Frequency Shifts of Energy Particles into the Domain Space-Time (3+1)D

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Abstract

Let us study at first the representation of energy of ordinary bodies and of massive elementary particles into the domain space-time (3+1)D, then let us consider energy particles represented by photons and by energy quanta. It is known that kinetic energy presents a factor 1/2 for ordinary force fields, but we will demonstrate that factor is absent in determinate physical conditions through the use of the Dirac impulsive function and this consideration can be useful also for energy particles. Frequency shifts of energy particles can be interpreted in the light of new considerations on energy, that prove cosmological shift is the overall outcome of different physical effects due whether to redshift or to blueshift.

1. Introduction

In our views force field is a vector field defined in all points of the domain of the field and it is different from other types of field, like for instance scalar field and tensor field. The domain of field is defined by all points (x,y,z,t) of non-entangled space-time (3+1)D in which space is three-dimensional and time is one-dimensional. Vector field is connected with force through a convenient relation that depends on physical field. Force fields can be conservative and non-conservative. In conservative field of force work that force of field performs from a point A to a point B of the field domain is independent of the path and it depends only on points A and B, i.e. the work performed by the field force along a closed path is always zero. Conservation Principles define then the invariance of particular quantities in physical processes before and after the process. Conservation Principles of physics regard important physical quantities: energy, mass, momentum, angular momentum, electric charge, spin.
At times energy and mass are enclosed into only one conservation principle even if it needs to consider that anyway mass and energy are two different physical quantities and in that case the Conservation Principle of Mass and Energy defines the overall conservation of mass and of energy when the physical process involves also a mass-energy or energy-mass conversion.

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Similarly also angular momentum and spin are often unified into only one Principle considering nevertheless angular momentun concerns more really ordinary bodies of classic physics while spin regards elementary particles.
In the Standard Model of postmodern physics there are other three disputable conservation principles regarding the number of electron family, the number of muon family and the number of baryon family, but those principles are valid only inside the SM while they are not necessary into the Non-Standard Model. Certainly the most important conservation principle in physics is the Conservation Principle of Energy that is also the most hard to control and to verify because not always all shapes of energy that are implicated in a physical process are well-known.
Let will us begin our study starting from kinetic energy that is certainly a very important concept of physical processes.

2. Kinetic energy of moving systems

Kinetic energy represents motion energy of a physical system, and it represents further the work performed by a force in order to accelerate the physical system from the zero speed to the final speed v_o. In order to move a system with mass m_o, initially at rest, along an elementary distance ds, a force F executes a work dW=Fds. Supposing that force field is conservative (in that case k=0, where k is the coefficient of mechanical resistance of medium), for the general law of motion[1] we have

$$dW = m_o \frac{dv}{dt} ds \qquad (1)$$

$$dW = m_o v\, dv \qquad (2)$$

Because the system is initially at rest (v=0), the work W performed by the force F in order to accelerate the physical system to the final speed v_o is given by

$$W = \int_o^{v_o} m_o v\, dv \qquad (3)$$

and prosecuting the calculation we have

$$W = \frac{1}{2} m_o v_o^2 \qquad (4)$$

The (4) is the kinetic energy E_c=W acquired by the system in time that the physical system spends for passing from the state at rest to the speed v_o. If force F is constant then the time t_o that the system spends for passing from speed zero to the speed v_o is given by

$$t_o = \frac{m_o v_o}{F} \qquad (5)$$

If the resistant coefficient k is null or practically null (k=0, k≈0), the work executed by the force F to lead the system to the speed v_o is converted completely into kinetic energy. Naturally in these physical consitions, under the continuous action of the force F, the system tends to accelerate and consequently its kinetic energy increases for every new value of speed according to the (4), if it leaves from zero speed, or according to $W=m_o(v_1^2 - v_o^2)/2$ if it leaves from speed v_o.
Let us wonder what happens for kinetic energy if body, after having reached the speed v_o, continues to move with constant speed v_o. It is manifest that in order to reach it, it needs to void the force F, and in those conditions kinetic energy remains constant.
Let we deduce from the (3), at constant speed v_o,

$$W = \int_{v_o}^{v_o} m_o \, v \, dv \qquad (6)$$

$$W = 0 \qquad (7)$$

Therefore if the system moves with constant speed, there is need no work in conditions of zero resistance of medium. If instead force field isn't conservative (i.e. k≠0), then in that case in order to maintain the constant speed it needs a constant force given by $F=kv_o$.
Let us suppose that the system is at rest and the force field is conservative (k=0), let us wonder if in these physical conditions it is possible to lead instantly the physical system from speed zero to the constant final speed v_o practically in null times (i.e. t_o=0). To that end it is possible to use a very useful mathematical function for the study of the dynamic behavior of physical systems: the Dirac impulsive function, that in the event of an impulsive force is $F(t)=F\delta(t)$, where F is a dimensional constant and $\delta(t)$ is the Dirac dimensionless function (fig.1).

