5. THE GRAVITATIONAL FIELD EQUATION

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5.1 Changes of the non local gravitational potential

Above and below, from several different ways, it has been proved that one of the main differences between E fields and G fields is that *the G field itself has no energy.* The energy released after a free fall of a particle is a fraction of the NL mass-energy the same particle. Thus, *the net G work is more properly* *done by the particle*, not by the field as usually assumed in current literature. Such work corresponds to a fraction of the mass-energy of the same particle.

$$dW_{r*} = -dm_{r*}(0,r) = -hd\nu_{r*}(0,r) \qquad \text{E5.1}$$

Then we can define "*the infinitesimal change of NL potential*", *df(r)*, after a free fall between r_{r*} and $r_{r*} + dr_{r*}$. This one is the fraction of the NL mass-energy lost by a particle model after an infinitesimal free fall and stop between such positions[1]. During the fall, the model NL dual vectors, in Fig. 4.2b, rotate after an angle *dq*, due to G refraction, by keeping their absolute values. Thus *their transversal components decrease in identical proportions by a common factor of d*[*cosq*]. During the stop at $r_{r*} + dr_{r*}$, according to special relativity and momentum conservation, the transversal components don't change. However, the model gets to a stop in a space with lower NL speed of light. This is the reason for which the model eigen frequency in its new position is lower that the one in its initial one. Then, during the stop, the model must give away both the energy and the momentum in excess. Thus the final NL rest frequency of the model in the final position is smaller that the initial one by the factor of *d*[*cosq*.] The same holds for *the NL wavelength. Then, the final model NL wavelength is shorter than the original one*.

From this definition, E5.1 and E4.13,

$$d\phi(r) = \frac{dm_{r*}(0,r)}{m_{r*}(0,r)} = \frac{-dW_{r*}(r)}{m_{r*}(0,r)} = \frac{d\nu_{r*}(0,r)}{\nu_{r*}(0,r)} = d\cos\theta = d\left[\frac{1}{\gamma(r)}\right] \qquad \text{E5.2}$$

From E5.2 and E4.13,

$$d\phi(r) = \frac{dm_{r*}(0,r)}{m_{r*}(0,r)} = \frac{d\nu_{r*}(0,r)}{\nu_{r*}(0,r)} = \frac{d\lambda_{r*}(0,r)}{\lambda_{r*}(0,r)} = \frac{1}{2}\frac{dc_{r*}(r)}{c_{r*}(r)} = d\left[\frac{1}{\gamma(r)}\right] \qquad \text{E5.3}$$

Notice that the subscript of *df(r)* has been omitted because all of the members of E5.3 are dimensionless. They do not depend on the position of the observer.

The liberation of this energy accounts for the changes of NL eigen-frequencies of the atoms located in different G potentials, i.e., for *G time dilation* and *G red shift*. This one also accounts for the NL mass-energy given away either during the stop or during the real *G work* ***done by the body***.

From E5.2 the change of NL G potential, after a change of NL position, between r_{r*} and $r_{r*} + dr_{r*}$, are directly related to the NL acceleration of gravity which in turn is related to the conventional G potential.

$$d\phi(r) = \frac{d\nu_{r*}(0,r)}{\nu_{r*}(0,r)} = \frac{1}{2}\frac{dc_{r*}(r)}{c_{r*}(r)} = d\left[\frac{1}{.\gamma(r)}\right] = -\frac{g_{r*}(0,r)}{c^2_{r*}(r)}dr_{r*} \cong d\left[-\frac{GM}{r}\right] \qquad \text{E5.4}$$

in which $g_{r*}(0,r)$ is the NL acceleration of gravity and $G = \boldsymbol{G}^{newt}/c^4$.

From E5.1 and E3.9b, a change of NL potential *df(r)* is related to a change of the Newtonian potential changes, *d(r)*, by:

$$d\phi(r) = -\frac{dW(joule)}{m(joule)} = -\frac{dW}{m^{newt}c^2}; \quad d\varphi(r) = -\frac{dW(joule)}{m^{newt}(kgm)}; \qquad d\phi(r) = \frac{d\varphi(r)}{c^2}$$ E5.5

5.2 The main non local gradients of a G field

According to the Huygen's principle, the net deviation of light occurring within the model depends only on "*the net gradient of the NL wavelengths*" that exists in model.

Since the NL wavelength is a ratio between the NL speed of light and the NL frequency, then the wavelength gradient is the result of *two gradients:*

a) The gradient of the NL speed of light of the space.

b) The gradient of the NL frequencies that should exist in the model, according to E5.1

From E4.13, the two kinds of gradients should exist. The last kind of gradient stands out most clearly in the NL experiments on gravitation refraction, gravitational time dilation and G red shift. The first one stands out most clearly in the experiments on G refraction and time delay of radar waves travelling close to the Sun.

