RADIAL GRAVITATIONAL WAVE STUDY, PHYSICAL INTERPRETATION OF THE FINE-STRUCTURE CONSTANT, RESOLUTION OF THE PROBLEM OF WAVE-PARTICLE DUALITY FOR ELECTROMAGNETIC RADIATIONS, AND QUANTIZATION OF SPACE-TIME

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ABSTRACT

We will study a so-called radial gravitational wave corresponding to a wave which is not diffused in all directions, but in a single direction. We will establish that its energy level depends, in the same way as an electromagnetic radiation, of its amplitude (constant over all its trajectory), correlated then to its electric field, and of the discrete potential of energy, then given by its frequency multiplied by the Planck constant. We will then observe the structure of the wave, corresponding to a series of contractions and dilations of space. This will describe the discrete nature of the radiation and provide a beginning of response to the paradox of increasing mass, directly derived from General Relativity. By considering the quantity of energy of the radial wave and in application of the Special Relativity, we will note its contraction which will make it possible to explain the observed corpuscular aspect of the radiation. It will thus be determined that an electromagnetic radiation, then identified as a radial gravitational wave, is in reality neither exclusively a wave nor actually a corpuscle, these notions not being dissociable here, but as a radial wave whose space, in which the quantity of energy is distributed, is, from the point of view of an external observer, infinitely contracted. The "problem" of the wave-particle duality will then be solved in the case of electromagnetic radiations, ie relativistic particles (of zero mass), whose discrete nature will be determined, a physical meaning will be given to the constant of fine-structure, the electric field will then be described as a property of Space-Time (more than a force field), and a quantization start of Space-Time compatible to the observation will be provided.

Keywords Gravitational wave · Electromagnetic radiation · Wave-particle duality · Photon · General Relativity · Special Relativity · Discrete Space-Time · Fine-structure constant · Quantization of Space-Time

1 Introduction

Gravitational waves, although they were indirectly detected well before [1, 2], were recently detected by LIGO-VIRGO collaborations [3, 4, 5], confirming once again the predictions of General Relativity [6].

A polarization is associated with a gravitational wave, whose definition is identical to the classical definition of the polarity of electromagnetic radiations. The wave is then associated with an amplitude correlated to the electric field of the wave. Albert Einstein had already predicted that these waves carried an energy emitted by the source binary system [6]. It is also thanks to this loss of energy that it was possible, for the first time, to detect "indirectly" these waves. The diffusion in all directions of these waves induces, as for the sets of electromagnetic radiations, a loss of amplitude throughout their propagation, to which is added a redshift, in particular quantified at the time of the most recent detections [4, 5]. Gravitational waves accumulate enough resemblances with electromagnetic radiations to be interested in what would be a radial gravitational wave, that is to say a gravitational wave that would propagate in a proper direction, in the same way that an electromagnetic radiation emitted in a single direction from its source.

We will try to use this axis of reflection to determine the nature of electromagnetic radiations.

2 Radial diffusion of gravitational wave

Consider a Ω gravitational wave on a circular dispersion plane of l radius.

This wave is associated with a frequency and a decreasing amplitude as the dispersion increases, having spread over a distance l.

We will then have:

$$\pi l A_{(r=\frac{l}{2})_\Omega} \nu_\Omega = 2\pi l A_{(r=l)_\Omega} \nu_\Omega \tag{1}$$

Where ν is the frequency of the wave, postulated too little variant over the duration of the entire propagation of Ω so that its variation due to an evolution of the emitting system is taken into account. Here ν will be considered constant. A is the amplitude factor of the maximum contraction, effective thereafter, for ω, in the form of an integer noted a, and η, constant, also associated with ω whose existence and value we will demonstrate in the next section (until this demonstration, the continued nature of A_Ω and the discrete nature of A_ω will not matter much).

Let's now model the ω wave so that:

$$A_{(r=l;\varphi=\frac{\pi}{2})_\omega} \nu_\omega = A_{(r=\frac{l}{2};\varphi=\frac{\pi}{2})_\omega} \nu_\omega \tag{2}$$

We will then obtain a radial wave coincident with the radius of length l of the plane.

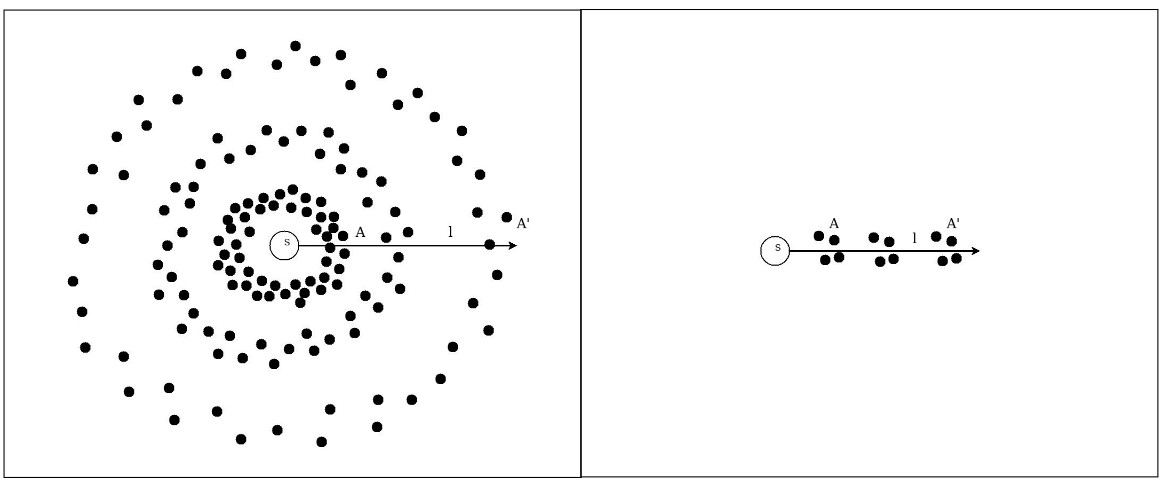
Thus, the amplitude, correlated to the electric field, and the frequency are constant regardless of the distance r at which the wavefront associated with ω is located from the source. So, we get:

$$A_{(r=l;\varphi=\frac{\pi}{2})_\omega}\nu_\omega = 2\pi l A_{(r=l)_\Omega}\nu_\Omega \tag{3}$$

With:

$$\nu_\omega = \nu_\Omega \tag{4}$$

Figure 1: Diagram of the two wave types



On the left, we have represented a gravitational wave diffused in all directions of a plane, over a length l from its source S. We can see that each cloud of points surrounding S has the same number of points, but not the same density. For example, the cloud at A will be denser than the cloud at A'. This represents the intensity of the spatial contractions. Thus, the amplitude of the wave in A is greater than in A', the amplitude decreasing as l increases.