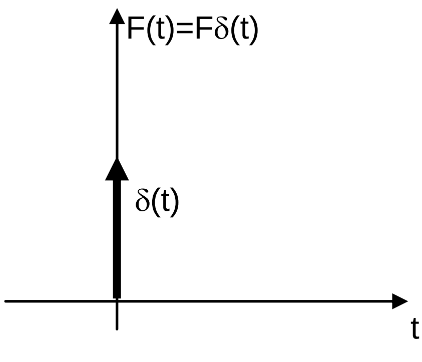

Fig.1 Representation of an impulsive force through the Dirac function

The Dirac function is a very characteristic function of the mathematical analysis and it is equal to zero everywhere unless in one point where it has theoretically infinite value, like in fig.1. In practice the value is greatest but finite in a smallest time but non-null. Besides it has the following important property

$$\int_o^t \delta(t)dt = 1 \qquad (8)$$

and therefore

$$\int_o^t F\delta(t)dt = F_\delta \text{ [Ns]} \qquad (9)$$

Consequently if a Dirac impulsive force is appied to a system with mass m_o, from the Newton law we have

$$F\delta(t) = m_o \frac{dv}{dt} \qquad (10)$$

and integrating between 0 and t

$$F\int_o^t \delta(t)dt = m_o \int_o^{v_o} dv \qquad (11)$$

from which for every t, also smallest,

$$v_o = \frac{F_\delta}{m_o} \qquad (12)$$

It follows that a system, in tha absence of medium resistance, under the action of a Dirac impulsive force gains instantly a constant speed v_o given by the (12). The Dirac force is an ideal force that takes an infinite value in the instant of application and is null in all other instants. In actuality it can be obtained through a force that gains a greatest value in a smallest interval. If we calculate the work performed by the Dirac force on the system with mass m_o, we obtain

$$dW = F\delta(t)ds = F\delta(t)\, vdt \qquad (13)$$

Integrating the (13) and considering the constant speed $v=v_o$ is given by (12), we have

$$W = v_o F\int_o^t \delta(t)dt \qquad (14)$$

and from (12)

$$W = F_\delta v_o = m_o v_o^2 \qquad (15)$$

Therefore when a system takes instantly a constant speed under the action of an impulsive force, its kinetic energy is given by the (15) and not by the (4).

3. Energy of force fields into the domain space-time (3+1)D

Let us intend to examine the behaviour of energy and in particular the Conservation Principle of energy in main physical events. Let us consider here linear or rectilinear motions and they have to be distinguished from non-linear bending motions.

3.a Energy in fields of force for ordinary bodies

If an ordinary body with resting inertial mass m_o is subjected to a force F into a force field with coefficient of mechanical resistance k≠0 (non-conservative field), the motion equation in vector shape is

$$\mathbf{F}(t) = m_o \frac{d\mathbf{v}}{dt} + k\mathbf{v} \qquad (16)$$

We can consider only intensities of vectors because in the event of linear motions vectors **F**, **a**, **v** have the same direction and integrating the (16) we gain the scalar law of motion

$$v(t) = \frac{F}{K}\left(1 - e^{-kt/m_o}\right) \qquad (17)$$

where v_o=F/K represents the final speed of system. Mass m_o of ordinary body is the inertial mass that is constant with the speed of the body.
The elementary work performed by the force field in order to move mass m_o along the elementary distance ds is[1]

$$dW = Fds = m_o\frac{dv}{dt}ds + kvds \qquad (18)$$

$$dW = m_o v dv + kv^2 dt \qquad (19)$$

The work executed by the force F for leading the mass to the speed v_o is obtained integrating the (19), for t between 0 and t, anf for v between 0 and v_o. We obtain therefore

$$W = \frac{m_o v_o^2}{2} + k\int_o^t v^2 dt \qquad (20)$$

The first term $E_c=m_o v_o^2/2$ represents the kinetic energy while the second integral term

$$E_k = k\int_o^t v^2 dt \qquad (21)$$

represents energy that is dissipated by the force field because of the medium with mechanical resistance k.
It follows that in a force dissipative field, non-conservative, the Conservation Principle is valid anyway on condition that considering energy that is converted in different shape from kinetic energy, for instance heat.
If k=0, i.e. the force field is conservative and non-dissipative, we have

$$W = \frac{m_o v_o^2}{2} = E_c \qquad (22)$$

and the Conservation Principle of Energy expresses in that case all work performed by the force of field is under shape of kinetic energy of body.