The role of such gradients can be studied more easily from the free fall of a transversal model followed by a local stop, as in section **4.3**.

Each member of this non-dimensional relation depends on a single variable. Thus the integration of these equations for infinitesimal free falls and stops between any two arbitrary NL positions, like r^o and r, gives the following transformation factors between such NL positions:

$$T_{r^o}(r) = \frac{m_{r*}(0,r)}{m_{r*}(0,r^o)} = \frac{\nu_{r*}(0,r)}{\nu_{r*}(0,r^o)} = \frac{\lambda_{r*}(0,r)}{\lambda_{r*}(0,r^o)} = \sqrt{\frac{c_{r*}(r)}{c_{r*}(r^o)}} \cong \exp[\,\phi(r) - \phi(r^o)]$$. E5.6

It is interesting to observe that the 3rd, 4th and 5th members of this relation are consistent with the frequencies of any LC resonant circuit. Such *eigen frequencies* turn out to be, *in general*, proportional to $\sqrt{c_{r*}(r)}$. This stands out the importance that G refraction must have for a deeper insight on the nature of the particles and its fields. This subject will be discussed in more detail below.

After dividing E5.3 by *dr**, the basic gradients existing in a G field, and in the bodies at rest in it, turn out to be related to the NL acceleration of gravity given by E5.2, by:

$$\nabla\phi_{r*}(r) = \frac{\nabla m_{r*}(0,r)}{m_{r*}(0,r)} = \frac{\nabla \nu_{r*}(0,r)}{\nu_{r*}(0,r)} = \frac{\nabla\lambda_{r*}(0,r)}{\lambda_{r*}(0,r)} = \frac{1}{2}\frac{\nabla c_{r*}(r)}{c_{r*}(r)} = -\frac{g_{r*}(0,r)}{c_{r*}^2(r)}$$ E5.7

The gradient of the NL rest masses has been included, according to E3.5, because it will be used later.

Thus, the space in a G field has *a gradient of the NL speed of light, i.e., a gradient of the NL refraction* *index*. This one fixes the internal gradients of the eigen values of the NL frequencies and of the NL wavelengths of the model at rest[2]. As a net result of such gradients, *the model propagates itself towards lower G potentials, i.e., towards lower NL speed of light (higher NL refraction index).*

5.3 The non local potentials derived from the wave nature of matter

The main aim of this work is to try to understand the nature of the physical phenomena involved in gravitation, according to the nature of matter fixed by the more explicit form of the EP.

According to the nature of the particle model, its G field properties can only come from long range properties of the stationary radiation's confined in it. So far, these properties are normally described in terms of the so-called *wavelets*. They turn out to be the most basic elements that should exist in nature. Indeed, they are like the "missing links" to explain, in a self-consistent and unified way, the most elemental properties of matter and of the space.

As said before, in order that the radiation cannot escape from the particle model, only non-coherent wavelets, with *random phases*, can be coming back and forth from the model. Then *the model G field can only depend on the gradient of the NL perturbation rate of the space produced the "random-phase" wavelets crossing it.*

Notice that no body could deny, by sure, that the wavelets do not exist. Nobody could also swear that the empty space in a G field is empty. The wavelets are bounded to be crossing such space, and they are more elemental than matter and radiation. They must be "something" in between nothing and everything. Since we cannot detect them, we can infer their general properties from the general properties of radiation.

a) The cosmic wavelet background.

According to the common nature of the particle model and of the radiation's, the space should be crossed by *a high density of random phase wavelets* coming back and forth from all of the particles and radiation's in the universe. In the space between particles that are close to each other, some standing waves can exist between them, i.e.; the wavelets would interfere to each other with coherent phases so that their net amplitude in such field is not zero. This means that some real energy would exist in such kind of field. Such field "belongs" the closed (uncharged) system. On the other hand the G fields are open ones, and of long range. Thus far away from the bodies, the wavelets would be with random phases with respect to each other. Then the single NL parameter that can fix the properties of the empty space is *its NL perturbation rate* produced by *wavelets with random phases*. This one should be proportional to *the sum of the NL frequencies of all of the wavelets crossing such position, weighted after their corresponding NL amplitudes*.

The same as in the Olber's paradox, it is simple to prove that the space perturbation rate produced by a universe of uniform density would be infinite unless that some kind of *wavelet red shift* proportional to the distances exists.