On the right, we have represented a radial gravitational wave, diffused in a single direction of a plane, over a length l from its source S. We can see that each cloud of points along l has the same number of points and has the same density. For example, the cloud at A will be as dense as the cloud at A'. This represents the intensity of the spatial contractions. Thus, the amplitude of the wave in A is as important as in A', the amplitude not decreasing as l increases. However, it must be remembered that the geometry of the radial wave on a plane can only be represented accurately in one dimension, the present representation being an approximation offering a visual clarity and not a conceptual accuracy.

3 Amplitude and discrete potential energy of radial gravitational wave

3.1 Preamble

Since the polarization of a Ω gravitational wave is identical to that of an electromagnetic radiation, it can be assumed that a radial gravitational wave ω can be associated with an amplitude factor A, corresponding to a electric field, of discrete value, of form:

$$A = a\eta \tag{5}$$

With η constant and $a \in \mathbb{N}$.

To demonstrate this and prove that η depends on the invariant and discrete charge e of the source, we will use the similarity between the polarization of gravitational waves and that of electromagnetic radiations.

First, we will observe the construction of the amplitude H of a gravitational wave Ω diffused in all directions [6]:

$$H_\Omega = \frac{2G}{c^4}\frac{\ddot{Q}(t - lc^{-1})}{l} \tag{6}$$

Where $\frac{2G}{c^4}$ translates the rigidity (high) of Space-Time and $\frac{\ddot{Q}(t-lc^{-1})}{l}$ the set of factors determining the amplitude H_Ω with respect to this rigidity.

If we report all the diffusion of this wave on an axis (that of the ω wave), as seen in the first section, we obtain a continuous amplitude. However, the amplitude of a gravitational wave, in the same way as an electromagnetic radiation, is correlated to its electric field. We will imagine that a gravitational wave ω can be emitted by a particle ϱ of charge q. In the same way as for electromagnetic radiations, the amplitude H (and thus the amplitude factor A) will correspond to the amplitude of the electric field of the wave, the unique polarization of the electromagnetic radiations being identical to the polarization of gravitational waves. We will speak here of rectilinear polarization.

However, the development from the equation mentioned above and determined by Albert Einstein in 1916 will be exposed in section 4 [6], the present development covering the electromagnetic aspect of the wave (consideration of its polarization, his electric field, ...).

Let's consider now an electric field S induced by a point charge q:

$$S = \frac{q}{\varepsilon_0 4\pi d^2} \tag{7}$$

The Coulomb constant is equal to $k = (4\pi\varepsilon_0)^{-1}$, where ε_0 is the electrical permittivity of the vacuum.

We thus obtain the point charge effect Z distributed over the surface $4\pi d^2$, such that:

$$Z = \frac{q}{\varepsilon_0} \tag{8}$$

Knowing that $c = (\sqrt{\varepsilon_0 \mu_0})^{-1}$, the charge effect is also expressible in this way:

$$Z = qc^2\mu_0 \tag{9}$$

Where μ is the magnetic permeability of the vacuum.

We then deduce that $k = \frac{\mu_0 c^2}{4\pi}$.

In order to determine that the energy level of our ω wave corresponds to a discrete value, it is necessary to solve the problem of the interpretation of the fine-structure constant [7].

3.2 Physical interpretation of the fine-structure constant

Let's start by recalling that:

$$e = \sqrt{\frac{h2\alpha}{\mu_0 c}} \tag{10}$$

Where α is the coupling constant, such as:

$$\alpha = \frac{ke^2}{\hbar c} = \frac{e^2}{2\varepsilon_0 hc} \tag{11}$$

We can then continue:

$$\alpha = \frac{ke^2 2\pi}{hc} \tag{12}$$

$$\alpha = \frac{\mu_0 c^2 e^2 2\pi}{4\pi hc} \tag{13}$$

We know that:

$$Z = \frac{e}{\varepsilon_0} \tag{14}$$

And that:

$$S = \frac{e}{\varepsilon_0 4\pi d^2} \tag{15}$$

In addition, if:

$$Z = \frac{e}{\varepsilon_0} \tag{16}$$

So:

$$Z = e\mu_0 c^2 \tag{17}$$

Also:

$$S = \frac{Z}{4\pi d^2} \tag{18}$$

And:

$$S = \frac{e\mu_0 c^2}{4\pi d^2} \tag{19}$$

We can then develop:

$$\alpha = \frac{Sd^2 e 2\pi}{hc} \tag{20}$$

$$\alpha = \frac{Sd^2 e 4\pi}{2hc} \tag{21}$$

$$2\alpha = \frac{(Z.e)}{hc} \tag{22}$$

$$2\alpha = \frac{(Z.e)}{\frac{E}{\nu}c} \tag{23}$$

$$2\alpha = \frac{(Z.e)\lambda^{-1}}{E} \tag{24}$$

To finally conclude:

$$2\alpha = \frac{(Z.e)\lambda^{-1}}{E} \tag{25}$$

The physical significance of the fine-structure constant is half the ratio of the charge effect Z of the electric field S, of the point charge e, exerted on e, on a wavelength and on the other hand the level of energy carried by the wave emitted by the charge source e (and charge effect Z). Insofar as, as specified in section 1:

$$A_{(r=l;\varphi=\frac{\pi}{2})_\omega}\nu_\omega = A_{(r=\frac{l}{2};\varphi=\frac{\pi}{2})_\omega}\nu_\omega \tag{26}$$

And:

$$E_\omega = A_{(r=l;\varphi=\frac{\pi}{2})_\omega}\nu_\omega \tag{27}$$

And that the factor A depends on a, we get, for $a = 1$:

$$E_\omega = \eta\nu_\omega \tag{28}$$

$$E_\omega = \eta\frac{c}{\lambda_\omega} \tag{29}$$

We can deduce that $\lambda\ _{omega}$ is inversely proportional to $E\ _{omega}$ and that η is independent of E.

