The cognitive process in physics

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Only a few highlights are here given. The interested reader ought to refer to Gregori (2006), or to a previous more extensive discussion in Gregori (2005, where the genesis is outlined of the present, otherwise apparently arbitrary, proposal, and also in 2006f, 2006g). The plan of the present paper, mainly resulting from a copy-and-paste of a few previous papers, is as follows:

1 – Introduction. Definition of *emp* and of *generalised momentum*. Dynamics with no Newton's principles

The *principle of absolute reality*, which is called *realism* by d'Espagnat, claims that every phenomenon occurs independent of the observer who monitors it. Such principle (according to Einstein) is shared by every theoretical approach, being a true and unanimously agreed "faith".

The *empirical constraint* claims that we can know only what we can observe. For instance, suppose that all humans are blind. We could live and achieve some knowledge of science and reality, although at the expense of a conspicuous effort. But our understanding would remain severely biased. Indeed, we are truly "blind" for several phenomena (e.g. for detecting neutral particles, which are non-ionising). Nature is like a nice garden, which is perceived and understood in a completely different way by a worm or by a bee, by a cat or by a swallow, or by a fish in the pool, etc. The humans are no exception to such rule. In several respects, they are like a fish having a very limited consciousness of the beauty and perfume of the flowers of the garden. Such viewpoint should not be confused, however, with a strict positivist position, as the essential role of scientific creativity and speculation (which is "mystic" according to Popper) ought to be emphasised in every case. The empirical constraint implies that the humans can have only a perception of some *limited truth*. When the principle of empirical constraint is applied to the subatomic world, it coincides with the Heisenberg's indeterminacy principle.

A widespread belief claims that, sometimes in the future, we will be capable of envisaging a small set of fundamental physical laws, by which we can explain all observations in terms a few elementary interactions (gravitational, electro-weak, strong, etc.). Indeed, this is an untenable belief, as we can envisage the laws that explain *only, and strictly only*, the observational evidence that we are capable of collecting. For instance, the Maxwell's laws are an excellent explanation for the *laboratory* experiments in electromagnetism (e.m.), while they badly fail in the subatomic world. Therefore, we should be more understating, and consider every kind of knowledge that we can achieve as some kind of "*thermodynamic*" understanding, much like e.g. the gas law gives no justice for the elementary interactions between single molecules. Differently stated, we can always add, to every assessed model, some arbitrary set of *hidden parameters* that increase the details of our explanation, although by raising eventual concerns about the requirements by the Ockham's razor. Hence, owing to the empirical constraint, we are incapable of inferring any "fundamental" "eternal" "universal" physical law. We can only envisage some explanation, concerned with some given amount of observations carried out within some given scale size, suitably conforming to the natural scale size of the humans and of their instruments. For instance, there is no fundamental difference

between the Maxwell's' laws, or the Titius and Bode law, or the Schrödinger equation, etc. They just refer to attempts at envisaging an *empirical* relation referring to different observational evidence. In addition, in general, for *every* given database, *no unique* explanation can be envisaged. Different explanations can be eventually proposed, and several theories can be simultaneously correct, or wrong. A choice can be made, whenever possible, only by means of crucial additional observations for discriminating among some controversial predictions. The present generally agreed feeling about the human capability of discovering some ultimate fundamental laws recalls the presumption by the ancient Greek thinkers of being capable of replicating the logics of the Divine Perfection of the creation of the world. Some hypothetical humans with the size of an ant or of a mountain, and/or with a total life span of hours or of millennia, would have a completely different knowledge and perception of natural reality.

A concern deals with the distinction of the *absolute vs.* the *human*. A "universal" law is an absolute concept, analogous to the idea of "absolute" reference frame - which was historically conceived as being either geocentric, or heliocentric, or galactocentric, or big-bang-centric, etc. Only Einstein attempted at giving a reply to such disquieting cognitive uncertainty, upon considering whether it is actually possible recognising the existence of some "absolute" reference frame. He rather concluded in terms of a realistic denial of such possibility, and he introduced the *principle of relativity*. Such item is later here re-discussed.

Let us introduce some definitions. "*Existence*" is synonymous of something that has a non-vanishing content of "*emp*". *Emp*, denoted by $\mathcal{E}$, is the acronym for "*energy, mass, primordial*", and it refers to something that is eventually manifested like energy, or eventually like mass, or eventually it exists, although it is not perceived by the "blind" humans (e.g. refer to dark matter, etc.).

"*Time*" is a psychological feeling (Seneca, Proust, Severi, …). In addition, "*ageing*", i.e. the direction of the arrow of time (Prigogine), is an additional and unconscious, though quite real and effective, psychological feeling, being the innate capability of recognising that the entropy steadily increases within all natural systems. And the increase of entropy, or the irreversibility of natural processes, is one concrete great fundamental paradox of our understanding of natural phenomena (but such drawback is only seldom emphasised). Such paradox is solved by the present approach. "*Space*" is a similar psychological feeling, and, according to our understanding and conforming to the empirical constraint, it is inferred being 3D (see section 6).

According to the heritage by the ancient Greek philosophy, we are acquainted considering a 3D "*space*", and a "*time*", as being two "absolute" and basically independent entities, which pervade, everywhere and at every time, the entire universe, which is conceived as including all what exists. The theory of relativity showed, rather, that we must refer to a 4D "*spacetime*". Its supporting observational evidence is discussed in section 2, altogether with our assessment about the Euclidean or Riemannian nature of our spacetime.

One classical and important logical dichotomy is the "*inertia*" *vs.* the "*virtus*" viewpoint. At present, the "inertia" standpoint is more common - by which nothing happens unless something causes it - unlike the "*virtus*" viewpoint that reminds about the ancient Aristotelian approach - by which something happens due to some intrinsic natural properties of the constituents of the system. "*Virtus*" (plural "*virtutes*") is a Latin term. For instance, Kepler unsuccessfully attempted at explaining the planetary orbits by means of "*virtutes*", and by appealing to the magnetic force. At present, all *quantum numbers* of elementary particles, even including electric charge, mass, spin, etc. are to be considered "*virtutes*". Our present knowledge is therefore a suitable combination of *both* such "*inertia*" and "*virtus*" viewpoints.

The competitive role of *finite vs. infinite* quantities leads our concern about the essential role of our arbitrary abstraction in an attempt at fitting natural reality with the unavoidable requirements for simplicity by the human mind. In fact, the asymptotic properties are not features of natural reality, both when we extrapolate to "*infinite*" values or to "*infinitesimal*" values. Such concepts are rather suitable algorithms, arbitrarily introduced by the humans. Avoiding such drawback is here referred to as the "*finite principle*", and it has important consequences. Such principle is applied, e.g., although only to infinitesimal quantities, by the string theory. Continuous functions – and as a consequence also potential functions, fields, forces, etc. - are to be conceptually degraded to some much limited "thermodynamic" information. Even general relativity has to be considered as a "thermodynamic" description that cannot hold on spacetime scale sizes below some threshold. No infinitesimal quantity exists. Rather everything can be reduced, at most, to some "granules" that, when dealing with the e.m. field, were historically called "quanta" or "photons". Every interaction has to be interpreted in terms of an exchange of some "granules", much like it occurs in the classical Feynman graphs, which are here generalised into the much more general concept of *QAT* (*Quantum Action Transmission*). The Feynaman graphs, or the analogue *QAT* graphs, are symbolic representations of a

physical process. Every observation of some phenomenon implies the *strictly necessary* ensemble of three elements, i.e. of a "*source*", of a "*carrier*", and of a "*receiver*". If either one of them is missing, we can perform no observation; we are "blind".

For instance, the Poynting vector describes an e.m. field, which is released by some device that changes in time, and it travels through space at the finite speed *c*. After a while, let us suppose that we reshape the original device to its original configuration. An opposite flux of Poynting vector must flow backward in order to recover to its original state. If no "receiver" afforded in capturing the former Poynting vector, its energy shall be anew available to the "source", which recovers to its original configuration. That is, the Poynting vector appears curious in the fact that it is "virtual". It is something that exists within our imagination (or, which is the same, within the mathematical model that depicts natural reality according to our abstraction by means of the Maxwell's laws and of their solutions). We can actually detect the Poynting vector *only* in the case that some "receiver" captures it and transforms its energy into some observable effect. It should be stressed that it makes actually no difference whether the former energy flux, associated with the outflowing Poynting vector, is later compensated by a backward energy flux, or whether, in contrast, one should appeal to the role of some hidden calorimeter, composed of dark matter or dark energy or dark *emp* $\mathcal{E}$, which absorbs the former outflowing flux, and returns back the energy associated with the backflowing flux: since we *cannot* observe the dark *emp*, such distinction is just a matter of semantics, not of physics.[1]

Such concern typically occurs in every case history, even other than dealing with the e.m. interaction, and depending on the *finite* speed of propagation of whatever signal.[2] That is, the concept of *action-at-a-distance* must be strictly rebutted. Upon some more specific discussion it is promptly concluded that *every* physical system results confined within some limited domain of spacetime, as every action, or change of the system, and its eventual recovery, must last only during some finite time lag, and the propagations speed of signals is finite. Such concept is quite general. Hence, the world is composed of such closed domains called "*monads*", which appear like some kinds of black holes, *incapable of communicating* among each other.

Such disquieting and devastating logical perspective ought to forbid e.g. even the existence of chemistry. However, such unfortunate situation is overcome by the fact that, owing to the finite principle, the local density of *emp* $\mathcal{E}$ can never exceed some (unknown though finite) upper limit. Whenever such condition is eventually violated, some *emp* $\mathcal{E}$ coagulates into some "granule", which, compared to its former monad of concern, becomes an independent entity. Every such granule is then free of moving independent of its parent monad, and such granules are responsible for the communication and interaction between different monads through the *QAT* process. Such occurrence can be called "*slingshot process*" or "*generalised Kant-Laplace mechanism*" (reminding about the classical concept of planetesimal accretion).[3]

Monads occur in nature, and different monads span different scale-sizes. For instance, an atom is one monad. But suitable consideration must be given to subatomic monads, or to monads of several different scale sizes, until the entire observed universe, which can be called the "big bang monad", etc. Every monad can be associated with its respective, suitably defined, reference frame. The reference frame of the big bang monad can be used like the *common* reference frame for *all* observed monads of *every* scale size. The big bang reference frame is not the "absolute" reference frame. However, it works effectively as a common standard, for describing all phenomena measured by different observers. Even in the case that, according to

[1] Such choice is only apparently arbitrary, as such arbitrariness is dropped in the case of the *SVAT* assumption discussed in section 6.

[2] In general, the *QAT* process occurs between every couple of objects, just because they have an *emp* content. This implies that even two *emp* contents identified with two kinetic energies experience universal gravitation ("*pan-Newtonian assumption*"). Such fact seems to be implicitly assumed by every previous treatment of relativity theory. Hence, the gravitational attraction depends on the speed of the objects with respect to the pre-chosen and arbitrary frame of reference. This violates the principle of realism. Such paradox can be avoided only by assuming the existence of an absolute reference frame, i.e. of some kind of ether. In addition, the transformations between different frames of reference is no more a matter of mere kinematics. Rather, it is a physical fact, upon considering the energy (or the *emp*) that is required for accelerating any object relative to another.