3.b Energy in force fields for massive elementary particles

If a massive elementary particle is accelerated into a field of force it needs to consider massive particle is characterized by electrodynamic mass and not by inertial mass of ordinary bodies. Let us know in fact in TR electrodynamic mass changes with the speed according to the relation

$$m = m_o \left(1 - \frac{v^2}{2c^2}\right) \qquad (23)$$

Massive elementary particles, unlike ordinary masses, have a real intrinsic energy at rest given by

$$E_{io} = m_o c^2 \qquad (24)$$

and because electrodynamic mass changes with the speed, consequently it is possible to define a moving intrinsic energy

$$E_i = mc^2 \qquad (25)$$

For the Conservation Principle of Energy we have

$$E_{io} = E_i + E_c \qquad (26)$$

where $E_c=m_o v^2/2$ is kinetic energy of particle. Considering the (24) and (25), from (26) we deduce the (23).
We know an accelerated particle emits electromagnetic radiant energy E_r and in the Theory of Reference Frames it was demonstrated this emission happens at the expense of intrinsic energy of particle. Therefore it is possible to write for the (26)

$$E_r = E_{io} - E_i = E_c \qquad (27)$$

From the equation (27) we deduce for electrodynamic particles the concept of kinetic energy has a particular meaning because electrodynamic mass changes with the speed while for ordinary bodies inertial mass is constant with the speed and kinetic energy is exclusively a motion energy. For elementary particles, as per the (27), kinetic energy coincides with radiant energy: i.e. motion energy, gained by accelerated particle and due to the work performed by field force, is radiated in the shape of electromagnetic energy and as we know this radiation happens in actuality in quantum modality in the shape of energy quanta[2]. In particular at the physical speed of light particle emits a first quantum of energy that is equivalent to half of electrodynamic mass ($m_o c^2/2$) and at the critical speed $v_c=\sqrt{2}\,c$ it emits a second quantum that is equal to the first.
The motion equation in the event of an accelerated particle into a force field is

$$F(t) = m\frac{dv}{dt} + kv \qquad (28)$$

in which m is given by the (23). Taking on a constant force F, the elementary work performed along the elementary distance ds is

$$dW = Fds = m_o\left(1 - \frac{v^2}{2c^2}\right)\frac{dvds}{dt} + kvds \qquad (29)$$

$$dW = m_o vdv - \frac{m_o v^3}{2c^2}dv + kv^2dt \qquad (30)$$

Integrating the (30) for t between 0 and t and for v between 0 and v_o, the work performed by field force in order to lead massive particle to the speed v_o is

$$W = \frac{m_o v_o^2}{2} - \frac{m_o v_o^4}{8c^2} + k\int_o^t v^2\,dt \qquad (31)$$

$$W = E_c + E_k - \frac{v_o^2}{4c^2}E_c \qquad (32)$$

$$W = \left(1 - \frac{v_o^2}{4c^2}\right)E_c + E_k \qquad (33)$$

With massive elementary particles field forces execute a work W, that is lower than that necessary for an ordinary body, in order to lead particle from speed zero to the speed v_o.
Assuming k=0 and therefore E_k=0, the work performed by field forces, for an elementary particle, is

$$W = \left(1 - \frac{v_o^2}{4c^2}\right) E_c = E_c' \qquad (34)$$

and it is smaller than the work $W=E_c$ (see (22)) performed by field forces in the event of an ordinary body with constant inertial mass. It is due to the fact that mass of an electrodynamic particle decreases with the speed and it produces a decrease of the work performed by field forces. We observe whether for conservative fields or for non-conservative fields, the difference of work performed and of kinetic energy for massive elementary particles is given by a term of the second order