Here, η itself depends on α, independent of E because:

$$2\alpha = \frac{(Z.e)\lambda^{-1}}{E} \tag{30}$$

And since E is inversely proportional to λ, then α is independent of E and λ and depends only on E.

Z varying according to q of ϱ, it is constant for $q = e$, which will allow us to define η for a q charge of the source equal to e.

3.3 Structural definition of the constant linking wave energy and frequency

$$E_\omega = \eta\nu_\omega \tag{31}$$

η corresponding to the ratio in the energy and the frequency of the ω wave, it is natural that the ratio between the effective electric field on a wavelength is inversely proportional to η. Indeed, if this ratio increases, the energy emitted by an invariant charge body will decrease with respect to this charge. Thus, for a fixed wavelength, if α increases, η decreases, and E decreases.

Also, if:

$$\eta = \frac{X}{2\alpha} \tag{32}$$

And if:

$$2\alpha = \frac{(Z.e)}{hc} \tag{33}$$

And if:

$$2\alpha = \frac{(Z.e)}{\frac{E}{\nu}c} \tag{34}$$

$$2\alpha = \frac{(Z.e)\nu}{Ec} \tag{35}$$

So, for $Z = ec^2\mu_0$:

$$E = \frac{X}{2\alpha}\nu \tag{36}$$

$$X = \frac{E2\alpha}{\nu} \tag{37}$$

$$X = \frac{E\frac{(Z.e)\nu}{Ec}}{\nu} \tag{38}$$

$$X = \frac{(Z.e)}{c} \tag{39}$$

From this follows the meaning of X:

$$X = \frac{(Z.e)}{c} \tag{40}$$

$$X = \frac{(Z.e)}{\lambda\nu} \tag{41}$$

$$X = \frac{(Z.e)\lambda^{-1}}{\nu} \tag{42}$$

The physical meaning of X is the ratio between, on the one hand, the charge effect Z of the electric field S, of point charge e, exerted on e, on a wavelength and on the other hand, the frequency of the wave emitted by the charge source e (and charge effect Z).

We can then conclude that X, just like 2α is independent of E, ν and λ, for the same reasons.

η then corresponds to the ratio between these two structural constants 2α and X, so that the physical meaning of η becomes:

$$\frac{\begin{array}{c} Ratio : charge \cdot effect \cdot of \cdot the \cdot electric \cdot field \cdot of \cdot the \cdot wave \cdot exerted \cdot on \\ a \cdot charge \cdot e \cdot for \cdot a \cdot wavelength/frequency \cdot of \cdot the \cdot wave \end{array}}{\begin{array}{c} Ratio : charge \cdot effect \cdot of \cdot the \cdot electric \cdot field \cdot of \cdot the \cdot wave \cdot exerted \cdot on \\ a \cdot charge \cdot e \cdot for \cdot a \cdot wavelength/energy \cdot of \cdot the \cdot wave \end{array}} \tag{43}$$

So we can continue to develop:

$$X = \frac{(ec^2\mu_0.e)}{c} \tag{44}$$

$$X = e^2 c\mu_0 \tag{45}$$

Also:

$$\eta = \frac{e^2 c\mu_0}{2\alpha} \tag{46}$$

But:

- $e = 1,6.10^{-19}$
- $c = 3,0.10^8$
- $\mu_0 = c^{-2}\varepsilon^{-1} = (3,0.10^8)^{-2}.(8,9.10^{-12})^{-1} = 1,2.10^{-6}$
- $\alpha = 7,3.10^{-3}$

Which leads to the conclusion that:

$$\eta = h \tag{47}$$

For a radial gravitational wave emitted by a charge source e. We have shown that, like electromagnetic radiations, ω has a minimum amplitude for which:

$$E_\omega = h\nu_\omega \tag{48}$$

The minimum amplitude of the wave is therefore the amplitude for which $E = ah\nu$ with $a = 1$, that is to say for a quantum of energy associated with the wave. As we have seen, its value is due to the fact that the electric charge of the particle ϱ constituting the source of the wave is equal to the elementary charge e.

Thus, assuming that the polarization of gravitational waves was identical to that of electromagnetic radiations, we concluded that a radial gravitational wave emitted from a charge source e could be an electromagnetic radiation. To demonstrate that an electromagnetic radiation is in fact completely equivalent to a radial gravitational wave and that its electric field is in fact only a property of Space-Time (speaking well here of that described by General Relativity) it is necessary to establish the significance of h from a gravitational point of view and to reach the same conclusions as its electromagnetic meaning.

4 Radial gravitational wave structure in Space-Time

4.1 Structure

The structure of a radial gravitational wave would be a series of expansions and contractions of space, the amplitude of which would be correlated with the electric field assimilated to the charge-dependent wave e of the source that emitted the wave.

Thus, we should now be able to determine the minimum amplitude (smallest possible amplitude for a radial gravitational wave) of these contractions and dilations, taking into account the results obtained previously.

First, let's take a look at the construction of the H amplitude of a Ω gravitational wave diffused in all directions [6]:

$$H_\Omega = \frac{2G}{c^4}\frac{\ddot{Q}(t - lc^{-1})}{l} \tag{49}$$

Where $\frac{2G}{c^4}$ translates the rigidity (high) of Space-Time and $\frac{\ddot{Q}(t-lc^{-1})}{l}$ the set of factors determining the amplitude H_Ω with respect to this rigidity.