[3] A related remark is that, in the case that we have observations capable of inferring the internal structure of one such given granule, we can consider it as a new kind of monad, eventually by making reference to some hidden parameters, etc. That is, ultimately even the distinction between granule and monad depends on the limits imposed by our "blindness", i.e. by the empirical constraint.

the Einstein's approach, we are incapable of assessing the specific identity of an "absolute" reference frame, we are actually capable of defining the reference frame of the big-bang monad, and such frame can effectively work as the unifying frame for describing the entire observed universe.

Different kinds of "*carriers*" are to be considered. The best known is the photon, which is associated with the e.m. interaction. Another likely carrier is the graviton, which however at present was never detected (see section 11). The subnuclear world certainly contains other carriers, here not of direct concern. In principle, one can envisage every kind of eventual additional carrier, even for explaining e.g. psychological communication, etc.

The evidence of the finite speed of propagation of light, including the Michelson-Morley (and analogous) experiments, can be most simply explained upon supposing that every photon is a *volley of miniphotons* - e.g. liken it to a volley of bullets released by a gun-machine (figure 1). Every miniphoton has the constant speed *c*. However, when the photon source and the receiver move at some given relative speed, the distance is accordingly changed between the miniphotons along the volley, thus resulting into the Doppler's effect. Therefore, we should be concerned with *miniphotons*, rather than with *photons*. Photons reflect *per se* the physics of the monad atom, which released the entire volley of miniphotons, rather than the physics of the granule of e.m. radiation. By this, we get rid of the paradox by which the speed of light is not changed by the relative speed of source and observer, while the energy or frequency of light is affected. Analogously, it appears very reasonable considering several minigravitons, rather than one graviton, and such item is further discussed in section 4.

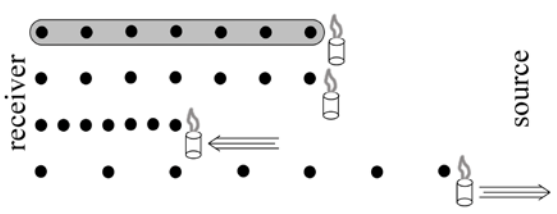

Figure 1 – Leftward photon propagation like a bullet (top line) *vs.* a volley of miniquanta (2^{nd}, 3^{rd}, 4^{th} lines; top to bottom). In every such case, every photon and/or every miniquantum is ejected from the source at the constant speed *c*. If the photon is composed of a volley of miniquanta, approximately equally spaced, released from the source at some approximately constant timing, the Doppler effect is simply explained. After Gregori (2005).

The concern about the Doppler effect shifts our mind towards the early times of the discussion on relativity, when the Doppler effect was much debated, although its concern was later apparently abandoned. What the difference is of a relative movement of source and receiver, compared to a relative movement of a receiver and of a mirror that reflects a light beam? What the physical meaning of "mirror" (which is rather only an abstraction, much like e.g. a geometrical object)? In addition, it is well known that the relativistic Doppler effect implies an effect associated with the component of velocity *perpendicular* to the line of sight between source and receiver: what physical implications are to be expected from such apparently paradoxical conclusion?

A reply can be inferred only after consideration of the *definition of units*, which is explained in section 2. In addition, whenever three observers are considered, let us call them A, B, and C (for Alice, Bob, and Charlie, respectively), and whenever B moves relative to A at a speed **v**, and C moves relative to B at a speed **–v**, it follows that A and C are reciprocally standing, having an eventually different origin of their respective coordinate axes. Therefore, owing to the principle of absolute reality, A and C must give the identical description of every given phenomenon. Such argument was applied in detail by Einstein in his famous paper (Einstein, 1905), and is here called *tout court* the "ABC argument" or "ABC theorem". All presently used formulas for the Doppler effect – either classical or relativistic - do *not* satisfy such ABC constraint. A more general formula for the Doppler effect has therefore to be used, having eventual implications in astrophysics and cosmology. Such much general perspective leads to the very important conclusion (see below) that some asymptotic speed *c* must exist, and no object can be accelerated to such speed *c* by any finite amount of *emp €*.

A fundamental item to be later recalled deals with the identification of the speed of light with such ultimate asymptotic speed *c*. The resulting entire scenario appears consistent with the assumption that every object that moves at such asymptotic speed *c* must have a null mass, and viceversa. Therefore, the realm of all what exists, and that moves at such asymptotic speed *c*, is inhabited by granules or particles of null mass. Does the miniphoton or the photon partake to such realm? Or should we consider other kinds of granules or particles partaking to such realm? Are minigravitons to be included? Do minigravitons (if they exist) partake

to such realm, while miniphotons are massive particles, having some very small though not strictly null mass? Such questions are to be discussed in sections 8 through 11.

The present axiomatic approach still requires specifying some formal definitions. After having defined the units (see section 2), let us first define "*energy*" by referring to a photon, in terms of the photoelectric effect, being $h\nu$. Then, the existence of "*something that exists*" is identified with its non-vanishing *emp* content, independent of whether such *emp* $\mathcal{E}$ is eventually manifested to the humans, or not. The "*mass*" of every existing "something" is then defined by means of its *emp* content divided by c^2, independent of whether c is the light speed or the speed of some other kind of granules of null mass. One then introduces the "*momentum*" of a photon by means of a weighted flux of its associated *emp* $\mathcal{E}$. The weigh has to be suitably defined in order to fit the ABC argument, and therefore reference is made to a "*generalised momentum*" $\vec{\mathcal{P}}$. In addition, by means of a simple generalisation, the momentum $\vec{\mathcal{P}}$ of a massive particle can be accordingly defined. Finally, upon considering a thought experiment describing a forward Compton scattering, it is possible to envisage the correct relation between the $\mathcal{E}$ and $\vec{\mathcal{P}}$ contents of a photon (or of a granule of strictly null mass and travelling at the asymptotic speed c), and the $\mathcal{E}$ and $\vec{\mathcal{P}}$ of a massive particle.

The Newton principles are to be substituted by the assumption that, within every interaction, the total balance must hold of the *emp* $\mathcal{E}$ content and of the *generalised momentum* $\vec{\mathcal{P}}$. Such law is expressed by a set of 4 scalar relations in the 4D linear vector spacetime. Such approach gives justice of several previous apparent paradoxes of standard theoretical physics. It requires no *ad hoc* assumption, rather it needs for some substantial change of our basic gnoseology. Detailed formulas are as follows (see Gregori, 2005, 2006b).

Let us define the *generalised momentum* $\vec{\mathcal{P}}$ of a photon by means of a (weighted) flux of $\mathcal{E}$

$$c\,\vec{\mathcal{P}} = \mathcal{E}\; f\left(|\mathbf{c}|/c\right)\cdot\left[\mathbf{c}/c\right] \tag{1}$$

where the weigh $f(|\mathbf{c}|/c)$ is some suitable function of $\beta \equiv (|\mathbf{c}|/c) \equiv 1$. Such weight shall be later specified, and $\mathbf{c}$ is the velocity of the photon or miniphoton. In order to keep the agreement of the present reformulation with the previous standard theoretical physics, we have to assume $f(|\mathbf{c}|/c) \equiv f(1) \equiv 1$. It can be shown that this implies no loss of generality. In addition, we have only to request that $f(0)$ is finite.

Let us now formally introduce a new definition that is lacking, i.e. the "*mass*". We observationally assess the existence of massive particles. We associate, with every such particle that moves at a velocity $\mathbf{v}$ within the reference frame of every given observer, a "*mass*" m identified with the scalar quantity

$$\mathcal{E} \equiv c^2\, m \equiv c^2\, m_0\, \xi(\mathrm{v}/c) \equiv \mathcal{E}_0\, \xi(\mathrm{v}/c) \tag{2}$$

where $\mathcal{E}$ is the given intrinsic *emp* content of the particle, and $\xi(\mathrm{v}/c)$ is a function of $\beta \equiv (\mathrm{v}/c)$, to be suitably defined in the following. It must be (by definition) $\xi(0/c) \equiv 1$. Therefore, m is called "*inertial mass*" (for the reasons that shall later appear evident), and m_0 is called "*rest mass*". In contrast, in principle, $\xi(1)$ can be either finite or divergent.

The *generalised momentum* $\vec{\mathcal{P}}$ of a *photon* was defined by (1). Define now the same, i.e. the *generalised momentum* $\vec{\mathcal{P}}$ for a *massive particle*, by the relation (i.e. as a weighted flux of *emp*)

$$c\,\vec{\mathcal{P}} = \mathcal{E}\; f(\mathrm{v}/c)\,[\mathbf{v}/c] \equiv\; c^2\, m\;\; f(\mathrm{v}/c)\,[\mathbf{v}/c] \equiv\; c^2\, m_0\, \xi(\mathrm{v}/c)\;\; f(\mathrm{v}/c)\,[\mathbf{v}/c] \tag{3}$$

The formal definition of "dynamics" (opposite to the previous definition by means of the Newton's principles of dynamics, either in their classical form or in their relativistic expression) is thus formally given by means of the two axioms of the *conservation laws of emp* and of the *generalised momentum*.

Let us apply such formalism to a thought experiment, where a photon is totally absorbed by a massive particle (Compton forward scattering). In this way, prove the formal relation between the former definition of *emp* (or energy) associated with a photon, with the *emp* associated with a massive particle. Then, apply the ABC argument. Such very simple and intuitive inference implies strict constraints on the definition of $f(|\mathbf{v}|/c)$ and of $\xi(\mathrm{v}/c)$. The final result after simple algebra is

$$c\,\vec{\mathcal{P}} = \mathcal{E}\; f(\mathrm{v}/c)\left[\frac{\mathbf{v}}{c}\right] = -\,\mathcal{E}\left\{1 + \sum_{p=1}^{\infty} a_{2p+1}\left(\frac{\mathrm{v}}{c}\right)^{2p}\right\}\frac{\mathbf{v}}{c} \qquad\qquad \sum_{p=1}^{\infty} a_{2p+1} = -\,2 \tag{4a,b}$$

where $\{a_j\}$ is a set of suitable coefficients, which contain physics, although it appears awkward determining them observationally (either by using interactions of very high energy, or by some much specific experiments on the Doppler effect; details not here given). In addition it is formally shown that

$$\left[1 - f\left(\frac{\mathrm{v}}{c}\right)\frac{\mathrm{v}}{c}\right] = 1\Big/\xi\left(\frac{\mathrm{v}}{c}\right) \tag{5}$$

A most important physical finding is that

$$\lim 1/\xi \xrightarrow[\mathrm{v}\to c]{} 0 \qquad\qquad \lim \xi \xrightarrow[\mathrm{v}\to c]{} \infty \tag{6a,b}$$

Differently stated, no massive particle can be accelerated to the speed *c* by any finite amount of *emp*. Therefore, *c* plays the role of an asymptotic velocity.