To prove it, let us call $w_{r*}(i)$ to the net NL perturbation rate produced by all of the wavelets crossing the position *i*. The contribution of the wavelets coming from some particle *j*, to the NL perturbation rate of some point *i*, *is proportional both to the frequency and to the NL amplitude of the wavelets crossing such point*. Assume that r^{ij} is the NL distance between *i* and *j*. According to the wave properties, the wavelet amplitude is proportional to the inverse of such NL distance.

$$w(i) = \sum_{j=1}^{\infty} K \frac{v_{r*}(r^j)}{r^{ij}} = \frac{K}{h} \sum_{j=1}^{\infty} \frac{m_{r*}(r^j)}{r^{ij}} . \qquad \text{E5.9}$$

After summing up all of the contributions of thin shells of matter within *r* and *r* + *dr*, for a universe of uniform mass-energy density (*r*) and unlimited extension,

$$w(i) = \frac{K}{h} \int_{r=0}^{\infty} \frac{4\pi\rho\, r^2 dr}{r} = \frac{K}{h} \infty \qquad \text{E5,10}$$

Thus in order that the perturbation rate cannot diverge, K should be zero. This would mean that the space would be saturated of wavelets and, therefore, the bodies could not produce any gradient of the space properties.

b) The cosmic wavelet red shift

Then, in order that the NL perturbation rate can be finite, some kind of *"wavelet red shift" (WRS) proportional to the NL distances* must exist. Such red shift is obviously consistent with the so-called *cosmological red shift of light*.

Thus, whatever may be the cause of the wavelet red shift, this one turns out to be most important for understanding why Gravity can exist in a universe with rather infinite extension[3]. For the moment, it is not necessary to speculate about the origin of such red shift because we must accept it as a matter of facts.

If the average density of the universe is constant, the percentage of red shift of wavelet frequency occurring during its trip between *r* and r + *Dr*, is proportional to the additional NL distance *dr*.

$$\frac{d v_{r*}(r)}{v_{r*}(r)} = -C dr . \qquad \text{E5.11}$$

For an arbitrary NL distance between the NL positions *i* and *k*, called r^{ik}, the integration E5.11 gives *a NL frequency attenuation factor*:

$$f(r^{ik}) = \frac{v_{r*}(r^k)}{v_{r*}(r^i)} = \exp\left[-\frac{r^{ik}}{R}\right] \qquad \text{E5.12}$$

In which *R* = 1/*C*. *R* is <u>*the typical NL distance at which the NL frequency is red shifted by the factor 1/e.*</u> Since light would be red shifted in the same proportion as its wavelets, then this attenuation factor is consistent the "*Hubble law*". Effectively, the first order approximation of E5.12 has the Hubble law form. Then R can be identified with the *Hubble radius, R = c/H.*

c) The NL perturbation rate of the space

Then, in E5.10, the contribution of each particle model (*j*), to the NL perturbation rate at some point *i*, must be corrected by its corresponding *wavelet red shift* factor given by E5.12. Thus the net NL perturbation rate of the space at *i* is:

$$w(i) = \sum_{j=1}^{\infty} K \frac{v_{r*}(r^j)}{r^{ij}} f(r^{ij}) = \frac{K}{h} \sum_{j=1}^{\infty} \frac{m_{r*}(r^j)}{r^{ij}} \exp \frac{-r^{ij}}{R} \quad \text{E5.13}$$

For simplicity, since *K* is an arbitrary constant, let us redefine the NL perturbation rate so that *K/h* = 1.

$$w(i) = \sum_{j=1}^{\infty} \frac{m_{r*}(r^j)}{r^{ij}} \exp \frac{-r^{ij}}{R} \quad \text{E5.13a}$$

Notice that *w(i)* has no subscript because frequencies and distances, according to E5.3, change in just proportion after a change of potential of the observer, i.e., their ratio remain unchanged after a change of G potential of the observer.

If matter were homogeneously distributed in the universe, with a density r^u equal to the average one in the universe, then, from E5.13, the NL perturbation rate would be:

$$w(U) = \int_0^{\infty} \frac{4\pi\rho r^2 dr}{r} e^{-r/R} = 4\pi\rho^u R^2 \quad \text{E5.14}$$

Then the G gradients existing in the space can only be due to the larger contribution of the wavelets of the nearest bodies compared with that of the rest of the universe.