We know that:

$$\ddot{Q} \approx mf^2R^2 \tag{50}$$

Corresponding to the variation of quadrupole moment (as a function of time, so that the initial amplitude that we will adapt is adimensional), whose value however corresponds here to a net variation.

Where $f = 2\pi\nu$ and where R is the distance between the two objects emitting Ω, in joint rotations, around the same point.

In the case of ω, it will be necessary to take into account the geometry of the non-binary system (of unique object here). Let's first reexpress H_Ω, before adapting it to the emission of a radial wave by a non-binary system:

$$H_\Omega = \frac{2G}{c^4}\ddot{Q}\frac{(t - lc^{-1})}{l} \tag{51}$$

Now, $\ddot{Q}$ corresponding to a kinetic energy difference between the first and second state of the source particle, we would have, for a single source particle:

$$\ddot{Q} = \frac{dE_c}{dt} \tag{52}$$

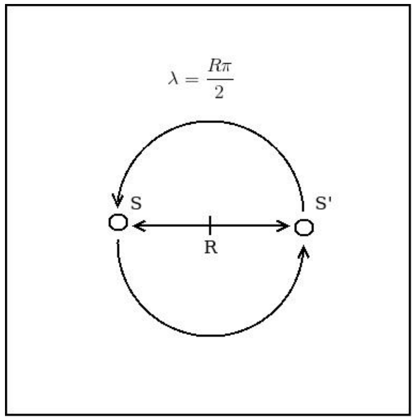
Now, this is a single emission by the source system, $\frac{dE_c}{dt}$ corresponds to a punctual emission of energy $\Delta E_c = E_{c_1} - E_{c_2}$, whose value can be determined as follows:

$$\ddot{Q} = \Delta E_c \tag{53}$$

$$\ddot{Q} = \frac{1}{2}m\Delta v^2 \tag{54}$$

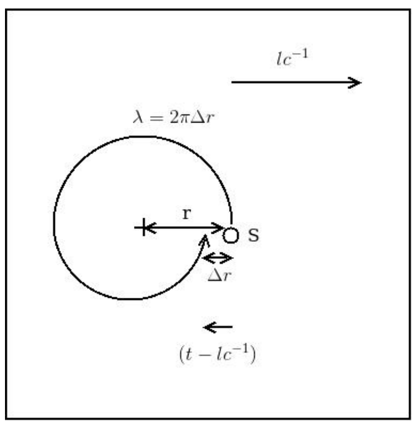
Now, as seen in Figures 2 and 3:

Figure 2: Binary system diagram



It will be observed that the wavelength of a gravitational wave emitted by a binary system (sources S and S') corresponds to the distance R, so that $\lambda = \frac{R\pi}{2}$.

Figure 3: Non-binary system diagram



While in a non-binary system (source S), $\lambda = 2\pi\Delta r$, so time interval for λ correspond to $(t - lc^{-1})$.

The difference between velocities $v_1 = \frac{r_1}{\delta t}$ and $v_2 = \frac{r_2}{\delta t}$ is equal to:

$$\Delta v = \frac{\Delta r}{\delta t} \tag{55}$$

As mentioned above, if we consider that the electron "traverses" the angle 2π periodically, a difference of radius $r_1 - r_2$ generates, in the case of the non-binary system (source unique), a wave of wavelength $\lambda = (r_1 - r_2)2\pi$.

That is, since $\Delta r = \frac{\lambda}{2\pi}$ and therefore $\Delta t = \frac{T}{2\pi}$, Δv being then independent of λ and T for a radial gravitational wave emission by a non-binary system.:

$$\Delta v = 2\pi T^{-1} \frac{\lambda}{2\pi} \tag{56}$$

And so:

$$\Delta v = f\frac{\lambda}{2\pi} \tag{57}$$

Also:

$$\ddot{Q} = \frac{1}{2}m(f\frac{\lambda}{2\pi})^2 \tag{58}$$

Moreover, in order to operate at an equivalence between H_ω and H_ω, we must consider twice the quadrupole moment variation in the equation, since the object alone shall, for an equivalent transported energy wave, have the same moment as that of the binary system, so that:

$$2\ddot{Q} = 2(\frac{1}{2}m(f\frac{\lambda}{2\pi})^2) \tag{59}$$

Which is quite logical, since for a mass equivalent to half the total mass of the binary system, the object of the non-binary system will have to generate the same amount of energy as the binary system and emit a wave by "traversing" an angle of 2π (instead of π for each binary system object of equivalent mass m).

Moreover, in the case of a radial gravitational wave, H_ω does not decrease as a function of l. Indeed, as seen previously, we can consider that:

$$A_{(r=l;\varphi=\frac{\pi}{2})_\omega}\nu_\omega = 2\pi l A_{(r=l)_\Omega}\nu_\Omega \tag{60}$$

Thus, we can express:

$$H_\omega = 2\pi l H'_\Omega = 2\pi l\frac{2G}{c^4}2(\frac{1}{2}m(f\frac{\lambda}{2\pi})^2)\frac{(t-lc^{-1})}{l} \tag{61}$$

Here, H'_Ω is already partially adapted and t is a time interval. Now, for our radial wave emission, we can observe that, if $\Delta t = t_1 - t2$, then the interval $\Delta t = l_1c^{-1} - l_2c^{-1}$, which makes it possible to supply $t_1 = (l_2 + \lambda)c^{-1}$, for a single emission of a discrete potential energy. Indeed, if Δr corresponds to $\frac{\lambda}{2\pi}$, here we have a Δl which corresponds to the linear trajectory of the radial wave, and not to a shape circumference $2\pi r$. Thus, we can develop:

$$\frac{(t-lc^{-1})}{l} = \frac{((l+\lambda)c^{-1} - lc^{-1})}{l} \tag{62}$$

$$\frac{(t-lc^{-1})}{l} = \frac{\lambda c^{-1}}{l} \tag{63}$$

$$\frac{(t-lc^{-1})}{l} = \frac{T}{l} \tag{64}$$

So:

$$H_\omega = 2\pi l \frac{2G}{c^4} 2(\frac{1}{2} m (f \frac{\lambda}{2\pi})^2) \frac{T}{l} \tag{65}$$