Let us recall that the definition of *c* was formerly introduced as an inference from the Maxwell's equations, i.e. from laboratory experiments on electromagnetism. Such experiments entered into the definition of the Lorentz transformations. Then, from the Michelson-Morley experiment *c* resulted to be an asymptotic speed. Such same concept has to be here later reconsidered (see sections 2 and 4).

Such same functions $f(|\mathbf{v}|/c)$ and $\xi(\mathrm{v}/c)$ enter into the formal definition of the generalised and correct formulation of the Doppler effect. Compared to the standard classical formulas, they imply only minor relativistic corrections. However, in general it appears awkward, if possible at all, to assess the entire set of the empirical coefficients $\{a_j\}$. This implies serious consequences for the applications to astrophysics (see section 11).

2 - The main differences compared to the Einstein's formulation

I – Einstein (1905) referred to two observers, i.e. Alice or A, who is "standing", and Bob or B who "moves" relative to A in terms of a *rectilinear* and *uniform* motion, at a velocity **v** oriented along their common X-axis. Such Einstein's starting point implicitly introduces two assumptions.

First, the concept of *straight line* must be given for assessed. In contrast, it is *not* obvious. The concept of straight line is well defined like a mere abstraction. The concern is rather about what entity in natural reality can be likened to it. The common intuitive reply is by referring to a "rigid rod". Even the concept of rigidity is, however, the result of an abstraction, much like every concept of geometry (such as a point, a line, a plane, …): rigidity is the invariance of the geometrical distance between points of the same object. In addition, independent of this, we use sight for "seeing" whether a rod is straight or not. That is, we do refer to light rays for deciding what can be likened to a straight line. Differently stated, we do assume that a light ray is a materialisation of our abstract concept of straight line. This means that we *do* assume, i.e. we do *not* prove, that light rays propagate along straight lines. We eventually check whether some physical entities, other than light, do propagate along straight lines or not. That is, we use light rays much like we use the reference grid on a sheet of a drawing paper. But we have no alternative primitive reference grid on our drawing paper, which is suited for checking whether light rays propagate along our primitive straight lines or not.

This amounts to assuming that our spacetime is Euclidean. The famous experiment, showing the effect of the gravitational lens of the Sun during a solar eclipse, has to be reinterpreted upon considering that we know the position of stars during the eclipse, in terms of a model of astronomical observations based on the assumption of the straight line propagation of the star light. It is therefore much "simpler", i.e. more "beautiful", describing the available observations by assuming that light rays are bent – i.e. for reasons of "beauty" we do prefer and shift to assuming a curved spacetime - instead of using a Euclidean spacetime that should require incredible efforts for justifying the apparent shift of the stars. That is, in the ultimate analysis we unconsciously prefer using the most beautiful (or simple) conceptual scheme.

In addition, the often quoted argument *cannot* apply, of using the sum of the internal angles of one triangle for testing whether spacetime is curved or not. In fact, while curving spacetime, even all protractors are curved, and the final result is independent of the eventual curvature of spacetime. For instance, let us think in 2D, and consider a flat sheet of drawing paper with grid lines, angles, protractors, etc. drawn over it. Then, stretch the paper sheet for getting curved grid lines, etc. All angles and protractors are changed accordingly, while the sum of the angles of one triangle always remains *180*°, because the angles are measured by such deformed protractors. If we live on such 2D paper sheet, and we have no knowledge about the existence of the third dimension in space, we cannot realise that our protractors are deformed. That is, a Euclidean or a Riemannian spacetime is the result of the *arbitrary* choice by the observer in terms of some algorithm suited for the needs for "simplicity" by the human mind, and it is *not* a physically intrinsic feature of natural reality.

Second, assuming that B moves relative to A at a *uniform* speed, presumes that A and B already defined their respective units. Indeed, Einstein assumes that both A and B have, each one, *identical* rods and *identical* clocks. This is however an unrealistic constraint, which, in fact, results having devastating consequences, as it is specified here below.

Consider, instead, a preliminary definition of units by one observer alone, e.g. by A, who begins her investigations independent of B. Alice has a specimen, say, of hydrogen, call it H_A that is excited and releases light. Independent of Alice, also Bob has a similar specimen, call it H_B and Alice observes the light emitted by H_B while, by means of spectroscopy, she can recognise that H_B is composed of hydrogen. Finally, Alice chooses one specific spectral line, and she uses its wavelength λ as her length unit, and, upon considering that c is constant, she claims that its frequency $\nu = c/\lambda$ is the inverse of her time unit. Upon comparing the wavelength of the identical spectral line that she observes and that are emitted by H_A and H_B , she can finally assess the ratio between her length- and time-units, and the analogous units used by Bob. The reciprocal argument applies to Bob when he chooses his units. Such procedure gives justice for eventual and unknown physical differences that can affect the Einstein's rods and clocks, depending e.g. on the different influence by local gravitation, when comparing the performance of "identical" rods or clocks within the A or B environment - and it should be emphasised that, in general, no two identical rods or clocks do perform identically when they are in different environments.

Such procedure, however, has the strict implication that the ratio of the length units is *the same* along *every* axis in 3D space - i.e. it does *not* apply only to the X-axis as for Einstein (who, however, borrowed such concept from some previous literature). In addition, *length and time* units are transformed according to the same ratio. Hence, *every velocity component is the same* for A and for B. Unfortunately, compared to Einstein's, such entire cognitive scenario results substantially modified by such new perspective.

II – A related discrepancy deals with the "proof" of the famous relation $E = m\,c^2$. Einstein gave two proofs, one in *1905* (Einstein, 1905a), and one (Einstein, 1950) much later in *1946*. According to the present formulation (see section 1), $E = m\,c^2$ is an assumption needed for introducing the axiomatic definition of mass. In contrast, the Einstein's *1905* proof begins by considering an electron that releases two identical photons along opposite directions, and by comparing how such phenomenon is observed by A and by B, respectively. If the units of A and B are *identical* (being based on strictly *identical* rods and clocks as Einstein supposed; see above), a relativistic change results to occur for the energy of the photon, though *not* for the mass of the electron. In this way, the relation $E = m\,c^2$ is found (after applying some approximation). However, if one suitably considers the formally more realistic and rigorous unit definition as mentioned above, the aforementioned Einstein's derivation leads only to a simple identity, i.e. such argument gives no proof. That is, Einstein inferred a correct final result upon inadvertently compensating the roles of his different assumptions. Obviously, such bias does not diminish the historical relevance of such Einstein's fundamental finding. In any case, such drawback does not apply to the Einstein's *1946* proof, which is based on a Compton scattering of two photons incoming from opposite directions and being simultaneously absorbed by one electron – and such logical approach is analogous to the thought experiment of a forward Compton scattering mentioned in section 1. The *1946* Einstein's derivation is fully correct. For additional discussion refer to Gregori (2005, 2006b).

III - A severe and devastating disagreement with the Einstein's derivation unfortunately deals with the so-called Einstein's *simultaneity* or *synchronisation* argument (Einstein, 1905).

Let us consider a classical logical process, which is well known in philosophy and which is called *reductio ad absurdum*. By it, we introduce two hypotheses, let us call them e.g. H_1 and H_2 , respectively. Let us drop, say, H_2 and suppose that we can prove that, as a consequence, also H_1 must be dropped. We conclude that H_2 is a *necessary* condition for H_1 to hold. In contrast, we *cannot* claim that we have thus "proven" that H_1 is violated, at least unless we can preliminarily prove that H_2 has been violated.

Einstein (*ibid.*) implicitly uses H_1, being the *principle of absolute reality*, and H_2 , being the *constancy* of *c*. Let us describe one given phenomenon P within the big bang reference frame, and let us consider how it can be observed either by A or by B. If a phenomenon P precedes another phenomenon Q, and if P is e.g. the cause of Q, the time sequence "P occurs before Q" must be identical for both A and B, due to H_1 i.e. to the *principle of absolute reality* – and Einstein claims that such principle is a "faith" for every theory that was ever proposed in the history of science. Subsequently, Einstein implicitly (though undeclaredly) violates the *principle of constancy* of *c* in the fact that he repeatedly uses expressions such as [v+*c*] and [v-*c*]. That is, he assumes that the light speed *c* can be either summed or subtracted with the speed of B relative to A. However, such expressions [v+*c*] and [v-*c*] can be used *only* if one violates H_2 . The Einstein's argument finally shows that, under such premises, some phenomena that result simultaneous in the

A reference frame eventually are no more simultaneous in the B reference frame. That is, Einstein (undeclaredly although implicitly) drops H_2 , and he infers that H_1 (i.e. synchronism and/or simultaneity) is violated. That is, if we drop the assumption of *constancy* of *c*, we violate the *principle of absolute reality*.

Einstein claims and concludes that, by this, he has "proven" that *simultaneity* (i.e. H_1) must be violated in natural reality. Or, he claims that upon assuming that H_2 is violated, we find that H_1 is violated, and he concludes that we have thus "proven" that H_1 must be violated. Such Einstein's inference appears untenable, at least according to the author's understanding about the aforementioned *reductio ad absurdum*. In any case, such "proof" resulted crucial during the subsequent *100 years*, being the origin of a large amount of concern in the literature – such as the famous "*killing the grandfather before the father was born*", etc. Some additional discussion is given in Gregori (2006b), although for more extensive and detailed related items the interested reader should refer to Gregori (2005).

IV – Presumably, a likely reason for such Einstein's inference derived from the fact that, at the conclusion of his argument, he unexpectedly found the same relations as the Lorentz transformations. In this respect, let us consider the origin, and the physical meaning, of the Lorentz transformations. Let us suppose that we perform *laboratory* experiments in e.m., and we finally infer the Maxwell's equations. By this, we conclude that, according to the Poynting vector formalism, some radiation propagates at some strictly constant speed *c*. Owing to the principle of absolute reality, since A and B *must* observe and describe *the same* phenomena, we do conclude that the Maxwell's laws, which must hold for both A and B, must transform according to the so-called Lorentz transformations. Such laboratory experiments are the actual fundamental observational support for claiming that we must refer to 4D spacetime, rather than independently referring to the 3D space and to the 1D time. This is one most important achievement of the so-called theory of relativity.

However, upon a closer inspection of such derivation of the Lorentz transformations, it is concluded that such entire argument and inference has *per se* no actual direct implication for the formal derivation of the relativity theory, at least according to the formulation here proposed. According to the author's understanding, it appears reasonable guessing that it was unfortunate that the aforementioned Einstein's argument, dealing with the aforementioned H_1 and H_2 etc., led to some formula that looked to him much like the Lorentz transformation. Such accidental coincidence probably resulted misleading, and it apparently convinced Einstein about the correctness of his argument.

