left[\frac{(4V^2/c^2 - 2)}{\sqrt{1 - V^2/c^2}}\right]. \qquad (86)$$

The second term on the right hand side of Eq.(86) results from the particle's interaction with the *electromagnetic field*. Note the similarity between the obtained Hamiltonian and the well-known Hamiltonian for the particle in an electromagnetic field [32]:

$$H = m_{i0}c^2 / \sqrt{1 - V^2/c^2} + Q\varphi. \qquad (87)$$

in which Q is the electric charge and φ , the field's *scalar* potential. The quantity $Q\varphi$ expresses, as we know, the particle's interaction with the electromagnetic field. Such as the second term on the right hand side of the Eq.(86).

It is therefore evident that it is the same quantity, expressed by different variables.

Thus, we can conclude that, in ultra-high energy conditions $(Un_r \cong M_i c^2 > m_{i0}c^2)$, the gravitational and electromagnetic fields can be described by the *same* Hamiltonian, i.e., in these circumstances they are *unified* !

It is known that starting from that Hamiltonian we may obtain a complete description of the electromagnetic field. This means that from the present theory for gravity we can also derive *the equations of the electromagnetic field*.

Due to $Un_r = \Delta pc \cong M_i c^2$ the second term on the right hand side of Eq.(86) can be written as follows

$$\Delta pc\left[\frac{(4V^2/c^2 - 2)}{\sqrt{1 - V^2/c^2}}\right] =$$

$$= \left[\frac{(4V^2/c^2 - 2)}{\sqrt{1 - V^2/c^2}}\right] M_i c^2 =$$

$$= Q\varphi = \frac{QQ'}{4\pi\varepsilon_0 R} = \frac{QQ'}{4\pi\varepsilon_0 r\sqrt{1 - V^2/c^2}}$$

whence

$$(4V^2/c^2 - 2)M_i c^2 = \frac{QQ'}{4\pi\varepsilon_0 r}$$

The factor $(4V^2/c^2 - 2)$ becomes equal to 2 in the ultra-relativistic case, then it follows that

$$2M_i c^2 = \frac{QQ'}{4\pi\varepsilon_0 r} \qquad (88)$$

From (44) we know that there is a minimum value for M_i given by $M_{i(min)} = m_{i(min)}$. The Eq.(43) shows that $m_{g(min)} = m_{i0(min)}$ and Eq.(23) gives $m_{g(min)} = \pm h/cL_{max}\sqrt{8} = \pm h\sqrt{3/8}/cd_{max}$.

Thus we can write

$$M_{i(min)} = m_{i0(min)} = \pm h\sqrt{3/8}/cd_{max} \qquad (89)$$

According to (88) the value $2M_{i(min)}c^2$ is correlated to $(QQ'/4\pi\varepsilon_0 r)_{min} = Q^2_{min}/4\pi\varepsilon_0 r_{max}$, i.e.,

$$\frac{Q^2_{min}}{4\pi\varepsilon_0 r_{max}} = 2M_{i(min)}c^2 \qquad (90)$$

where Q_{min} is the *minimum electric charge* in the Universe (therefore equal to minimum electric charge of the quarks, i.e., $\frac{1}{3}e$); r_{max} is the *maximum distance* between Q and Q', which should be equal to the so-called "diameter", d_c, of the *visible* Universe $(d_c = 2l_c$ where l_c is