We can then develop:

$$H_\omega = \frac{2G2\pi}{c^4} 2(\frac{1}{2} m (2\pi\nu \frac{\lambda}{2\pi})^2) T \tag{66}$$

$$H_\omega = \frac{4G\pi}{c^4} m (\nu\lambda)^2 T \tag{67}$$

$$H_\omega = \frac{4G\pi}{c^4} mc^2 T \tag{68}$$

$$H_\omega = \frac{4G\pi}{c^2} mT \tag{69}$$

With m the mass of the source,

We have thus been able to "postpone" the total amplitude of a gravitational wave scattered in all directions of a plane on a 1 radius of this plane (of origin corresponding to the source of the wave), in order to conceive the amplitude of a radial gravitational wave, as geometrized in section 1.

Considering H_ω linearly, like the amplitude of a radial gravitational wave, it will be a multiple of $E_s = mc^2$. Thus, as seen in the previous sections, if we want to demonstrate the amplitude corresponds to a field, we must highlight the discrete nature in h (which we already know), in which way this potential field would be exercised on the object that generates this field itself. Thus, in h, we will have to find the mass energy of the source E_s which will be factor of H correlated with this same mass energy E_s. Indeed, in order to have the ratio between E and ν as depending on the amplitude of a wave emitted by a source of mass energy $E_s = mc^2$ where m is the mass of the source, H will have to be multiplied by E_s.

Thus, the ratio $\frac{HE_s}{\frac{HE_s}{h}}$ should link the E and ν values as follows:

$$E = \frac{\frac{4G\pi}{c^2} mTE_s}{\frac{\frac{4G\pi}{c^2} mTE_s}{h}} \nu \tag{70}$$

The important thing here is not to fall back on h, as we have already been allowed in section 2, but to determine the physical meaning of h in Space-Time.

Taking again:

$$E = \frac{\frac{4G\pi}{c^2} mTE_s}{\frac{\frac{4G\pi}{c^2} mTE_s}{h}} \nu \tag{71}$$

We will try to give a meaning to this ratio $\frac{HE_s}{\frac{HE_s}{h}}$ and it will be compared with the meaning given to h (η) in the previous section, developing:

$$E = \frac{\frac{4G\pi}{c^2}mTmc^2}{\frac{\frac{4G\pi}{c^2}mTmc^2}{h}}\nu \tag{72}$$

$$E = \frac{4G\pi mTm}{\frac{4G\pi mTm}{h}}\nu \tag{73}$$

After translating the standard gravitational parameter Gm into a $\frac{Gm}{d^2}$ field to which the parameter corresponds, while maintaining the ratio, we get [8]:

$$E = \frac{\frac{4G\pi d^2}{d^2}mTm}{\frac{\frac{4G\pi d^2}{d^2}mTm}{h}}\nu \tag{74}$$

Let a g field generated by a point mass m such that:

$$g = \frac{Gm}{d^2} \tag{75}$$

We will then have:

$$E = \frac{g4\pi d^2Tm}{\frac{g4\pi d^2Tm}{h}}\nu \tag{76}$$

The κ gravitational mass effect of the g gravitational field generated by a m point mass results in:

$$\kappa = g4\pi d^2 \tag{77}$$

We would then have:

$$E = (\frac{(\kappa.m)T}{(\kappa.m)T}h)\nu \tag{78}$$

And will can continue :

$$E = (\frac{(\kappa.m)T}{(\kappa.m)T}\frac{E}{\nu})\nu \tag{79}$$

$$E = (\frac{(\kappa.m)T}{(\kappa.m)T}\frac{\nu^{-1}}{E^{-1}})\nu \tag{80}$$

However, as seen at the end of section 3.2 (equation 30), the terms upper and lower must be constant and respectively independent of ν^{-1} and E^{-1}. Thus, a new common variable at the top and bottom terms will have to be extracted from h, to mimic the form seen in section 3.2, so that the added factors that will be extracted from h are equal, do not compensate for ν^{-1} nor E^{-1}, and are inversely proportional to the terms ν^{-1} and E^{-1} (it is not enough just to make appear two identical variables in the upper and lower terms). Thus, we can not get the parameters λ, T, T^{-1}, ν, ν^{-1}, E, or E^{-1} of the wave. We will therefore extract the last relevant parameter λ^{-1}:

$$E = (\frac{(\kappa.m)T}{(\kappa.m)T}\frac{\nu^{-1}}{E^{-1}})\nu \tag{81}$$

$$E = (\frac{(\kappa.m)T}{(\kappa.m)T}\frac{\lambda c^{-1}}{E^{-1}})\nu \tag{82}$$

$$E = (\frac{(\kappa.m)T}{(\kappa.m)T}\frac{cTc^{-1}}{E^{-1}})\nu \tag{83}$$

$$E = (\frac{(\kappa.m)T}{(\kappa.m)T}\frac{T^{-1}\lambda Tc^{-1}}{E^{-1}})\nu \tag{84}$$

$$E = (\frac{(\kappa.m)TT^{-1}c^{-1}}{(\kappa.m)T}\frac{\lambda T}{E^{-1}})\nu \tag{85}$$

$$E = (\frac{(\kappa.m)\lambda^{-1}\nu^{-1}}{(\kappa.m)T}\frac{1}{\lambda^{-1}T^{-1}E^{-1}})\nu \tag{86}$$

$$E = (\frac{(\kappa.m)\lambda^{-1}\nu^{-1}}{(\kappa.m)T\lambda^{-1}T^{-1}E^{-1}})\nu \tag{87}$$

$$E = (\frac{(\kappa.m)\lambda^{-1}\nu^{-1}}{(\kappa.m)\lambda^{-1}E^{-1}})\nu \tag{88}$$

The expression of h thus fulfills all the criteria for constituting a ratio between two structural constants, these criteria being intrinsic to the definition of the constant h, as demonstrated in section 3.3.