V - In any case, one much important discrepancy of our final result with the classical Einstein's treatment is that the relativistic transformation for length, time, mass, energy, etc. must be a function, which can be expressed (as per (4)) by a series of terms of *odd* powers of $\beta = v/c$. Such inference is much different compared to the Einstein's formula $\sqrt{1-\beta^2}$, which rather contains only *even* powers of β . This has the important consequence that one should consider sometimes a relativistic *compression*, and sometimes a relativistic *expansion*, of such units – while Einstein can deal only with *compression*. In addition, the classical twin paradox no more exists. As far as the several well known experimental tests are concerned of the theory of relativity, all such experiments can be adapted to the improved formulation here envisaged. Compared with the previous standard Einstein's inferences, the improvements here proposed can be appreciated only whenever dealing with comparatively high values of β, i.e. normally ranging outside the realm of the experiments that are feasible in the laboratory. Only astrophysical experiments could perhaps be considered, or (maybe) even by observing some interactions between elementary particles of extremely high energy, etc. Up to the author's knowledge, no such case history or facility, however, seems presently available, and in any case such entire topic requires much harder thinking.

3 - Three worlds

The existence of every existing thing ought to be primarily referred to a timeless space, called β-world. The "existence" is identified with a non-null *emp* content (section 1). Since such β-world is timeless, no definition can be given of "before" and "after", or "first" and "second", etc. and no numbering is possible. Hence, it makes nonsense speculating whether such β-world is 3D or nD. No length measurement can be carried out, because a measurement should imply putting several rods one close to the other, and then *counting* them. We cannot count the number of dimensions, and we can recognise no straight line, because no time is defined, hence no speed and no asymptotic speed, which is the prerequisite for defining a light ray to be identified with a straight line. We ride a photon (according to Einstein); hence, we cannot perceive its propagation. We cannot decide whether such space is Euclidean or not. We can measure no length along any

axis. We can define no coordinate. Hence, we can recognise no individual item. We can measure no *emp* density within such space. Hence, we can have no feeling about some eventual excess of the local density of *emp* capable of triggering a slingshot process. The empirical constraint, and the impossibility of measuring several hidden parameters, plays a devastating role for our understanding. We can, however, observe the eventual granules that "occasionally" are generated by such generalised Kant Laplace mechanism, and that are ejected off the β-world.

Such β-world is the absolute reference frame of natural reality. It can be considered as the modern version of the ancient ether, and it can give justice for the evidence given by the cosmic microwave background (*CMiB*), etc. We should not be concerned with the fact whether we can actually detect it or not (for sure we cannot measure it, as we cannot even assess the number of its dimensions). Much like one can envisage hidden parameters for explaining the processes that occur inside the atom monad, such β-world is some kind of "hidden" world, being speculated to be the *real* backbone for everything that exists, notwithstanding the humans are essential "blind" with respect to it. The ultimate true essence of natural reality is such timeless β-world.

Therefore, let us suppose that – notwithstanding we cannot observe such fact - whenever some excess *emp* density occurs "somewhere" within such β-world, the slingshot process generates an *emp* granule that must escape from the β-world. In this way, a new axis, i.e. the time axis, is "exhaled", while the number of dimensions increases by one unit. The result is just our 4D observable spacetime, or α-world. Hence, with no loss of generality and for "simplicity" or for the "beauty" of our theory, we can consider a β-world having, say e.g. 3D, in order that the simple exhalation of the time axis justifies the conceptually smoothest possible transition from the β-world through our α-world.

Let us suppose that, owing to reasons of similarity with the α-world, the identical conservation laws hold within the β-world for both *emp* and generalised momentum. In reality, no time axis exists in the β-world; hence, no momentum can be defined. However, we like "beautiful" theories, and we seek the smoothest logical processes that can lead us through the domains of different worlds. Such assumption implies that the "exhalation" of a time axis, which is implied by the generation of some momentum, *must* be compensated by something that has the opposite vector-momentum. Such condition can be achieved only by assuming that an antitime axis is exhaled, locally and simultaneously with the time axis, i.e. being a time axis with the reversed time arrow (figure 2). This is equivalent to the exhalation of a γ-world, which results symmetric to the α-world with respect to the β-world.

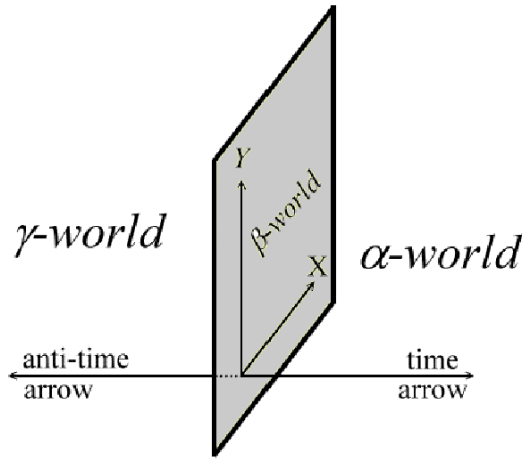

Figure 2 - The α-world and the γ-world are, respectively, a mirror image of each other, with respect to the β-world. The β-world is 3D, with no time axis, and it contains carriers of null mass (i.e. maybe miniphotons, photons). When such carriers are observed from either the α-world or the γ-world, they appear to move at the asymptotic speed *c*. The formalism of complex variates appears very well suited for depicting natural reality. The time axis in the α-world is [*ict*], and in the γ-world [–*ict*], and the α-world and the γ-world are the complex conjugate of each other. The same formalism extends to the energetic tensor of special relativity, where only the momentum components are reversed by time reversal, unlike the components related to various forms of energy. That is, every momentum has an anti-momentum, unlike energy, mass, and *emp* for which no antienergy, no antimass, no anti-*emp* can be defined. *Emp* and generalised momentum are conserved. Two time axes of opposite arrow exhale from the β-world, giving thus rise to exactly symmetrical (due to momentum conservation) worlds of matter and antimatter, respectively. Matter and antimatter must experience an ageing within their respective α-world or γ-world, and they finally must sometimes collapse again into their original β-world, where, however, every kind of individuality cannot be assessed. Entropy increases in both α- and γ-world, and their collapse into the original parent β-world resets the entropy of the system. An alternative and competing interpretation implies the Dirac's negative energy states (see sections 5 and 9). After Gregori (2006f).

The α-world and the γ-world look therefore much similar, except that their respective time arrows have opposite directions. Mass is defined in either one of them, by formally dividing by c^2 the *emp* content of "something". The definition of mass implies the definition of dynamics, while no dynamics can be defined within the β-world. We can define a mass within the β-world, which coincides with the rest mass, because everything moves at the speed c and the inertial mass should therefore be infinite. Such item is further discussed in section 8.

For brevity purposes, for future reference let us call A, B and C the 3 aforementioned observers living in the α-world. In addition, let us call D or Deborah an observer who, according to Einstein, "rides" through the β-world a photon (or some other suitable minigranule), and F or Frank an observer located in the γ-world.

For the time being, let us first suppose that photons have null mass – this shall result being a crucial item within our entire discussion. Since we actually detect photons, we have to conclude that A, B and C shall detect the objects partaking into the β-world, which shall appear to them like objects moving at the speed c. The same holds for F, with reversed time arrow. In addition, whenever either A or B or C affords in detecting "something" that exists in the γ-world, such "something" shall eventually appear to her/him (see below) as moving at some speed $> c$. That is, the γ-world shall appear to A, B and C like the realm of superluminal phenomena. The reciprocal situation holds upon exchanging the roles of α-world and γ-world, respectively, and reversing the time arrow.

Therefore, owing to the strict requirement of the supposed conservation of the generalised momentum, the resulting picture implies the existence of a perfect symmetry between α-world and γ-world. That is, for every quark located somewhere in the skin of one hand of the reader, some corresponding quark must exists within the γ-world, being eventually part of an anti-stone, or other, etc. Every physical system, within both the α-world and the γ-world, must experience "ageing", due to the unavoidable irreversibility of phenomena. That is, the "ageing degradation" or "dispersion" or "entropy increase" occur within *both* worlds, although along *opposite* time arrows.

Occasionally, some matter of the α-world encounters its respective symmetric, or twin, matter of the γ-world, or *tout court* of antimatter – although one should be aware of the fact that A, B or C can recognise no individuality in the β-world. On such occasions, matter and antimatter "annihilate", and they return back into their parent β-world, where their *entropy balance is reset*. In this way, even the old classical and logically much disquieting paradox can be most simply solved, of the ever increasing entropy of the universe.

Such way of looking at the natural reality, of both the α- and γ-worlds from a platform supposedly located within the β-world, recalls the aforementioned Einstein's speculation about riding a photon.

For clarity purposes, it should be specified that the wording "antimatter", "antiparticle", etc. can be misleading. In fact, no anti-*emp* exists, hence no antimass and no antienergy. Rather, the γ-world is inhabited by *emp*, by matter and by energy, although within a space with a reversed time arrow. That is, consistently with the former Feynman (1949) suggestion, an antiparticle is just a particle running from the future towards the past. If one makes a different choice and he assumes that the time arrow is the same in both the α-world and the γ-world, negative energy or negative *emp* states have to be considered, according to the former guess by Dirac, and such negative quantities can be called "antimatter" (see section 5).

Let us consider the topology of such three worlds. The β-world is the "brane" that divides, or confines, domains of α-world and of γ-world, respectively. We should not think about large bubbles of either one world, embedded within some wider domain of spacetime of its respective anti-world. We should rather conceive the topology of such worlds in terms of a ubiquitous presence of all three worlds altogether. The prime ruler is the *finite principle*, which is applied to the occasional excess of *emp* density that occurs within the β-world – and such prime fact is unobservable by A, B, C and F. When a granule is released from the β-world and it enters, say, into the α-world, and a symmetrical granule enters into the γ-world, such two granules result into the generation of a couple of particle and antiparticle (such as e.g. of electron and positron). When such two objects cross through their world or anti-world, respectively, they experience a dynamics or antidynamics, respectively, and finally they eventually recombine, annihilate, and return back into their parent β-world. That is, instead of some large bubble of one kind of space embedded into its respective anti-space etc., one should consider a topology of worlds and anti-worlds reminding about the bubbles in a glass of sparkling wine, with bubbles of progressively smaller size contained inside

comparatively larger bubbles, etc. and such topological feature ought to be observed down to the smallest possible size, compatibly with the scale size of the monads that are being involved or that can be detected by the humans and by their instruments.

The mechanism for world-transition can therefore be *conventionally* depicted by supposing that one granule, which is eventually generated from the β-world, runs through the α-world (or the γ-world, respectively) until it encounters a "brane", i.e. a β-world, where it annihilates and returns back into the β-world. For simplicity, and notwithstanding no individuality can be recognised within the β-world at least by A, B, C and F, let us suppose that, at some "site" within the β-world, the annihilation process occurs and it eventually generates a local excess density of *emp*. Let us suppose that such "temporary" granule of excess *emp* density moves through the β-world (although Alice can detect no movement through the β-world). Such "temporary" granule shall therefore generate a new couple of particle and antiparticle, etc. That is, notwithstanding according to such conventional way of representing phenomena no individuality can be recognised by A, B, C and F, for "simplicity" we can suppose of being capable of mapping the trajectory of the initial couple of granules, originally launched from the β-world through their respective α-world and γ-world, etc. (figure 3).