$$\Delta E_c = E_c - E_c' = E_c \left(\frac{v_o}{2c}\right)^2 \qquad (35)$$

4. Frequency shifts of energy particles in the space-time (3+1)D

Energy particles are energy quanta that travel at the physical speed of light c and they cover the frequency spectrum that goes from the infrared band (3×10^{11}Hz) to the delta-Y band ($\geq 1.13 \times 10^{23}$Hz) of electromagnetic spectrum[3][4]. In this spectrum photons represent quanta in the visible band of light that goes from the red radiation to the violet radiation. Under the infrared band there are classic electromagnetic waves, from ultra-long waves to microwaves. Energy of each quantum is given by the Planck relation $E=hf$ and any variation of energy affects frequency and wavelength ($\lambda=c/f$) . Energy processes and consequent frequency and wavelength shifts are due essentially to two different causes: the relative speed and the gravitational field. Frequency shifts due to the speed are defined by the relativistic Doppler effect that is caused, like for light and for electromagnetic waves, by a relative motion between quantum source and observer, whether in approach or in separation. Gravitational shifts are caused instead by gravitational field in which the source of quantum is and by gravitational field in which observer is. Let us distinguish three types of frequency shifts:

4.1 Doppler effect that generates whether redshift or blueshift
4.2 Shifts into a gravitational field that generate whether redshift or blueshift
4.3 Atomic cosmological redshift.

4.1 Doppler effect for energy quanta

By analogy with light and electromagnetic waves, the Doppler effect for an energy quantum is given by[5][6]

$$f_m = f_s \sqrt{1 + \frac{v^2}{c^2} - \frac{2v}{c} \cos\Phi_2} \qquad (36)$$

where f_m is the frequency measured by observer, f_s is the initial frequency of quantum emitted by source, Φ_2 is the angle between the line OO' and the relative speed **v** between the source and the observer. O represents the origin of the reference frame S[O,x,y,z,t], supposed at rest, in which the resting observer is, and O' is the origin of the moving reference frame S'[O',x',y',z',t'], in which the moving observer is (fig.2). Positions of the source and of the observer can be reversed without no change in (36). The longitudinal Doppler effect is deduced from the (36) assuming $\Phi_2=0$ (separation between source and observer) and $\Phi_2=\pi$ (approach), for which we have

$$f_m = f_s\,(1 \pm \beta) \tag{37}$$

with $\beta=v/c$.

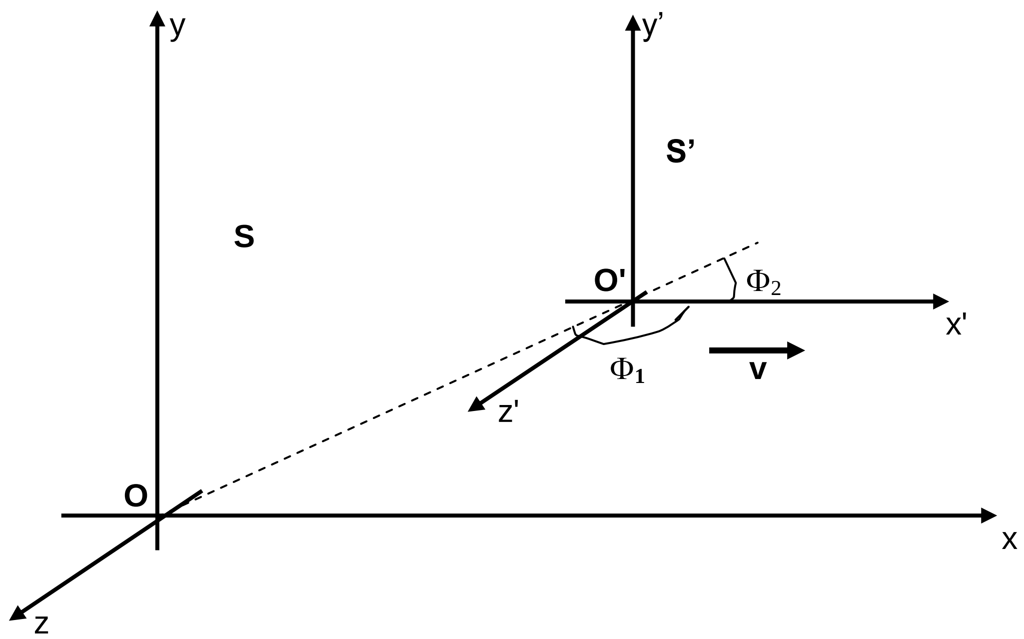

Fig.2 S[O,x,y,z,t] is the resting reference frame and S'[O',x',y',z',t'] is the moving reference frame

In the relation (37) the sign + is in concordance with blueshift and the sign - with redshift, therefore in the event of relative separation it needs to consider the sign - .