Which allows us to note that:

$$\frac{H_\omega.E_s.\lambda^{-1}.\nu^{-1}}{H_\omega.E_s.\lambda^{-1}.E^{-1}} \tag{89}$$

That is to say, approximately:

$$\frac{2\pi l(2H''_\Omega).E_s.\lambda^{-1}.\nu^{-1}}{2\pi l(2H''_\Omega).E_s.\lambda^{-1}.E^{-1}} \tag{90}$$

Where H''_Ω, already partially adapted to radial emission type, so $2\pi l(2H''_\Omega).E_s.\lambda^{-1}.E^{-1}$, and also $H_\omega.E_s.\lambda^{-1}.E^{-1}$ is dimensionless, just like 2α (see equation (23) for symmetry confirmation between ratios), which is a good sign for the rest.

We can finally interpret this ratio as the relationship between

$(\kappa.m)\lambda^{-1}\nu^{-1}$, itself the ratio between, on the one hand the gravitational mass effect κ of the gravitational field g, of punctual point mass m, exerted on the mass m, on a wavelength and, on the other hand, the frequency of the wave emitted by the mass source m (and mass effect κ).

And

$(\kappa.m)\lambda^{-1}E^{-1}$, the same ratio between, on the one hand, the κ gravitational mass effect of the gravitational field g of punctual mass m, exerted on m, on a wavelength and, on the other hand, the energy of the wave emitted by the mass source m (and of serious mass effect κ).

As a reminder, the objective of the development was not to determine h, as we have already been allowed in section 1, but to provide a physical meaning of h in Space-Time.

Also:

$$\frac{(\kappa.m)\lambda^{-1}\nu^{-1}}{(\kappa.m)\lambda^{-1}E^{-1}} = \frac{(Z.e)\lambda^{-1}\nu^{-1}}{(Z.e)\lambda^{-1}E^{-1}} \tag{91}$$

This allows us to note, after studying our radial gravitational wave, that the electric field, here equivalent to the gravitational field, appears very clearly as a property of Space-Time, and not as a force field, in the same way as gravity. Thus, to associate an electric field with an electromagnetic radiation amounts to associating it with a gravitational field and to establish that an electromagnetic radiation is actually a succession of contractions and expansions of space, the electric fields being in fact more properties of Space-Time as fields of force. This, coupled with the demonstration of the discrete nature of the radial gravitational waves, provides a beginning of Quantization of the Space-Time [9, 10, 11] quite in conformity with the observation and resulting from models already benefiting from strong experimental confirmation (Relativity [12, 13, 14, 3, 4, 5, 15], electromagnetic character of the light, ...).

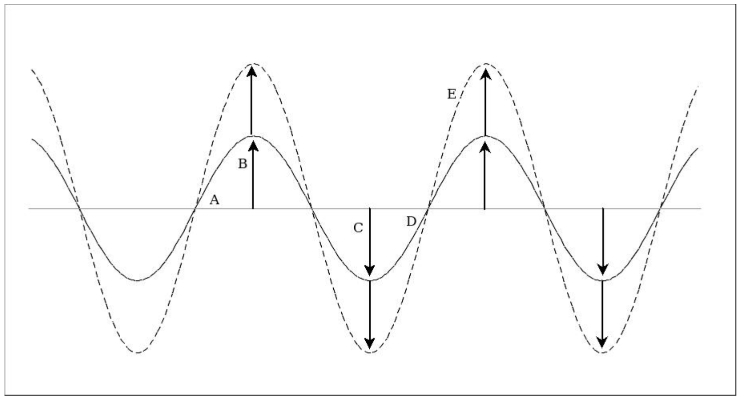
4.2 Example of interference

Let there be two radial gravitational waves ω_1 and ω_2 of respective frequencies ν_1 and ν_2 equal to each other.

If the waves are emitted in phase, there will be amplification of the contractions and spatial dilations of the two waves.

In the exactly opposite case, the spatial contractions will be superimposed on spatial expansions of the same amplitude and will compensate each other, so as to cancel the wave phenomenon. This phenomenon will be represented in Figure 4.

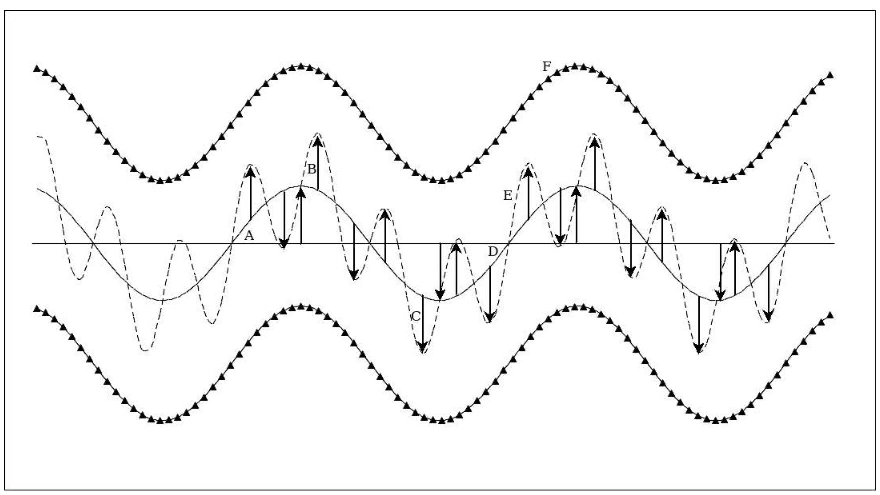
Figure 4: Interference diagram with equal frequencies



We can observe, on a median A that these two waves "in phase" and of equal frequencies produce a wave E of doubled amplitude with respect to a first wave D. It will be here to cumulate the space contractions B and space dilations C.