For an inhomogeneous universe, we can define by *z(i)* "*the relative perturbation rate produced by the actual universe compared with that of a universe of uniform density*". Thus, from E5.13 and E5.14, for any NL position *i*, this parameter would be:

$$z(i) = \frac{w_{r*}(i)}{w_{r*}(U)} = G^U \sum_{j=1}^{\infty} \frac{m_{r*}(r^k)}{r^{ik}} \exp \frac{-r^{ik}}{R}; \qquad G^U = \frac{1}{\sum_{j=1}^{\infty} \frac{m_{r*}(r^j)}{r^{ij}} \exp \frac{-r^{ij}}{R}} = \frac{1}{4\pi\rho^U R^2}$$

E5.15

In the equation to the left, the sum for the *ik superscripts* is for the actual universe. The gravity constant to the right is the theoretical value for a "uniform distribution of matter in the universe". Then, for a universe of a uniform density,

z (i) = 1, in anywhere. E5.15b

Notice that *z(i)* is a non-dimensional parameter of the space.

The constant G^U was obtained after integration of E5.15, for the entire universe. In this case

In an inhomogeneous universe, *z(i)* can be divided into two terms: *the contribution of the rather uniform universe, which is close to 1, and the contribution of the relatively local bodies,* in excess over the first one.

$$z(i) = z(U) + \Delta z(i) \qquad \text{E5.16}$$

After use of E5.15 and E5.16, in the general case and in the case of central fields,

$$z(i) = \frac{w_{\gamma *}(U) + \Delta w_{\gamma *}(i)}{w_{\gamma *}(U)} \cong 1 + G^U \sum_{k=1}^{N} \frac{m_{\gamma *}(r^k)}{r^{ik}} \exp\frac{-r^{ik}}{R} \approx 1 + \frac{GM}{r^i} \quad . \qquad \text{E5.17}$$

[The last member is for a central field. Its first term is approximately constant and equal to 1. Its last term is just the contribution of the central field compared with the general background of the universe. This one is, currently, of many orders of magnitude lower than GM/r. This fact accounts for *the weakness of the current G fields and for the high isotropy of the space properties*.]

d) Relation between the relative perturbation rate of the space and the NL field potential

From E5.15, the contribution of each particle *k* of the universe, to the NL perturbation rate at some point *i*, would be red shifted by its corresponding *wavelet red shift factor $f(r^{ik})$. Thus the approximated form of the NL G potential derived from experiments, given by E5.5, should have a better defined form like:*

$$d\phi(i) \cong \frac{dm_{\gamma *}(0,r)}{m_{\gamma *}(0,r)} = Gd\left[-\sum_{j=1}^{k} \frac{m_{\gamma *}(r^j)}{r^{ij}} \exp\frac{-r^{ij}}{R_{\gamma *}}\right] \cong Gd\left[-\frac{M}{r}\right] \qquad \text{E5.18}$$

In which the last member is for a central field. This one is just the relative contribution of the central body compared with that of the total one, mainly produced by the rest of the universe. The constant *G* is the gravitational constant in the *meter-joule-second* (*mjs*) system of units.

On the other hand, according to the particle model, “the space properties should be some well defined function of the NL perturbation rate of the space”. Thus, after comparing E5.17 and E5.18, the NL field potential *f(r)* of equation E5.4 would have the form

$$\phi(r) = \text{Constant} - Gz(r) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{E5.19}$$

However, the same approximation is obtained from:

$$\phi(r) \cong -Ln(z(r) \cong 1 - z(r) \qquad \text{E5.19a}$$

Thus, according to the first order approximation, the difference of the NL potential between two NL positions of a G field can be written in the form:

$$\Delta\phi = \phi_{r^o}(r) \cong \int_{r^o}^{r} d\phi(r) \cong \phi(\mathrm{r}) - \phi(\mathrm{r}^o) = -z(r) + z(r^o) \cong -\frac{G^U M}{r} + \frac{G^U M}{r^o}; \qquad \text{E5.20}$$

Below it is proved that the equation E5.19 is in full agreement with the results of the determinations of *the perihelion shift of the planets*, as shown below. This phenomenon depends on second order approximation for the NL field potential, in strict agreement with E5.19.

By comparing E5.20, E5.19 and E5.18, and using E5.15, it is inferred that,

$$G \cong G^U \cong \frac{1}{4\pi\rho^u R^2} \quad . \qquad \text{E5.21}$$

Thus, the constant *G* turns out to be equal to the *gravitational constant*, whose value is discussed below.