Alice shall therefore detect photons travelling through the β-world, and such granule, observed by her, shall appear like moving at the asymptotic speed c. It shall be awkward, if possible at all, for her detecting phenomena that occur within the γ-world, which shall appear to her like superluminal effects. More in general, however, it appears hard to believe that any observer shall eventually result capable of detecting events occurring within bubbles of world or antiworld of some higher order-degree within the hierarchy of the sizes of bubbles and anti-bubbles.

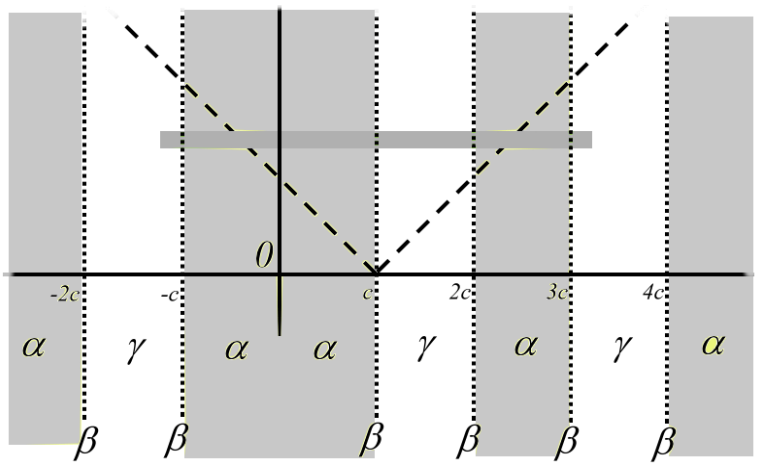

Figure 3 - The hierarchy of bubbles, contained within bubbles of their respective complex conjugate world, etc., can be logically, though conventionally, unified into a common cognitive scheme, upon considering time and anti-time axes, respectively, "touching" each other of the same (non-measurable though existing) point on their common 3D "brane" of β-world. Every such conventional composite light ray, which moves through such sequence of bubbles within bubbles, … alternatively with a time arrow of opposite direction, is the most reasonable candidate for being the picture of our actual physical perception of galaxies and anti-galaxies. That is, the photons (to be associated with the horizontal bar in the figure), which we do receive from far space, can be released either by galaxies or by anti-galaxies, having a relative speed $|\mathbf{v}|$, measured in our frame of reference that is embedded in our α-world, which eventually results to be superluminal. After Gregori (2006f).

In the case that the photon mass μ is not zero, i.e. that its speed is close to, though not exactly coinciding with, c – and such case history is expressively discussed in sections 8 and 9 – we can make a different guess. Maybe, in such case Alice can detect photons only because they partake into our α-world, while, perhaps, she could be incapable of detecting any granule that partakes into the β-world – such as e.g. (maybe) minigravitons. In the ultimate analysis, nothing really changes compared with the previous argument and with the model here reported, except some speculative and easy-to-envisage adaptations.

Summarising, such bubble-antibubble structure is ubiquitous and it holds on every scale size. The smallest scale size is the (recently reported) experimental evidence of some elementary particle that "materialises" into a couple of some given particle-antiparticle, for "annihilating" again into the original particle, etc. according to a series of events that are repeated some very large number of times per second. The largest scale size is the analogous phenomenon of couples of galaxies-antigalaxies, etc.

As it will appear clear after the discussion of the next sections, such entire apparently much fanciful model was inferred for giving justice of several observational facts, and it appears justified by them. For the

time being, for the sake of completeness and for a matter of curiosity, a mention should be given about the fact that such model recalls the *Genesis* of the *Bible*. The *Bible* is one among the most ancient witnesses of the very first cultural heritage of humankind. It is a true great piece of archaeological information. It is the historical foundation for three among the most important religions, i.e. Judaism, Christianity, and Islamism. The existence of God is just a matter of Faith, and no scientific argument can prove it. But the attributes of God, described in the *Genesis*, closely coincide with the attributes of the aforementioned β-world. For instance, God cannot even be numbered (He is one, though identically including three Persons). For a matter of Faith, all human bodies have to resurrect (being the aforementioned backward transition into the β-world). Even the "reincarnation" doctrine of oriental religions can be considered within such frame. No concern exists anymore about the souls of people who were born before the Redemption, because Jesus Christ is divine, and He must be considered timeless (like everything that exists in the β-world, etc.). Does every human individual have some component part that eventually "survives" within the β-world? Where is the intellectual activity located of the humans? What is the meaning of "cerebral death"? Several disquieting questions can be raised, much outside the realm of mere science, and are discussed to some extent elsewhere (Gregori *et al*., 2006).

From a merely gnoseologic point of view, the concepts of an "absolute" 3D space and of an "absolute" time (see section 1) are part of our heritage deriving from the ancient Greek thinkers. The problem was however formerly debated, and the savants who wrote the *Genesis* were very likely concerned with speculating about a timeless world for assessing the attributes of God. In fact, such prime fundamental gnoseologic debate is still found e.g. in the thought by Origen, one of the most profound and speculative minds of ancient Christianity (Alexandria of Egypt?, *ca. 185* – Tyre, *253* or *254*), who attempted at combining the classic philosophical knowledge with the Christian thought. Such important historical aspects of the evolution of our prime cognitive process are, however, still to be investigated.

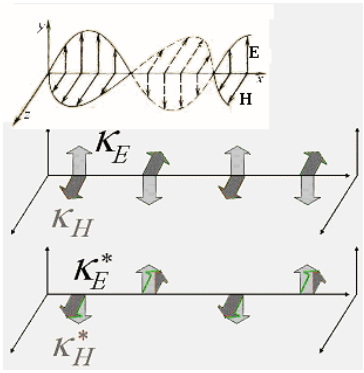

Figure 4 - The top plot is a college textbook representation of a polarised e.m. wave. The middle plot shows the same concept schematically showing the existence of a few (four in the present example) miniphotons, every one composed of two components perpendicular to each other, i.e. an electric component κ_E and a magnetic component κ_H . The bottom diagram shows the same concept when parity has been reversed (i.e. this amounts to assuming that the *e.m.f.* induced by the Faraday law is opposite to what is actually observed). That is, an anti-miniphoton is speculated as being the mirror image of a miniphoton i.e. with reversed parity, or a miniphoton and an anti-miniphoton are the same, though with a different parity, or with reversed time arrow. We are observers who are part of the α-world. Hence, we can *directly* observe only miniphotons, while we can eventually observe only some *indirect* effect associated with the anti-miniphotons. After Gregori (2006f).

4 - The parity of miniphotons

An important point for subsequent discussion deals with the parity of the photon. Consider figure 4, where every photon is symbolically represented as being composed of a volley of miniphotons, and every such miniphoton has a "*magnetic component*" and an "*electric component*", much like e.g. every given elementary particle is composed of quarks, gluons, etc. For future reference, let us speculate about the possible existence of miniphotons of opposite parity. It should be noted that the miniphotons with usual parity imply the correct Faraday's induction law, unlike the miniphotons of opposite parity, which should imply an opposite *e.m.f.* – i.e. they operate just like in the case that the Faraday law is embedded into a spacetime with reverse time arrow. Let us claim that the miniphotons of the correct parity partake into the α-world, while the miniphotons of the opposite parity partake into the γ-world, where the time arrow is reversed.

In this same respect, consider figure 5 - which is a slightly modified redrawing of figure 1. The new feature of figure 5 is that the conveyor belt is transparent, while the seeds dropped by the sower S remain now attached to the conveyor belt. Alice can therefore observe the seeds flowing on both sides of the belt. That is, Alice can detect even the seeds (i.e. the miniphotons) that move on the far side of the conveyor belt,

and that represent miniphotons moving with a reversed time arrow. This is a pictorial way of explaining how Alice can eventually detect, whenever applicable, something partaking into the γ-world.

All such apparently much speculative and imaginative models, and such axiomatic approach, shall appear less arbitrary after the discussion of section 5.

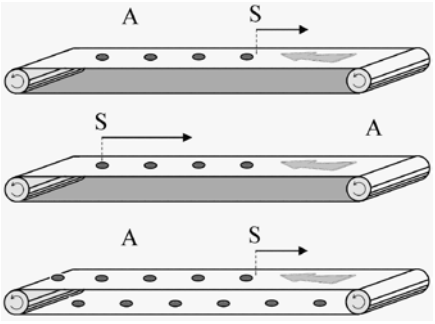

Figure 5 - A conveyor belt has an almost endless extension. The observer is located at A, while a sower is located at S, but A does not know the location of S. The belt moves at a uniform speed *c*. The sower drops one seed on the belt at some regular and constant time intervals. In the *top figure*, S moves *away* from A at some given speed v. In the *middle figure*, Alice observes the identical effect as in the top figure. However, S, instead of escaping outward from A, approaches A at a speed v > *c*. Consider that A detects *first* the miniphoton that was released comparatively *later* by S. Hence, according to A, there is a reversal of the time sequence, i.e. apparently a reversal of time arrow. This is the world of superluminal phenomena. *Bottom figure* – In some respect, the same effect of the top and middle figures can be described by a different and much simple model, where the conveyor belt is transparent, by which A can see the miniphotons that are attached to the conveyor belt and that flow on the lower side of the conveyor belt, i.e. they appear to be moving along the reversed time arrow. This is a different way of stating that A simultaneously observes events moving towards both directions of the time arrow. However, it is here suggested that Alice can *directly* observe *only* the miniphotons moving on the upper side of the conveyor belt. However, *indirectly* Alice eventually observes, e.g. as a "thermodynamic" effect, also the integrated averaged effects of the miniphotons moving on *both* sides of the conveyor belt, i.e. moving either along the time arrow or along the anti-time arrow. Such concept is further stressed by the discussion dealing with the *SVAT* hypothesis (see section 6). After Gregori (2006f).

5 - d'Alembert, Poynting, Dirac, and Feynman

Close to the end of the *XVIII century*, Jean Baptiste Le Rond d'Alembert (*1717-1783*) solved his celebrated equation for describing the vibration *w* of a cord in terms of two solutions *f* and *g*, representing (figure 6) two oscillations that propagate towards opposite directions

$$w = k\,\ddot{w} \qquad\qquad w = f(x - vt) + g(x + vt) \qquad (7a,b)$$

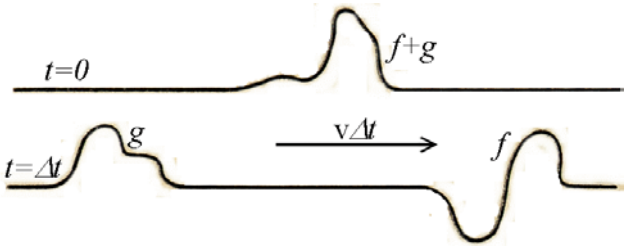

Figure 6 - At time *t=0* a violin string is triggered by its bow. The solution results from the d'Alembert's equation, being the sum of two general functions *f* and *g* expressing, respectively, two deformations that move in opposite directions along the string, at the same, though opposite, speed v. After some given time interval, Δt the two *f* and *g* solutions are separated, although the final result is the sum of several such propagating signals, including the mirroring effects, here not shown. After Gregori (2006f).