If the waves have frequencies ν_1 and ν_2 unequal, the contractions and spatial expansions of the two waves can not be superimposed perfectly. There cannot therefore be complete cancellation of the wave phenomenon and the amplitude of a first series of contractions and spatial dilations will be found "marked" by the amplitude of the other series. This case will be illustrated in Figure 5.

Figure 5: Interference diagram with unequal frequencies



We can observe, on a median A that these two waves of unequal frequencies produce a wave E of amplitude corresponding to the sum of the amplitudes of the second wave and the first wave D. It will be here to cumulate the contractions B and dilatations C. It can then be observed that the contractions B and dilatations C of the second wave mark the contractions B and dilatations C of the first wave D, so that the total amplitude corresponds to the sum of the amplitudes of the two waves, first showing the frequency of the wave at the highest frequency (the second wave), while letting appear, in the wave corridor F, the frequency of the first wave D.

5 Radial gravitational wave contraction

A radial gravitational wave moving from the source over a length l, in a single direction, is deemed to have no precise position in its l space. Now, if I wish to know precisely the position of the quantity of energy which it transports, I will not be able to do it without admitting its corpuscular nature.

Indeed, if I observe my wave and I want to know the position of the quantity of energy that is assimilated, I observe a series of contractions and dilations carrying a power potential depending on its frequency and distributed. Now, this quantum of energy γ corresponding to the quantity of energy of said wave potential moves at the speed of the wave, ie at the speed of light.

Thus, the wave corresponds well to a series of contractions and expansions of space, but the observation of its energy potential by an outside observer implies to consider the relativistic effect that it undergoes because of its speed. Thus the potential of energy transported by the wave, expressed as follows:

$$E = A_{(r=l;\varphi=\frac{\pi}{2})_\omega} \nu_\omega \tag{92}$$

Implies that the wave and its energy potential are considered as geometric objects. Now, considering the energy potential E conveyed by the wave from the point of view of an observer external to the ω wave moving on l, the energy potential of the object The geometric representation of the wave would no longer be considered over the entire length l, because of the contraction of the lengths, but on an infinitely contracted space, as follows [16]:

$$l'_\gamma = l\sqrt{1 - \frac{v^2}{c^2}} \tag{93}$$

But $v = c$, so:

$$l'_\gamma = 0 \tag{94}$$

l' here represents the length of the quantum of energy γ, constituting the energy potential E distributed over the whole wave ω, from the point of view of an observer outside the wave.

Thus, the space in which the quantity of energy transported by the wave is distributed is only one point, corresponding to the contraction of the length l on which the wave moves.

This is, moreover, quite coherent with the theorem of indeterminacy (it is more a question here of an unobservability than an indeterminacy) [17], insofar as to determine the position of the wave would be to ignore its wave character, while considering the position of its energy potential E would, according to the Special Relativity, be considered to consider an infinitely contracted form of the wave moving on l, ie a point [16]. Indeed, an estimated length l in one dimension, a radial axis r, would actually be a point if it was infinitely contracted on the radial axis r.

The non-simultaneity of the two observations (observation of the wave and observation of its quantity of energy in a space corresponding to the infinitely contracted space of the whole wave) could be very important to explain the probabilistic aspect of the position of the quantity of energy in the probability wave associated with it and therefore in the probabilistic aspect of the behavior of the wave itself.

It should be noted that the quantum has no real physical existence, it is only the potential of energy transported by the wave, observed by an observer outside the wave. The energy potential is well distributed over the entire wave moving over l, but, the quantity of energy associated with the wave moving at the speed of light, the space allocated to it is punctual and corresponds to the length l, on which it can be distributed, infinitely contracted.

At this moment of the work, we have been able to describe the physical nature of an electromagnetic radiation, by demonstrating that it was actually a radial gravitational wave, its electric field being then considered as a property of the Space- Time and not as a force field. This allowed us to demonstrate that a wave is actually a series of contractions and dilations of the space carrying a potential of energy distributed over the whole wave, to which we will associate a quantum of energy of infinitely contracted length. (null), ie distributed on a punctual space, from the point of view of an observer outside the wave, because of the Special Relativity. The "problem" of wave-particle duality is solved. Electromagnetic radiation is neither a single wave nor a single corpuscle, insofar as we can not envisage the one without the other, the corpuscle corresponding to a contacted wave and the wave corresponding to a corpuscle (a quantity energy) dilated. A wave is therefore essentially the same thing as a corpuscle, the latter being only a quantity of energy in the space of its wave, infinitely contracted because of the Special Relativity.

6 Expected breaks in energy conservation

6.1 Gravitational redshift and blueshift

Gravitational shift phenomena are directly induced by Relativity and have been confirmed by the Pound-Rebka experiments [12, 13, 14]. The gravitational waves that can undergo these relativistic effects (insert here observed redshift reference), a radial gravitational wave would be sensitive in this way:

$$E = A_{(r=l;\varphi=\frac{\pi}{2})_\omega}\nu_\omega \tag{95}$$

$$E = \frac{A_{(r=l;\varphi=\frac{\pi}{2})_\omega}}{T_\omega} \tag{96}$$

After extracting the outer metric of Schwarzschild [8], we use the term $\sqrt{1-\frac{2GM}{c^2\rho}}$, as follows:

$$E = \frac{A_{(r=l;\varphi=\frac{\pi}{2})\omega}}{t_\omega\sqrt{1-\frac{2GM}{c^2\rho}}} \tag{97}$$

Where ρ would be the radial distance between ω of the object deforming the geometry of Space-Time near the wave ω, M the mass of the same object, and t would the period of ω for which:

$$E' = \frac{A_{(r=l;\varphi=\frac{\pi}{2})\omega}}{t_\omega} \tag{98}$$

E' corresponding to the energy potential of the wave if it were located in an almost flat space-time, here that of the observer.