According to equation E5.20, "*the NL potential at some point i turns out to be roughly equal to the converse of the relative perturbation rate of the space at such position.* Thus the changes of NL perturbation rate of the space, between *r* and *r + dr* can be added up to the above list of proportional changes associated to a change of NL potential.

$$d\phi(r) = -dz(r) = \frac{dm_{r*}(0,r)}{m_{r*}(0,r)} = \frac{d\nu_{r*}(0,r)}{\nu_{r*}(0,r)} = \frac{d\lambda_{r*}(0,r)}{\lambda_{r*}(0,r)} = \frac{1}{2}\frac{dc_{r*}(r)}{c_{r*}(r)} = d\left[\frac{1}{\gamma(r)}\right] \qquad \text{E5.22}$$

However, E5.19a is also another possible solution for the above differential equation coming from the observed facts.

$$d\phi(r) = -\frac{dz(r)}{z(r)} = \frac{dm_{r*}(0,r)}{m_{r*}(0,r)} = \frac{d\nu_{r*}(0,r)}{\nu_{r*}(0,r)} = \frac{d\lambda_{r*}(0,r)}{\lambda_{r*}(0,r)} = \frac{1}{2}\frac{dc_{r*}(r)}{c_{r*}(r)} = d\left[\frac{1}{\gamma(r)}\right] \qquad \text{E5.22a}$$

It is interesting that from E5.22a and E5.5, after some infinitesimal free fall,

$$\frac{d\nu_{r*}(r)}{\nu_{r*}(r)} + \frac{dz_{r*}(r)}{z_{r*}(r)} = \frac{d\lambda_{r*}(r)}{\lambda_{r*}(r)} + \frac{dz_{r*}(r)}{z_{r*}(r)} = \frac{1}{2}\frac{dc_{r*}(r)}{c_{r\cdots*}(r)} + \frac{dz_{r*}(r)}{z_{r*}(r)} = 0 \qquad \text{E5.23}$$

$$\nu_{r*}(0,r)z_{r*}(r) \approx C_\nu\,; \quad \lambda_{r*}(0,r)z_{r*}(r) \approx C_\lambda\,; \ \sqrt{c_{r*}(r)}z_{r*}(r) \approx C_c\,, \qquad \text{E5.24}$$

In which C_n, C_l, and C_c are constants. This means "*the radiation in stationary state of the model would be is in a sort of equilibrium[4] with the wavelet background*".

Notice that all of them, the G red shift, the G contraction of matter and the lower NL speed of light would occur in regions of higher wavelet densities with respect to the observer one. In this way, the space would react against the increase of the perturbation rate, i.e., by decreasing its NL speed of light and by decreasing the eigen-frequencies of matter located at rest in it.

e) The gravitational constant

From E5.15, the gravity constant (*G*) used here is the relative contribution of a mass-energy one joule, located at one meter, compared with that of the rest of the universe.

The correspondences between *G*, in the [*meter-joule-second*] (*mjs*) unit system used here, and the Newtonian constant of gravity, in the *mks* system, can be done by comparing the *non dimensional forms of the G potential*:

$$\mathbf{G}^{new}\frac{m[kgm]}{r[m]c^2} = \mathbf{G}^{new}\frac{m[joule]}{r[m]c^4} = G\frac{m[joule]}{r[m]} = \phi(r) \quad ; \quad G = \mathbf{G}^{new}c^{-4} \qquad \text{E5.25}$$

$\mathbf{G}^{new}$ is in the *mks unit system*. The constant *G*, in the *meter-joule-sec* unit system, is $7.4\text{x}10^{-43}$ [*m/joule*]

Notice that, due to the extremely low value of G constant, the last term of E5.20 is currently very small compared with 1. *This means that the G potential currently depends in a very small proportion on the inhomogeneities produced by rather local bodies*. This accounts for *the weakness of the G fields.*

From E5.6 and E5.20, the value of *z(r)* fixes the NL properties of the space and of the particle model, like the NL speed of light and the model dual vectors. Thus, the gradient of *z(r)* would be the ultimate cause of the G accelerations of bodies and of gravity refraction.

For non-cosmological distance ranges, the approximations E5.20 can be used, after neglecting the wavelet-red shift correction factor. In cosmological ranges, such approximations cannot be made because the wavelet red shifts become most important just for long distances.

In the particular cases of a *central G field*, produced by a point-like NL rest mass *M*, the equations E5.19 give an expression consistent with the traditional potential:

$$\phi(r) \cong 1 - \frac{GM}{r} \cong -Ln\frac{GM}{r} \qquad \text{E5.26}$$

This value used in E5.6 and E5.26 gives:

$$T_{r^o}(r) = \frac{m_{r*}(0,r)}{m_{r*}(0,r^o)} = \frac{\nu_{r*}(0,r)}{\nu_{r*}(0,r^o)} = \frac{\lambda_{r*}(0,r)}{\lambda_{r*}(0,r^o)} = \sqrt{\frac{c_{r*}(r)}{c_{r*}(r^o)}} = \frac{e^{\phi(r)}}{e^{\phi(r^0)}} \cong \frac{e^{-GM/r}}{e^{-GM/r^0}} \cong \frac{z(r^o)}{z(r)} \qquad \text{E5.27}$$

This common transformation factor relates the NL mass-energies, the NL frequencies, the NL lengths of matter at rest in any two different NL positions, and the corresponding NL speeds of light. They are given in terms of the corresponding NL perturbation rates, which would be the more elemental parameter of the space. The last term is the application of this relation to a central field.