About one century later, the solution of the identical equations was applied to e.m. waves, which can be derived from the axiomatic formulation by James Clerk Maxwell (*1831-1879*). The two solutions *f* and *g* that appear in (7b) were interpreted as evidence of e.m. waves propagating through space towards opposite directions. However, it had been possible interpreting them formally in a different way, upon considering a double flux of photons of different parity, moving through two different spaces with opposite arrows of time. If, in Maxwell's times, somebody had envisaged such possibility, such proposal had certainly appeared unrealistic. The author is aware of no such proposal.

Less than one century later, Feynman (1949) solved the Dirac's equation, dealing with the interaction of electrons and positrons. It appears worthwhile referring directly to the abstract of his paper. "*The problem of the behaviour of positrons and electrons in given external potentials, neglecting their mutual interaction, is analysed by replacing the theory of holes by a reinterpretation of the solutions of the*

Dirac equation. It is possible to write down a complete solution of the problem in terms of boundary conditions on the wave function, and this solution contains automatically all the possibilities of virtual (and real) pair formation and annihilation together with the ordinary scattering processes, including the correct relative signs of the various terms. In this solution, the 'negative energy states' appear in a form which may be pictured (as by Stückelberg) in space-time as waves travelling away from the external potential backwards in time. Experimentally, such a wave corresponds to a positron approaching the potential and annihilating the electron. A particle moving forward in time (electron) in a potential may be scattered forward in time (ordinary scattering) or backward (pair annihilation). When moving backward (positron) it may be scattered backward in time (positron scattering) or forward (pair production). For such a particle the amplitude for transition from an initial to the final state is analysed to any order in the potential by considering it to undergo a sequence of such scatterings." According to the viewpoint of the axiomatic formulation here proposed, the role of such Feynman's externally applied potential clearly refers to a "thermodynamic" concept (see section 1). Such "thermodynamic" aspect is indeed explicitly mentioned by Feynman (*ibid*.) who considers the statistics of multiple scattering, or of pair formation, or of pair annihilation, etc. and their implications for quantum electrodynamics (*QED*), etc.

That is, the solution of the wave equation, which is proposed by Feynman, is just the same as supposing that the two terms in the formal aforementioned solution of the Maxwell's e.m. waves do represent some real waves that move through every respective, and reciprocally symmetric, spacetime with opposite polarity and time arrow. Following such Feynman's suggestion, antimatter appears therefore just like *emp* moving with a reversed time arrow.

An alternative explanation is in terms of negative *emp* moving with the standard time arrow. In fact, the Feynman's mention about negative energy states is suggestive of a speculation as follows.

Let us begin by considering that the coordinates in the α-world are *x, y, z, ict*, respectively (as it is often reported by books on the theory of relativity). Some authors prefer proposing *ix , iy, iz, ct*, respectively. In either case, the metric is $dx^2 + dy^2 + dz^2 - c^2 dt^2$. With no loss of generality, let us refer the first choice. The coordinates within the γ-world can be proposed as being *x, y, z, -ict*, respectively. By this, the metric is always the same, while the time arrow and the parity of miniphotons are reversed.

One first relevant inference is as follows. It is normally believed that the entire realm of mathematics applied to natural phenomena is ultimately based on the sequence of the *natural integer numbers*, from which rational and irrational numbers are derived, etc. In contrast, the theoretical scheme here envisaged shows that natural phenomena are *intrinsically* concerned with quantities that can be most effectively described by means of *complex numbers*, where world and antiworld – which are two *objectively existing* realities, they are actual matter of facts, i.e. they are not mere abstractions - can be most naturally represented as being one the complex conjugate of the other. Their real part is just the timeless β-world, being the backbone from which the α-world and the γ-world are "temporarily" generated. Therefore, every truly existing natural object should be referred to its parent β-world, from which it "temporarily" exhaled, almost like for "spending a vacation" either within the α-world, or within the γ-world, respectively. As a corollary, such essential role of the complex numbers – and of complex functions, when dealing with "thermodynamic" knowledge - makes untenable the mixing of "*lottery statistics*" and "*SB statistics*", as it is often made in the discussion of quantum entanglement (refer to Gregori, 2005, 2006c for details).

An additional comment is needed about the well known *energetic tensor* T^{ji} ($i, j \neq 0, 1, 2, 3$) of special relativity, by which the energy (or *emp*) and the momentum are components of such double symmetric tensor in 4D spacetime, expressed by complex numbers. The terms T^{0i} are proportional to the momentum components, and the T^{ji} ($i, j \neq 0$) are related to various contributions to the kinetic energy of the system. All this applies to the non-generalised momentum. By a little algebra it can be formally shown that the same result applies to the generalised momentum. If [*ict*] is changed into [–*ict*], the components T^{0i} are reversed, while their respective absolute values are not affected, and all other components T^{ji} ($i, j \neq 0$) remain invariant. Refer to Gregori (2006b, 2006f).

A competing and different possible choice is, however, by changing *x, y, z, ict*, into *-x, -y, -z, ict*, respectively. The metric is always the same, and even the time arrow is invariant. But the parity (or chirality, or skewness) of 3D space is reversed. In such case, one must consider physical states of *negative energy*, thus fitting the former Dirac's suggestion, which he inferred from simple mathematical similarities. Therefore, we can equivalently choose keeping invariant the parity of 3D space and reversing the time arrow, or keeping invariant the time arrow and reversing the parity of 3D space, in which case we must consider states of negative *emp*, energy and/or mass.

Summarising, much like the solution for the e.m. waves derived from the Maxwell's equations can be interpreted in different formal ways, in the present case of concern we do realise the existence of analogies, symmetries, and curious behaviours of our formal mathematical solutions. They eventually admit different possible interpretations. None of such abstract schemes is eventually "the correct" unique possible choice, while no interpretation is *per se* "incorrect". They are just different ways of looking at formal analogies, which can be eventually translated into some concrete attempt for a physical understanding. In every such case history, mathematics is just one language suited for expressing the inferences derived by our abstraction, while nature *per se* has no embarrassment from any analytical complication (Fresnel).

Other equivalent alternative possible choices can be envisaged, upon either reversing the arrow of time, i.e. by changing *ict* into *–ict*, or not, and by reversing only one or two space axes, etc. Every such case history implies some formal overcomplicating distinctions, etc. and no physical motivation seems to justify such effort. That is, such differences are a matter of arbitrariness and of abstraction, not of physics.

6 - *SVAT*

Speculating about the existence of three worlds, i.e. *(i)* our α-world, *(ii)* the β-world inhabited by objects of null mass that move at the asymptotic speed *c* of the universe (either light's speed or other), and *(iii)* the γ-world inhabited by antiparticles, and either having a reversed arrow of time, or a non-reversed arrow of time although implying states of negative energy, such entire scheme seems to define an intriguing and "beautiful" new theoretical perspective. Several previously unexplained and curious apparent coincidences, or suggestions, appear now less "mysterious".

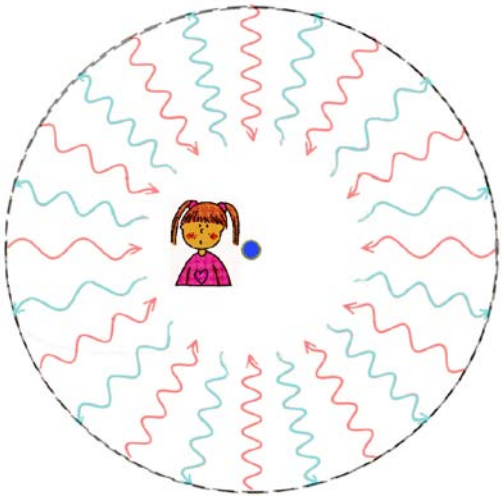

Figure 7 – Alice knows that "something" exists because it has a non-null content of *emp*. Such "something" has a "*virtus*" by which it releases, simultaneously, *virtual* Poynting vectors of both parities, which move outward at a finite speed *c*, and, at most, reach a finite radial distance, thus defining a monad. See text.

Photons are composed of miniphotons, and every miniphoton can have either positive or negative parity, being the representation of processes that occur in two mirroring or symmetric complex-conjugate worlds of natural reality. Since we do live in the α-world, we can get direct observation only of one facet of such objective natural reality, and only indirectly we can get observational evidence of the γ-world, for which, in general, we are "blind", or at most almost "blind".

Let us consider (see section 1) the definition of "existence", which is synonymous of a non-null *emp* content. Remind about the "virtual" character of the Poynting vector, which is "materialised" only in the case that some "receiver" transforms it into some observable physical quantity. With no such "receiver", the Poynting vector must return to its "source", where its energy content is newly available for eventually breeding some other Poynting vector release. Therefore, les us tentatively suppose (figure 7) that all what exists in nature has a "*virtus*", by which it steadily releases, through spacetime, and simultaneously, two kinds of "virtual" Poynting vectors, i.e. characterised each one by a different parity. They can propagate at some finite speed *c*, which is likely to be some typical constant of natural phenomena and which appears asymptotic for both Alice and Frank. Whenever either one such Poynting vector is eventually "materialised" by a "receiver", its former "virtual" character can be observationally manifested like miniphotons, which compose photons, of the corresponding parity. The same argument can be applied to the case history of *every* eventual additional "carrier", other than e.m. (for instance to minigravitons, etc.).

It should be stressed that such apparently much fanciful picture is *perfectly* analogous, and alternative, to the former generally accepted hypothesis of *action-at-a-distance* - which must be abandoned due to the finite speed of propagation of every "carrier". Instead of the *action-at-a-distance* hypothesis, and by means of a *perfectly* analogous abstraction, we can introduce, symmetrically, the aforementioned hypothesis, which can be called of the "*steady virtual action transmission*" (*SVAT*).