Let we can calculate the longitudinal Doppler effect also making use of the Conservation Principle of Energy that generally is used for energy balances inside the same reference frame. In the event of relativistic events referred to different reference frames it needs to consider between the two reference frames there is a difference of energy due to kinetic energy of relative motion. To that end let us consider a source S that emits an energy quantum at any frequency (a photon is inside visible field of frequency) $E_s=hf_s$ and let us suppose that between the source S and the observer O there is a vector relative speed **+v** in case approach and **-v** in case separation (fig.3).

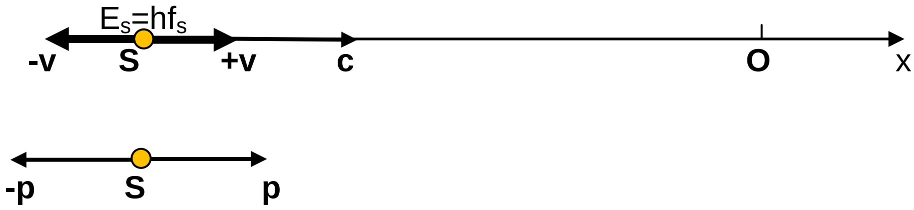

Fig.3 Longitudinal Doppler effect for an energy quantum emitted by a source S in relative motion ±v with respect to the observer O.

Energy quantum $E_s=hf_s=hc/\lambda_s$, emitted by the source S, has a constant physical speed c with respect to the reference frame S of the source, and because of the relative motion with vector speed **v** between source and observer, has a relative momentum **p**=m**v**, where m is the De Broglie equivalent mass of energy quantum, given by

$$m = \frac{h}{\lambda_s v} \qquad (38)$$

Because of its relative motion, at constant speed, energy quantum has an equivalent relative kinetic energy, given by the (15) instead by the (4),

$$E_c = W = mv^2 \qquad (39)$$

For the Conservation Principle of Energy this kinetic energy must be considered for calculation of energy. With respect to the reference frame of source energy quantum has an energy $E_s=hf_s$. With respect to the reference frame of observer who has relative speed ±v with respect to the reference frame of source, the energy $E_m=hf_m$ of energy quantum, where f_m is the quantum frequency that is observed and measured, is given by

$$E_m = hf_m = E_s \pm E_c \qquad (40)$$

according to kinetic energy has to be added or subtracted in concordance with the sign of relative speed. From the (39) and the (40) we deduce

$$hf_m = hf_s \pm mv^2 \qquad (41)$$

Considering kinetic energy is always positive, independently of direction of motion being a scalar quantity, while momentum can be positive or negative according to the direction of the speed, being a vector quantity, from the (38) we deduce

$$f_m = f_s \pm \frac{v}{\lambda_s} \qquad (42)$$

$$f_m = f_s\left(1 \pm \beta\right) \qquad (43)$$

where β=v/c. The (43) is exactly equal to the (37), where the sign "+" must be considered in the event of approach between source and observer, with positive relative speed v that produces increase of energy, while the sign "-" must be considered in the event of separation, with negative relative speed v that produces decrease of energy.
This result proves further the validity of the (15) for constant speeds that are gained instantly.
The same result (43) can be calculated also through the Conservation Principle of Momentum. To energy quantum E_s=hf_s, emitted by source with physical speed $c=\lambda_s f_s$, we can associate the equivalent momentum

$$p_s = mc = \frac{h}{\lambda_s} = \frac{h}{c} f_s \qquad (44)$$

Because of relative motion of the source with respect to the observer with relative speed ±v, according to relative motion is an approach motion or a separation motion, we can associate to the same quantum a second momentum due to the relative motion

$$p = \pm\, mv \qquad (45)$$

for which the overall momentum p_m of quantum, observed and measured by the observer, is

$$p_m = p_s + p = mc \pm mv = p_s(1 \pm \beta) \qquad (46)$$

Putting

$$p_m = \frac{h}{\lambda_m} = \frac{h}{c} f_m \qquad (47)$$

and replacing in the (46) we have, in concordance with the (43)

$$f_m = f_s(1 \pm \beta) \qquad (48)$$

In every physical situation the longitudinal Doppler effect can generate redshift o blueshift.
The transversal Doppler effect instead is given by the (36) for $\Phi_2=\pi/2$, and therefore

$$f_m = f_s\sqrt{1 + \beta^2} \qquad (49)$$

The transversal Doppler effect, unlike the longitudinal Doppler effect, generates in general always a blueshift, whether for energy particles or for light and e.m. waves.
With regard to the Doppler effect energy particles, that are e.m. nanowaves, behave therefore like e.m. waves and light.