5.4 Velocities and Accelerations in Fields with Respect to a Fixed Observer

According to NL mass-energy conservation, the NL mass of a free body in a G field remains constant during *free orbits or G falls*. Indeed this is the simplest equation for a free orbit in a G field.

For the special case a free fall from the observer position (*r**),

$$m_{r*}(0,r^*) = m_{r*}(\beta, r) = m_{r*} = \text{Constant} \qquad \text{E5.28}$$

More explicitly, after using E4.15, E5.28, and E5.27,

$$m_{r*}(\beta, r) = \frac{m_{r*}(0,r)}{\sqrt{1-\beta_{r*}^{\,2}(r)}} = \frac{m_{r*}(0,r^*)\exp\left[\phi_{r*}(r)-\phi_{r*}(r^*)\right]}{\sqrt{1-\beta_{r*}^{\,2}(r)}} = \text{Constant} = m_{r*}(0,r^*) \qquad \text{E5.29}$$

Thus, after using E5.28, the velocity and the acceleration of the body are related to the NL potential by:

$$\beta_{r*}^{\,2}(r) = 1 - \exp 2\left[\Delta\phi_{\,r*}(r)\right] \qquad \text{E5.30}$$

After deriving with respect to the NL time,

$$\frac{d\beta_{r*}(r)}{dt_{r*}} = -\frac{d\phi_{\,r*}(r)}{dr_{r*}} c_{r*}(r)\exp 2[\Delta\phi_{\,r*}(r)] = -\frac{[c_{r*}(r)]^2}{c_{r*}(r^*)}\frac{d\phi_{\,r*}(r)}{dr_{r*}} \qquad \text{E5.31}$$

From E5.31, the NL acceleration of Gravity is related to the G potential gradients by

$$g_{r*}(0,r) = \lim_{V\to 0}\frac{dV_{r*}(r)}{dt_{r*}} \cong c_{r*}(r)\frac{d\beta_{r*}(r)}{dt_{r*}} \cong \frac{c_{r*}^3(r)}{c}\frac{d\phi_{\,r*}(r)}{dr_{r*}} \approx c^2\frac{d\phi_{\,r*}(r)}{dr_{r*}}. \qquad \text{E5.32}$$

Notice that, to the contrary of general relativity, the NL acceleration of Gravity does not diverge for $r_{r*} = 2GM_{r*}$

The correspondence with Newtonian Gravity is most clear for the case of a central field. Since $G = G^{newt}/c^4$ and $M = M^{newt}c^2$

$$\phi_{r*}(r) = -\frac{GM}{r} + \frac{GM}{r^*} = -\frac{G^{new}M^{new}}{rc^2} + \frac{G^{new}M^{new}}{r^*c^2} = \frac{\varphi(r)-\varphi(r^*)}{c^2} \qquad \text{E5.33}$$

$$g_{r*}(0,r) \cong -c^2 \frac{d\phi_{\ r*}(r)}{dr} \cong -\frac{d\varphi(r)}{dr} \cong -\frac{c^2 GM}{r^2} \cong -\frac{G^{new} M^{new}}{r^2}$$ E5.34

5.5 Gravitational Refraction and Angular Momentum Conservation

From E5.6, the space is a dielectric that has a NL refraction index:

$$n_{r*}(r) = \frac{c_{r*}(r^*)}{c_{r*}(r)} = \exp 2\left[\phi(r^*) - \phi(r)\right] \cong \exp 2\left[z(r) - z(r^*)\right]$$ E5.35

According to the EEP and the Huygen principle, the propagation of *free photons and particles* in G fields depend, exclusively, on the gradients of the NL wavelengths coming from the gradient of the NL perturbation rate of the space.