In fact, from a strict gnoseologic viewpoint, such two choices are logically fully equivalent. Indeed, the apparently most innovative concept here envisaged deals with consideration of "virtual" quantities. In the ultimate analysis, compared with the standard concept of "field", no substantially new concept is implied. It

is rather more a matter of form than of substance. For instance, a planet feels the gravitational force of the Sun only if the planet is suitably located in spacetime. If no planet is located at that site and at the given instant of time, the Sun generates at that site a gravitational field, spending however no work because no force is exerted on any material body. That is, a field is *per se* "virtual", although - unlike according to the usual way of defining it, e.g. according to Faraday and Maxwell and to general relativity - it is here claimed that a field is *not* a physical modification of space. Rather, the concept of field is a "virtual" way of depicting a possible future physical "materialisation" of some observable effect, which shall occur *only* in the case that some object acts like a "receiver" of such "field".[4] By this, however, no concern is considered about the propagation speed of the action-at-a-distance exploited by the Sun. Such way of conceiving the Poynting vector is extensively explained in Gregori (2005, 2006a), and it was first stressed in Gregori (2002). Summarising, whether *(i)* one speculates (as usual) about an action-at-a-distance generating a field with no concern about the propagation speed of the signal (which is implicitly assumed infinite), or *(ii)* one speculates in terms of the *SVAT* hypothesis, this is just a matter of an arbitrary choice by the observer who favours either one of two equivalent logical approaches. The difference is that, owing to the unquestionable observational evidence of a finite speed of propagation of the e.m. signal, the *action-at-a-distance* hypothesis is untenable, unlike *SVAT* that displays no contradiction with such observations, at least as far as the presently available evidence is concerned. Therefore, *SVAT* is not logically "revolutionary" like it might appear at a first glance. *SVAT* is rather some kind of generalisation of the classical concepts of *field* and of *action-at-a-distance*, which requires the apparently least amount of arbitrariness, and which is suited for taking into account the finite speed of propagation of the signal.

Let us remind (section 1) *(i)* about the psychological definition of time, or *(ii)* about the perception of the time arrow direction, i.e. of the steady increase of entropy, or *(iii)* about the psychological feeling of 3D space. We can get consciousness of space because we can define straight lines, which cross it. We can do this by identifying our abstract concept of straight line with the physically existing light rays. With no light rays we can perceive no 3D space. This is indeed a matter of psychological perception. In addition, since we afford, by means of 3 coordinates, in locating every given observed object of every scale size, we state that our space has 3 degrees of freedom, or it is 3D, which is again a psychological perception.

That is, we do perceive the environment we live in, because we can "cross" it by our straight lines, and we can relate the reciprocal effects, or influence, or exchange of mutual information, between different objects (or monads) that can inform each other about their respective existence. We can perceive all this only because we can observe them and, in order to exploit our knowledge of reality, we make an arbitrary assumption either about an *action-at-a-distance* or about *SVAT*. That is, with no simultaneous existence of different objects, no perception of space could exist. Such argument recalls, in some way, the *Mach's principle*.

The release of some virtual entity (i.e. either e.m. by means of Poynting vectors, or other vectors leading to minigranules, miniphotons, or others), which propagate at the asymptotic speed *c*, defines a monad (figure 7). Such monad has a size that steadily increases in time. In contrast, the concept of monad was formerly applied e.g. to an atom (see section 1), upon considering that the physical systems should return cyclically, or periodically, to its original configuration, thus implying a reversal of the motion of the former outward propagating virtual Poynting vector. However, such cyclic or periodic character of the monad atom can be only "thermodynamically" perceived by us, while we stay *outside* the monad atom, and we miss any information about its internal processes that, as we realise, should be depicted only by speculating about some hidden parameters. Therefore, the concept of monad can imply either a finite domain in spacetime, almost like it occurs for some strictly isolated black hole, or it can apply to such steadily expanding monads associated with *SVAT*. Natural reality is composed of monads, while the humans have a different perception of them depending on the human scale size compared to the scale size of every given monad of concern.

7 – *SVAT* and Newton's gravitation. Minigravitons, miniphotons, and "thermodynamic" knowledge

Owing to the finite principle, every reference to any continuous function has to be rebutted, hence the use of force, potential, field. Therefore the law of universal gravitation has to be degraded to a

[4] It should be stressed that the energy and generalised momentum conservation apply to *observed* quantities, i.e. only to actually occurring "materialised" phenomena, *not* to "virtual" quantities, which have, rather, to be likened to abstractions. The same comment applies to the *principle of relativity*. That is, we must distinguish mere matters of abstraction opposite to real observational facts.

"thermodynamic" knowledge of natural reality. *Action-at-a-distance* and *universal gravitation* appear overcome, in a "beautiful" and straightforward way, by *QAT* and by *SVAT*.

Whether excessively speculative or not, such theoretical scheme appears intriguing. In general, the scientific knowledge is always based on some observational database, which *per se* is always biased by the empirical constraint. In general, every theoretical explanation, which is eventually proposed, can be either *(i) wrong*, or *(ii) redundant*, or *(iii)* (possibly) *correct*. If it contradicts some observational evidence, it is *wrong*. If it implies some paradox, or some discrepancy with the available observations, we must reasonably suspect that something *wrong* is involved by the theory. If it is *redundant*, somebody ought to afford in providing an apparently equally successful interpretation by means of comparatively simpler assumptions and/or more straightforward argument. In such a case, the Ockham's razor must be applied for choosing the apparently more "beautiful" theory. In either case, the availability of additional observational evidence can eventually result decisive for improving our progress in understanding. As far as the present available observational evidence is concerned, the theoretical frame that is here proposed appears *correct*, at least until somebody will prove that it is *redundant*.

For the time being, the main remaining unsolved problem deals with the relation between the e.m. and the gravitational interaction. For sure, the Newton's gravitational law is only a "thermodynamic" representation of natural reality, as we should rather deal only with minigranules, of a suitable kind, which are exchanged through the *QAT* process. The concern is about the physical nature of such minigranules. Maybe, they could be just miniphotons. In this case, *SVAT* by means of miniphotons does result to be a perfectly selfconsistent explanation, being a convincing possible hypothesis competing with the Newton's gravitational law. Otherwise, we should speculate about the existence of minigranules other than miniphotons, which can be generally referred to as "minigravitons". Even in this case, *SVAT* is a credible substitute for the Newton's gravitational law. The crucial ultimate concern is therefore about the mass μ of the photon, or is the photon a part of the β-world, or is it a particle of the α-world that moves at some high speed, though eventually close to the asymptotic speed c of natural reality? What is the relation between photons and gravitons? This is the concern of section 8.

8 - The mass of the photon

A few tens different experimental estimates are reported in the literature for the mass μ of the photon (refer to Gregori, 2006e and references therein). In general, it should be stressed that, on the one side, reference ought to be made to the mass of a *miniphoton* rather than of a *photon*. On the other hand, it appears difficult assessing whether every such estimate refers either to a *rest* mass or to an *inertial* mass, because it makes nonsense distinguishing rest mass and inertial mass for an object that is supposed to partake into the β-world and to move at the asymptotic speed c. The logical approach, which is used while exploiting every such μ estimate, is by assuming that the photon behaves just like *every* other massive particle. That is, they assume first that the photon does *not* partake into the β-world. Then, they estimate an upper limit for μ. In addition, every such estimate must be unavoidably based on some assumptions. Every group of authors explicitly warns about the possibility that their respective evaluation is biased by some apparently reasonable, although possibly untenable, hypothesis. In any case, since the several different estimates result apparently comparable with each other, it can be concluded that their evidence, considered altogether, appears seemingly reliable, at least when considering the orders of magnitude. Hence, every such experimental estimate ought to be critically and carefully reconsidered in detail, although the variety of the different subtle theoretical approaches should require the specific expertise of different specialists.

The generalisation of the Maxwell's equations to the case of a non-vanishing μ was extensively investigated, and it is known as Proca equations (refer to Gregori, 2005, 2006c, and references therein). The smallest (and seemingly most reliable) upper boundary (Luo *et al*., 2003) for μ is $\mu < 1.2 \times 10^{-51}\ g$.

An apparently paradoxical inference is derived whenever a photon is likened to every other particle or antiparticle, within the α-world and γ-world, respectively, which is associated with some typical total content of *emp*. Such total *emp* is defined by the rest *emp* plus the kinetic energy, and it can be expressed by multiplying the rest *emp* by a relativistic correction factor, which is somewhat different from the Einstein's factor (see sections 1 and 2). If we divide such total *emp* by c^2, we get the *inertial mass* – and according to the formulation here given, this is just a matter of definition. The inertial mass enters into play in the α-world or in the γ-world, being a consequence of dynamics or antidynamics, respectively, which can be defined only in the α-world and in the γ-world, after the "exhalation" of a time and antitime axis from the β-world,

implying some kind of injection of *emp* into the α-and into the γ-world – and such "exhalation" is strictly required for generating "massive" particles and antiparticles.

A photon has an *emp* content given by $h\nu$. Hence, the inertial (?) mass of the photon ought to be $[h\nu/c^2]$. But this gives a value much larger than the aforementioned upper limit for μ. For instance, *X*-rays or γ-rays in the energy range of $\sim 0.01\ MeV \div 1000\ MeV$, or $\sim 10^{-11}\ erg \div 10^{-3}\ erg$, should have a mass of $\sim 10^{-32}\ g \div 10^{-24}\ g$. For visible radiation, with $\lambda \sim 5\ 10^{-5}\ cm$, the photon mass should be $\sim 10^{-32}\ g$. Hence, the photon *cannot* be likened to other particles. It appears awkward, if possible at all, envisaging an explanation for such paradox.

Every aforementioned estimate, however, as it is stressed in the comments in a table reported by Barrow and Burman (1984), relies on some substantial assumptions and approximations, and every such value has to be accordingly taken with caution. In any case, upon considering its several observational implications, such fascinating "*amusing lines of speculation*"[5] appear intriguing.

As far as the present study is concerned - and independent of such very clever evaluations and observational analyses - the *rest energy* of the photon here considered is substantially different, because it is not concerned with the *inertial mass* of the photon, rather with a different and much specific property or "*virtus*". Moreover, consider that, according to the reformulation of theoretical physics here proposed, one defines the *rest energy* ε_0 of the miniphoton, although it seems presently *impossible* evaluating it, even only approximately. Such detailed argument is as follows (Gregori, 2005, 2006e).

A photon is a volley of miniphotons. Altogether such volley transports a total *emp* expressed by the energy of the photon i.e. $h\nu$. It is well known that every light beam can be used for carrying out interference phenomena, by superposing beams originated by the same source and having two optical paths that, compared with each other, differ by some total length. It is well known that such total length cannot exceed some empirically determined upper limit *L*, which is generally called "length of the wave-train of the beam". Let us tentatively guess that one such wave train is one photon. In fact, it is supposed that the atom monad must release some total amount of energy, "thermodynamically" determined by its intrinsic energy levels described by the Schrödinger's equation. The atom monad releases a volley of miniphotons, time delayed by some approximately constant time interval, thus simulating the wave behaviour of the Schrödinger function Ψ. The total number of miniphotons within one photon (with wavelength λ) is therefore $N = 2L/\lambda + 1 \sim 2L/\lambda$, and such *N* can be evaluated by measuring *L*. The energy of one miniphoton is $\varepsilon = h\nu / N = h\nu / [2L/\lambda + 1] \sim h\nu / (2L/\lambda) = hc/(2L)$, which is independent of the frequency ν and of the wavelength λ. Call τ_0 the time duration that, within the reference frame of the source of the miniphoton, is required by the slingshot process for generating the miniphoton through some kind of coalescence of *emp*. Call ε_0 the rest *emp* of the miniphoton, i.e. when it is referred to the same frame as τ_0 . Consider that,[6] according to (12) or (13) of Gregori (2006b), it is $\varepsilon / \varepsilon_0 = \xi(v/c) = \chi(v/c)$, and by (2) of Gregori (2006b), it is $\tau / \tau_0 = 1 / \xi(v/c) = 1 / \chi(v/c)$. Hence, it follows

$$N\,\varepsilon = h\nu \qquad\qquad \tau = L/(Nc) = 1/(2\nu) \qquad\qquad (8a,b)$$

$$[N\,\varepsilon_0]\ \tau_0 = [N\,\varepsilon]\ \tau = h\nu\, L/(Nc) = (h/N)\,(L/\lambda) \sim (hL/\lambda)\,[\lambda/(2L)] = h/2 \qquad (8c)$$

$$\varepsilon_0\ \tau_0 = \varepsilon\ \tau \sim (h/2)/N \sim (h/2)/(\lambda/2L) = (h/4)/(\lambda/L) = [h/(4L)]\,(c/\nu) \qquad (8d)$$

$$\varepsilon\ \tau \sim [h/(4L)]\,(c/\nu) = [h/(4L)]\,2c\,(1/2\nu) = [hc/(2L)]\,\tau \qquad (8e)$$

$$\varepsilon \sim (hc)/(2L) \qquad (8f)$$

that is, (8c) reminds about the Heisenberg's indeterminacy principle, and, in addition, this is a different (though tautological) way of expressing the definition of the Planck's constant *h* in terms of its relation with the energy (or *emp*) content of a photon.