4.2 Frequency shifts due to gravitational field

We distinguish two cases like for the relativistic Doppler effect:

4.2.a Gravitational blueshift
4.2.b Gravitational redshift

4.2.a Gravitational blueshift

Energy quanta, and consequently also light and e.m. waves, produce a gravitational blueshift when they go into a gravitational field. In fact a quantum with energy given by the Planck relation E=hf where f is the frequency of e.m. nanowave, that moves freely with the physical speed c of light into free space, is subjected to a small increase of speed when it goes with radial speed into a gravitational field, generated by a mass M_1 (fig.4). Motion law of quantum, assuming resistant forces are null (k=0), is given[7][8] by

$$\frac{dv}{dt} = \frac{GM_1}{r^2} \qquad (50)$$

and because

$$\frac{dv}{dt} = -v\frac{dv}{dr} \qquad (51)$$

the (50) can be written

$$vdv = - GM_1 \frac{dr}{r^2} \qquad (52)$$

Integrating the (52) between c and c_1 with respect to v and between r (practically infinite) and r_1 (radius of mass M_1) with respect to r, we have

$$c_1 = c\sqrt{1 + \frac{R_{s1}}{r_1}} \qquad (53)$$

in which r_1 is supposed to be also the radial position of the observer in the reference frame S[O,r] (with $r^2=x^2+y^2+z^2$) and

$$R_{s1} = \frac{2GM_1}{c^2} \qquad (54)$$

is Schwarzschild's distance of the gravitational field generated by mass M_1 in which the observer is placed.

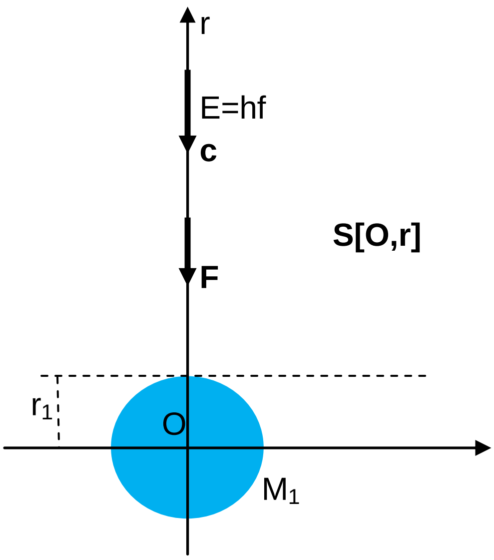

Fig.4 An energy quantum with radial direction goes into the gravitational field generated by mass M_1 suffering a small increase of speed

We can associate to the initial free quantum E=hf, that moves with physical speed c, a virtual equivalent mass

$$m = \frac{hf}{c^2} \tag{55}$$

and we can associate similarly to the same quantum, that moves into the gravitational field with physical speed c_1, a virtual equivalent mass

$$m = \frac{hf_1}{c_1^2} \tag{56}$$

It follows that quantum energy into the gravitational field is given by

$$E_1 = mc_1^2 = hf_1 \tag{57}$$

for which frequency of quantum becomes

$$f_1 = \frac{mc_1^2}{h} \tag{58}$$

and therefore for the (53)

$$f_1 = f\left(1 + \frac{R_{s1}}{r_1}\right) \tag{59}$$

An energy quantum that with radial direction goes into a gravitational field generated by the celestial body, with mass M_1 and radius r_1, experiences a **"blueshift gravitational"** that near the surface of the mass M_1, where the observer is placed, is given by the (59).