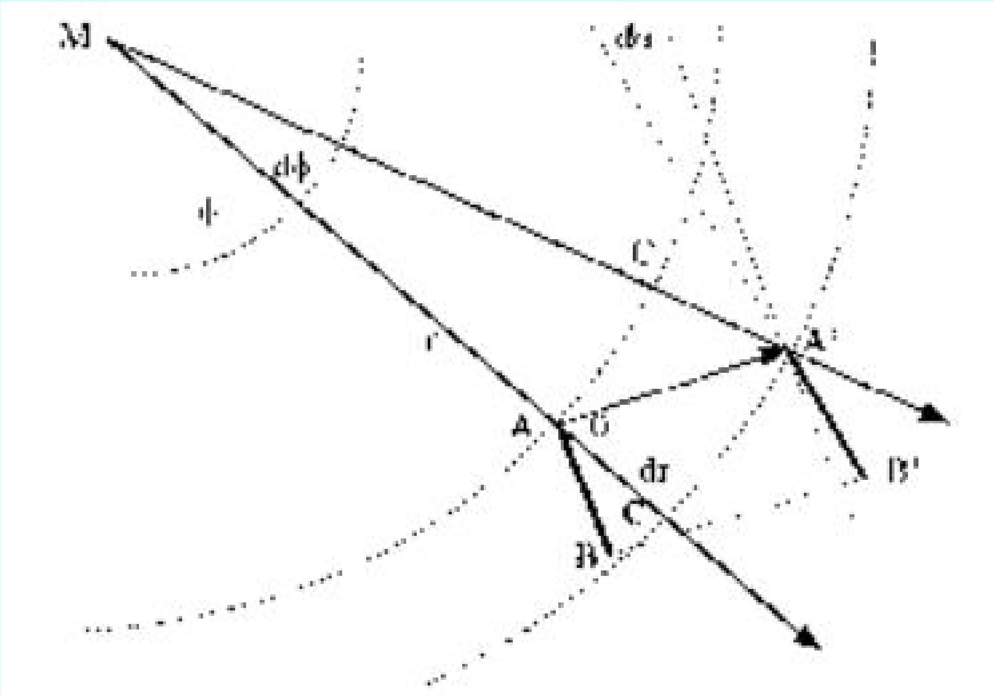

Fig. 5.1 *NL G refraction of the wave fronts AB produced by a gradient of NL wavelengths. The deviation da comes from the differences of the wavelengths AA' and BB'.*

Assume for simplicity that a wavefront travels an infinitesimal wavelength; from *AB* up to the NL position *A'B'*. According to Fig. 5.1 the net deviation of the wave fronts after each wavelength is

$$d\alpha = \frac{BB' - AA'}{AB} = \frac{\lambda_{\gamma*}(r+dr) - \lambda_{\gamma*}(r)}{\lambda_{\gamma*}(r)\cos\theta[\sin\theta]^{-1}} = \frac{d\lambda_{\gamma*}(r)}{\lambda_{\gamma*}(r)}\tan\theta$$ E5.36

This one is related to the angles *q* and *f* by

$$d\alpha = d\theta + d\phi = d\theta + \frac{dr\tan\theta}{r}$$ E5.37

From E5.5 and E5.37,

$$\frac{d\lambda_{\gamma*}(r)}{\lambda_{\gamma*}(r)} = \frac{d(\sin\theta)}{\sin\theta} + \frac{dr}{r}$$ E5.38

After integration,

$$\frac{r_{\gamma*}\sin\theta}{\lambda_{\gamma*}(r)} = \frac{\nu_{\gamma*}(r) r_{\gamma*}\sin\theta}{c_{\gamma*}(r)} = cons\tan t = C$$ E5.39

This is *the angular equation for the trajectories of photons and particles in central G fields*. Equations that are more explicit come out for photons and particles.

a) For free photons

According to E5.6, E5.35 and *NL frequency conservation*,

$$\lambda_{\gamma*}(r) = \frac{c_{\gamma*}(r)}{\nu_{\gamma*}(r)} = \frac{c_{\gamma*}(r^*)\exp[2\phi_{\gamma*}(r^*) - 2\phi_{\gamma*}(r)]}{\nu_{\gamma*}(r^*)} = \frac{\lambda_{\gamma*}(r^*)}{n_{\gamma*}(r)}$$. E5.40

The NL wavelength of free radiation decreases in regions of lower G field potentials (higher NL refraction index). This deviates of light towards lower G potentials.

The NL angular momentum law comes out by multiplying E5.39 by *h*.

$$L = h\frac{r_{\gamma*}\sin\theta}{\lambda_{\gamma*}(r)} = r_{\gamma*}p_{\gamma*}(r)\sin\theta = \frac{h\nu_{\gamma*}(r) r_{\gamma*}\sin\theta}{c_{\gamma*}(r)} = hC$$ E5.41

Since the NL frequency and the energy of a free quantum remain constant relative to a fixed observer, it is useful to define *the constant NL density of angular momentum of the photon, i.e., angular momentum per unit of energy*.

$$j_{\gamma*} = \frac{L}{h\nu_{\gamma*}(r)} = \frac{r_{\gamma*}\sin\theta}{c_{\gamma*}(r)} = \frac{r_{\gamma*}\sin\theta}{c}\exp[2\phi_{\gamma*}(r^*) - 2\phi_{\gamma*}(r)]$$. E5.41b