Inasmuch as the series of dilations and contractions would not see its amplitude changed, since not only would the spatial contractions increase, but also the dilations that would diminish. Indeed, in such a configuration, the difference between the maxima of the dilations and the maximum of the contractions would remain constant. On the other hand, the frequency-dependent energy potential, in addition to being dependent on the amplitude, would increase as the curvature of the space-time in which the radial gravitational wave evolves would be accentuated.

With this model, the conservation of energy is quite relative, but one can, provided to apply this principle to the mass particles and to eliminate the second problem of the paradox of the increasing mass (developed hereafter), to note despite all the curvatures of Space Time, they are preserved. This would make it possible to solve the first problem of the paradox of the growing mass and to eliminate the second, while allowing to satisfy the principle of mass-energy equivalence.

6.2 The paradox of increasing mass

The paradox of the growing mass is a highlighting of a gap between the predictions from General Relativity and those from the standard model [18]. It is an application of gravitational shift to mass particles, using the de Broglie relation [19]. The two "problems" raised are:

- An increase in the mass of a particle due to the accentuation of the curvature of the Space-Time in which it is located, as follows:

$$\lambda = \frac{h}{mv\beta} \tag{99}$$

Where $\beta = \sqrt{1-\frac{v^2}{c^2}}^{-1}$.

$$\Theta = \frac{h}{mv^2\beta} \tag{100}$$

$$\theta\sqrt{1-\frac{2GM}{c^2\rho}}=\frac{h}{mv^2\beta} \tag{101}$$

$$m=\frac{h}{v^2\beta\theta\sqrt{1-\frac{2GM}{c^2\rho}}} \tag{102}$$

So that, for $\rho_1 > \rho_2$, $m_1 < m_2$.

- An increase in the total mass of a system consisting of two particles continuously increasing their masses over the time of their cohabitation, the mass increase of one causing an amplification of the curvature of the space-time due to its mass involving the increase of the mass of the other particle, and so on, so that:

$$\begin{cases} m_{n+1}=\frac{h}{v^2\beta\theta\sqrt{1-\frac{2GM_n}{c^2\rho}}} \\ M_{n+1}=\frac{h}{v^2\beta\theta\sqrt{1-\frac{2Gm_n}{c^2\rho}}} \end{cases} \tag{103}$$

If the first problem makes it possible to establish a parallel with the offset suffered by the electromagnetic radiations and to confirm a certain mass-energy symmetry, the second one breaks completely with the mass-energy equivalence principle and does not seem to correspond at all to the observation, or in any case has never been evidenced by observation.

An application of the model outlined in the previous sections would eliminate the second problem. Indeed, if the mass, in the same way as the energy for the light, was the result of the deformation of the space-time, then the increase of mass due to the accentuation of its curvature would not be consider, to the extent that the mass and curvature of the space-time that "generates" it would always remain relative to the curvature of the space-time in which the particle evolves and that an accentuation of the curvature of the The space-time in which the particle evolves would not necessarily imply an increase in the deformation of the space-time geometry propagated from said particle ("generating its mass"). The second problem of the paradox would then be eliminated.

6.3 Overtures

The application of this model to mass particles would thus make it possible to solve the paradox of increasing mass and to maintain a certain mass-energy symmetry, in addition to completing the resolution of the "problem" of wave-particle duality. Moreover, this would explain the emergence of particle pairs in the void by fluctuations in the curvature of space-time. This is an opening that will not be dealt within this paper.

Moreover, this would solve the problem of incompatibility by reinterpreting the Principle of Uncertainty as a theorem of unobservability and solve the problem of the incompatibility between the dilation of time and the Principle of Uncertainty (this is say between the foundations of General

Relativity and Quantum Mechanics) [20], using the first prediction of the paradox of increasing mass [18].

7 Conclusions

By succeeding in extracting the Planck constant from the equations relating to the electric field of a radial gravitational wave, a gravitational wave propagating in a single direction, we have been able to demonstrate computationally the discrete nature of the amplitude and the level of the energy of such a wave, to establish a physical meaning for this constant, as well as for the fine-structure constant, the real physical interpretation of which escaped the scientific community since the 1920s [7]. Then, we have been able to establish the gravitational field to which the amplitude of the wave is correlated, as well as the electric field, and we have been able to demonstrate that the electric field was not a force field but, in the same way as gravitation, a property of Space-Time, while defining the electromagnetic radiations as radial gravitational waves, that is to say series of contractions and dilations of the space propagating in a single direction. We were then able to assign to this wave a quantity of energy, actually corresponding to the contraction of the energy potential distributed over the whole wave, because of its speed, thus making it possible to understand why the waves have this corpuscular aspect. Special Relativity will have solved the "problem" of wave-particle duality for electromagnetic radiations.

We have then briefly been able to address the question of mass particles, for which the application of this wave model could have the consequence of explaining the fluctuations of the vacuum such as fluctuations in the geometry of the space-time, the particles being then described as consequences of the deformation of the geometry of Space-Time. This approach would allow us to approach a little more than a conciliation of the notion of dilation of time and the principle of uncertainty, here used as a mathematical theorem of unobservability rather than as a physical principle of indeterminacy [20] . Indeed, by using the paradox of the increasing mass and using the concept of relative mass, the theorem becomes completely compatible with the Relativity, insofar as the abandonment of the absolute mass would make it possible to erase this incompatibility, the relative mass actually observed depending on the position of the object and can only be observed as quantity by ignoring the wave aspect of the mass particle, as explained in section 5. This reinterpretation refining the definition of the Principle of Uncertainty, to be effective, must however benefit from an enlargement of the present model to mass particles.

Moreover, it would also eliminate the second and main problem posed by the growing mass paradox.

Finally, the demonstration of the discretion of the amplitude of the contractions and dilations of the space makes it possible to provide a first quantization of the space-time [9, 10, 11] in conformity with the general relativity, based on models with strong observational substantiation, and, of course, consistent with all observations already made.

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Competing interests

The author declares no competing interests.

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