4.2.b Gravitational redshift

Let us consider now an energy quantum E=hf that moves away from the gravitational field generated by M_2 (fig.5). In that case, because particle is subjected to a slow-down because of gravitational force, the motion law into M_2's gravitational field is given[7][8] by

$$\frac{dv}{dt} = - \frac{GM_2}{r^2} \tag{60}$$

and because

$$\frac{dv}{dt} = v\frac{dv}{dr} \tag{61}$$

the (60) can be written

$$vdv = - GM_2 \frac{dr}{r^2} \tag{62}$$

Integrating the (62) between c and c_2 with respect to v and between r_2 (radius of M_2) and r, we have

$$c_2 = c\sqrt{1 - \frac{2GM_2}{c^2}\left(\frac{1}{r_2} - \frac{1}{r}\right)} \tag{63}$$

It is manifest that at great distance from the mass M_2, it is $r >> r_2$, for which the (63) becomes with good approximation

$$c_2 = c\sqrt{1 - \frac{R_{s2}}{r_2}} \tag{64}$$

where $R_{s2}=2GM_2/c^2$ represents the Schwarzschild distance of the mass M_2.
At great distance from M_2, quantum frequency undergoes therefore the change

$$f_2 = \frac{mc_2^2}{h} \tag{65}$$

and therefore for the (64)

$$f_2 = f\left(1 - \frac{R_{s2}}{r_2}\right) \tag{66}$$

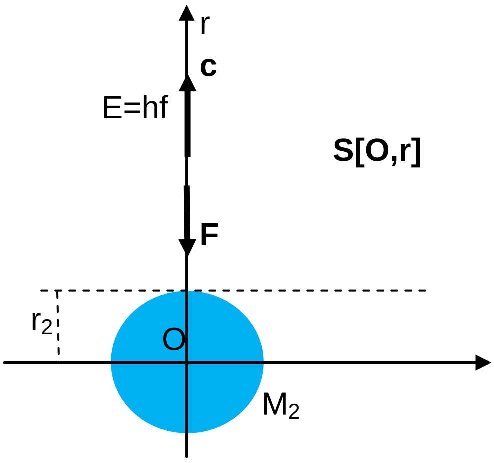

Fig.5 An energy quantum E moves away with radial direction from gravitational field generated by mass M_2 undergoing a small decrease of speed

An energy quantum that moves away in radial direction into the gravitational field generated by the celestial mass M_2 undergoes a **"gravitational redshift"** given by the (66) at great distance from surface of the mass M_2.
Considering (59) and (66) we can say gravitational shift in frequency for a quantum that moves away from mass M_2 and approaches mass M_1, with respect to the observer who is placed on the surface of M_1, is given by

$$f' = f\left(1 - \frac{R_{s2}}{r_2}\right)\left(1 + \frac{R_{s1}}{r_1}\right) \qquad (67)$$

4.3 Atomic cosmological redshift

In the study of atomic cosmological redshift[9] we have demonstrated the existence of a redshift of spectral lines of same atoms on surfaces of different stars, due to a variation of electrodynamic mass inside the Rydberg constant. That study led to the conclusion that atomic cosmological redshift is given by the relation

$$f_s = f_T\left(1 - \frac{GM_s}{c^2 r_s}\right) \qquad (68)$$

where f_T is the spectral line of a chemical element on Earth's surface, M_s is mass of the considered star, r_s is its radius and f_s is the spectral line of the same element on the stars' surface. Making use of the Schwarzschild R_{ss} of the mass M_s, the (68) can be written

$$f_s = f_T\left(1 - \frac{R_{ss}}{2r_s}\right) \qquad (69)$$

5. Cosmological shift in frequency of energy particles

As per considerations that we did it follows that any energy particle and consequently any radiation of energy particles with frequency f_g that is generated by a star and reaches the Earth undergoes in the domain space-time (3+1)D a cosmological shift in frequency that is given by mix of all effects that have been theorized in preceding reasonings:

1. relativistic shift due to the Doppler effect that is caused by the relative speed between emitting source (star) and observer (on the Earth); it is given by the (36) in general and by the (37) for longitudinal shifts.
2. gravitational shift due before to gravitational field where radiation is generated, that generates redshift, and after to gravitational field where the observer is placed, that generates blueshift; it is given by the (67).
3. atomic shift in frequency due to different electrodynamic masses of electrons on different stars; it is given by the (69).