After using E5.35,

$$j_{\gamma *}c = n_{\gamma *}(r)\sin\ \theta = cons\tan t \quad . \qquad \text{E5.42}$$

The last relation may be called *the NL Snell law for G refraction*. *For central fields*, by using E5.26, this one takes the form:

$$(r\sin\ \theta)\exp\left\{\frac{2GM}{r}\right\} = cons\tan t \quad . \qquad \text{E5.43}$$

Below, this relation accounts for the observed refraction of light in G fields.

b) For free particles

The particle model trajectory is fixed by the interference of the model waves, *i.e.*, by the De Broglie waves. According to E5.39 and E3.15,

$$L = hC = \frac{hr\sin\ \theta}{\lambda_{\gamma *}{}^{*}(\beta, r)} = \frac{hr\ \beta\ \sin\ \theta}{\lambda_{\gamma *}(\beta, r)} = \frac{h\nu_{\gamma *}(\beta, r)r\ \beta\ \sin\ \theta}{c_{\gamma *}(r)} = \text{constant} \qquad \text{E5.44}$$

$$L = \frac{m_{\gamma *}(\beta, r)r_{\gamma *}V_{\gamma *}(\mathrm{r})\ \sin\ \theta}{[c_{\gamma *}(r)]^2} = m_{\gamma *}^{new}(\beta, r)r_{\gamma *}V_{\gamma *}(r)\sin\ \theta = \text{Constant} \qquad \text{E5.44b}$$

This may be written in the vector form:

$$\mathbf{L} = \frac{m_{\gamma *}(\beta, r)}{[c_{\gamma *}(r)]^2}\mathbf{r}_{\gamma *}\mathrm{x}\mathbf{v}_{\gamma *} = m_{\gamma *}^{new}\mathbf{r}_{\gamma *}\mathrm{x}\mathbf{v}_{\gamma *} = \mathbf{r}_{\gamma *}x\mathbf{p}_{\gamma *}(\beta, r) = cons\tan t \qquad \text{E5.45a}$$

In a free trajectory, m_{r*} *(b,r)* is also constant and, therefore, it is useful to define a constant *density of NL angular momentum* for any specific trajectory[5].

$$j_{\gamma *} = \frac{L_{\gamma *}}{m_{\gamma *}(\beta, r)} = \frac{r_{\gamma *}\ \beta\ \sin\ \theta}{c_{\gamma *}(r)} = \frac{r_{\gamma *}V_{\gamma *}(\mathrm{r})\ \sin\ \theta}{[c_{\gamma *}(r)]^2} = \text{Constant} \qquad \text{E5.45b}$$

This can be done in terms of the angular velocity:

$$\mathbf{j}_{\gamma *} = \frac{\vec{r}_{\gamma *}\,x[\vec{\omega}_{\gamma *}(\beta, r)x\,\vec{r}_{\gamma *}]}{[c_{\gamma *}(r)]^2} = \frac{r_{\gamma *}{}^2}{[c_{\gamma *}(r)]^2}\vec{\omega}_{\gamma *}(\beta, r) = \frac{[n_{\gamma *}(r)\,r_{\gamma *}]^2}{c^2}\vec{\omega}_{\gamma *}(\beta, r) = \text{Constant} \qquad \text{E5.46}$$

Notice that the NL angular velocities of bodies, compared with the Newtonian ones, are lower in regions of lower NL speed of light. This is not due to the change of the NL masses of the bodies but due to *the* *lower NL speed of light.* In general, the trajectories fixed by E5.45 or E5.46 do not depend on the masses of the bodies.

The E5.44 is valid for other kinds of conservative fields in which the NL mass-energy changes with the velocity.

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[1] This quantity is non-dimensional and, therefore, it is independent on the unit system. It is not necessary to use partial derivatives because the NL rest masses do not depend on velocities.

[2] More elemental reasons for all of this will result below, after using waves that are more elemental.

[3]At the present stage of this study, it is not strictly necessary to speculate on the ultimate origin of the wavelet redshift. For reason of self-consistency it is better to let such question open until that, below, the answer may come out naturally from the new concepts learned from the model and radiation properties.

[4] Notice that nature should be plenty of similitude's, just because of the common nature of everything. Thus this equilibrium relation, for example, is just similar to that used in chemical equilibrium. Something similar holds in many other fields of interest, including that of the ideas.

[5] E5.45b is also valid for single photons traveling with velocity $\mathbf{v}_{r*}(r) = \mathbf{c}_{r*}(r)$