It follows that overall cosmological shift in frequency is given by the following relation relative to the measured frequency f_m with respect to the analogous frequency f_T that is measured on the Earth

$$f_m = f_T \sqrt{1 + \beta^2 - 2\beta\cos\Phi_2}\left(1 - \frac{R_{ss}}{2r_s}\right)\left(1 + \frac{R_{s1}}{r_1}\right)\left(1 - \frac{R_{s2}}{r_2}\right) \qquad (70)$$

If radiation comes from the Sun (radius r_S) and it is measured by the Earth's observer, then in that case the Doppler effect is largely transversal ($\Phi_2=\pi/2$) and therefore the frequency that is measured on the Earth's surface (radius r_T) is given by

$$f_m = f_T \left(1 - \frac{R_{sS}}{2r_S}\right)\sqrt{1 + \beta^2}\left(1 - \frac{R_{sS}}{r_S}\right)\left(1 + \frac{R_{sT}}{r_T}\right) \qquad (71)$$

Let us observe the two blueshifts, Doppler and gravitational, are practically negligible, and similarly the gravitational redshift is negligible, being

$$1 + \beta^2 \approx 1$$

$$1 + \frac{R_{sT}}{r_T} \approx 1 \qquad (72)$$

$$1 - \frac{R_{sS}}{r_S} \approx 1$$

The relative shift of frequency $\Delta f/f_T=(f_m-f_T)/f_T$ is therefore given with good approximation by

$$\frac{\Delta f}{f_T} = - \frac{R_{sS}}{2r_S} \qquad (73)$$

Making use of numeric values we obtain for the frequency shift of an e.m. radiation, that is generated on the Sun and is measured on the Earth, the following value

$$\frac{\Delta f}{f_T} \approx -0.2\times10^{-5} \qquad (74)$$

The calculated value is in concordance with experimental values and the cosmological shift of radiation coincides practically with the cosmological atomic redshift.

5. Energy process in the phenomenon of reflection

Optical reflection is a physical phenomenon in which an electromagnetic wave, a shaft of light or a single energy quantum, is completely reflected by an appropriate surface without absorption or dispersion of energy. It' s manifest that reflection must respect the Conservation Principle of Energy.

Let us consider therefore at first a fixed source S and a reflection surface R, itself fixed with respect to the same reference frame S[O,x,y,z,t]. Let us suppose that $E_s=hf_s$ is the energy emitted by the source in the shape of quantum and E_r is the energy reflected by surface. For the same nature of reflection, that involves no absorption or dispersion of energy, it is

$$E_r = E_s \qquad (75)$$

The (75) represents the Conservation Principle of Energy in physical phenomenon of reflection. If now the reflection surface, represented by the reference frame S'[O',x',y',z',t'], is provided with a relative speed $\pm v$ with respect to source, it needs to consider into the balance of energy also kinetic energy due just to the relative speed. Consequently immediately after emission of quantum and before reflection, emitted energy is E_s with respect to the reference frame S of source and it is, as per (15) and (38)

$$E_r' = E_s \pm E_c = E_s(1\pm \beta) \qquad (76)$$

with respect to the reference frame S' of moving reflecting surface. After reflection for the Principle of Reference[5][6] reflected energy is E_r' with respect to the reference frame S' and it is

$$E_s'' = E_r' \pm E_c = E_s \pm 2E_c = E_s(1\pm 2\beta) \qquad (77)$$

with respect to the reference frame S of source. Therefore during a physical process of reflection with reflecting surface in motion the Conservation Principle of Energy has to consider in the right attention kinetic energies due to the motion of reflecting surface.

6. A particular equation.

In postmodern physics the equation

$$E^2 = (mc^2)^2 + (pc)^2 \qquad (78)$$

is very popular but its physical meaning is certainly disputable. Let we observe this equation makes reference to squares of energy terms. Besides if we consider separately the two terms that compose the (78) we have the following two energy terms

$$E_1 = mc^2 \qquad (79)$$
$$E_2 = pc \qquad (80)$$

If the equation (78) refers to a massive particle with resting mass m_o, its intrinsic energy at rest is given by (79) with $m=m_o$. If particle moves with speed v, electrodynamic mass m of particle, according to the TR, decreases with the speed and it happens at the expense of intrinsic energy at rest through the emission of electromagnetic energy. In that case the term (80) has no real physical meaning unless it is associated with emitted e.m. energy. In that case nevertheless it represents a reproduction of the term (79) when v=c.
If the equation (78) refers to an energy particle, its energy is defined completely by (80), in which E_2=pc=hf. In that case the term (79) has no additional energy meaning and it is a reproduction of the term (80) and it can be used only in order to define a virtual equivalent mass for energy particle: m= hf/c^2. Anyway the (78) has no physical meaning and it could have only a geometric meaning as per Pythagora's Theorem, assigning to two energy terms the meaning of two perpendicular vectors, but no usefulness exists in this possibility.

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