The discrepancy between the several different available μ estimates could perhaps be explained (at least partially) by the fact that one should consider the rest energy (or the rest mass) of a miniphoton, while every different aforementioned experiment is concerned with comparatively different kinds of photons. In addition, on the one hand, we would like treating a photon or a miniphoton much like every other elementary particle. On the other hand, unlike for all elementary particles that populate the α-world or the γ-world, we have to be somewhat perplexed in defining exactly the meaning of mass – either rest mass or inertial mass – for a photon or for a miniphoton or for any other granule that is supposed being embedded within the β-world. Such uncertainty in the definition of the physical meaning of mass appears to be a key logical bias for

[5] According to Goldhaber and Nieto (1971), p. 281, footnote 3.

[6] Such formulas are implicit in the formulas here given in section 1.

the formulation here proposed, and, in addition, it is likely to affect (more or less unconsciously or declaredly) the different methods used for such μ estimates.

A few comments by Ginzburg (1979, p. 87-88) clearly show the intrinsic contradiction within such arguments. He evaluates the classical Laplace radius r_g by imposing that the potential energy (in the gravitation field of a given object) should be equal to the kinetic energy of something that escapes at a speed *c*. Such argument was formerly proposed in *1798* by Laplace, who claimed: *'owing to such reason the largest luminous stars of the Universe shall be invisible for us'*. Such argument applies to every process leading to a relativistic collapse (e.g. to a neutron star, or to a pulsar, or to a white dwarf, etc.). Ginzburg (1979) comments: *"In fact, let us suppose that light is composed of corpuscles of mass* m *(in agreement with modern representations, we can put* $m = h\nu/c^2$ *, where* hν *is the energy of the photon). Such corpuscle can propagate up to a distance* r *towards infinity from a body of mass* M *provided that* $GmM/r^2 = mv^2/2$ *, where* v *is the radial component of the velocity of the corpuscle. Upon including the light speed* v = c, *we get the condition* $r = 2GM/c^2$ *, where the mass* m *becomes inessential. It follows that light shall never go beyond the exact limit* $r < r_g = 2GM/c^2$ *. Such computation, however, is not consistent, because in reality when dealing with bodies that travel at a speed* v *comparable to the light speed* c, *the kinetic energy is equal to* $mc^2/\sqrt{1-v^2/c^2}$ *instead than* $mv^2/2$ *. If we suppose in the computation above that the energy of the corpuscle is* mc^2 *, in such case we would get* $r_g = GM/c^2$. *In this sense, the precise coincidence with* r_g *of the Laplace limit radius is a matter of a coincidence.*" It is here claimed that there is no coincidence, in disagreement with such Ginzburg's statement, because such argument treats a photon just like every other massive particle, and the formal derivation of r_g is therefore the same either for a massive particle or for a photon. In addition, according to section 1, the relativistic coefficient $\sqrt{1-(v^2/c^2)}$ ought to be changed.

Summarising, the observational evidence appears perplexing, which should decide whether photons or miniphotons have either a null or a non-vanishing mass.

An equivalent "*amusing line of speculation*" deals with an estimate of the upper limit for the electric charge of the photon. The principle idea is that a light beam, while travelling through interstellar space over large distances, should be deflected by **B**, and a spot focused by a telescope ought to loose angular resolution. Cocconi (1992) evaluated in this way, for radio sources, for visible radiation, and for *X*-rays (of *0.04 ÷ 2 keV*), a ratio of the photon electric charge *q* to the electron charge *e*, giving the upper limits $q/e < 10^{-27.7}$, $10^{-25.4}$, and 10^{-21} , respectively. He also estimated the ratio *R* between Coulomb's and gravitational forces, finding $R \approx 10^{42.6}$ for electrons, and, for photons in the aforementioned three energy ranges, he evaluated $R < 10^{7.5}$, $10^{2.6}$, and $10^{8.0}$, respectively.

9 - The relation between the electromagnetic and the gravitational interaction

Gravitation *vs.* e.m. is one classical and disquieting unsolved problem. Maybe, it is interesting that elementary particles exist, which have a non-vanishing rest mass and have either a positive or a negative electric charge, while particles of null, or almost null, mass are always neutral.

Let us consider the nature of the virtual signal of *SVAT*. It eventually leads to some observable minigranules. For brevity purposes, since we do not know the physical nature of such minigranules, let us call them "*elmgrains*" (which is acronym for "elementary minigranules"). One candidate *elmgrain* is the miniphoton, expressing the e.m. interaction. Other virtual signals for justifying the interaction between different objects lead to considering other possible *elmgrains*, e.g. gravitation leads to minigravitons, etc. But one can even speculate about possible additional virtual signals of other nature, etc. Refer to Gregori (2005, 2006, 2006f).

One possibility is that every given virtual signal, of any given kind, is eventually captured by a "receiver", which could display (perhaps) some comparatively different efficiency, depending on the parity of the incoming virtual signal.[7] Let us explicitly refer to the e.m. interaction. The aforementioned separation

[7] In principle, such "capturing" efficiency refers, however, also to the "releasing" efficiency, because, owing to the empirical constraint, we are incapable of recognising whether, e.g. within a Feynman graph, one miniphoton is either released or captured by either one interacting particle. For brevity purposes, let us call *tout court* "capturing efficiency" such more general concept, which should be rather called "efficiency in exploiting an *elmgrain* exchange". We just know that some given interaction occurs in some way, and that the action-reaction principle is satisfied, as either one interacting particle acts either like the source or like

of the final observed effect, depending on the parity of the virtual signal and on the different capturing efficiency, could explain e.g. the *existence of particles with either positive or negative electric charge.* However, why particles of null, or almost null, mass are always neutral? In any case, such guess appears reasonable, at least on a tentative basis. In addition, one can tentatively speculate that such asymmetric capturing of virtual signals should imply an increase of the mass of the particle. In contrast, when such capturing efficiencies are almost identical, signals with different parity in some way "compensate" with each other, and their resulting interaction is in terms of an electrically neutral particle, which reacts only due to its tiny gravitation. In this respect, as mentioned above, the electrostatic interaction between two electrons is ~ *42 orders of magnitude* greater than their gravitational interaction, which, however, is not null. In fact, the mass of the electron is not null. However, why some neutral particles exist having a non-vanishing mass? Neutrinos have null charge, or an almost null mass – although at present it is claimed that it is has been proven that they have a tiny though non-vanishing mass.

Every elementary particle contains some intrinsic "quantum numbers" or "*virtutes*", which in any case characterise its existence and physics, opposite to mere and strict "vacuum". In addition, we know that the observed masses of the different elementary particle display some empirical regularity, and show some dependence on such "*virtutes*". An additional and well known feature is that the electric charge appears to be the best exactly quantised physical feature. A reply to all such profound concerns should probably derive from some acute empirical investigation on the few possible different "carriers" that should explain, by means of *QAT* graphs in the subnuclear domain, the different observations of interactions between elementary particles. Maybe, every such elementary "carrier" (analogously to what occurs e.g. for a miniphoton) ought to transport its specific and pertinent "*virtutes*", which should probably be conserved, etc. and every such "*virtus*" ought to include (maybe) even some contribution to the definition of mass. Therefore, some acute analysis of the available observations dealing with the properties of elementary particles could hopefully afford in guessing the intrinsic "*virtutes*" of every such different kind of additional minigranules. Such study is outside the targets of the present study.

The focus is here, rather, on whether miniphotons alone are to be considered for explaining all observations, or perhaps whether, in addition and in competition with them, some other *elmgrains*, such as e.g. minigravitons, ought to be envisaged. The ultimate concern is therefore about the mass of the miniphoton. If it is null, and if it moves at the asymptotic speed *c*, the aforementioned asymmetry in the capturing efficiency of virtual signals of different polarity could be one possible explanation of the relations between e.m. and gravitation. In contrast, if the photon mass is not null, and it moves at some high speed, although slower than *c*, the photon must behave like every other massive elementary particle, i.e. being subjected to the effect of the large relativistic amplification of its inertial mass compared to its rest mass. In this case, we have to speculate about the existence of one or a few *elmgrains* other than miniphotons.

Summarising, let us first suppose that miniphotons are *elmgrains*, and therefore that they move at the speed *c*. Miniphotons of different parity correspond to the two solutions of the Maxwell's equations. Miniphotons with the standard [or opposite] parity move along the standard [or reversed] time arrow of the α-world [or γ-world, respectively]. Such two different kinds of miniphotons shall enter, respectively, into either the α-world or the γ-world. Miniphotons are associated with the *SVAT* process. *Only* whenever some "receiver" captures them, they enter into the balance, both of the total *emp* and of the total generalised momentum. In any case, under such assumptions, in principle one cannot *a priori* exclude that some additional *elmgrains* can eventually exist, although they are *not* necessary, because miniphotons alone are sufficient.

In the case that the capturing efficiency for miniphotons is identical for both parities, the final interaction shall be typical of an electrically neutral particle, i.e. it is likely to be simply gravitational. Differently stated, electrically positive and negative particles are expressions of worlds that are the complex conjugate of each other, while the gravitational interaction is their real part. Since the gravitational interaction, compared to e.m. interaction, is much smaller, we have to conclude that, owing to some unknown reason, the sum of the two supposedly identical and opposite effects is very small, though not null.

The alternative possibility is that the photon has a non-vanishing mass, and that additional *elmgrains* must be considered. We have to substitute the Maxwell's equations by the Proca equations. Light no more moves at the asymptotic speed *c*, rather at some very high speed close to *c*, though not coinciding with it. Miniphotons partake into the α-world. We are essentially incapable of measuring such tiny discrepancy from

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the receiver. We just do not know what particle is active, and what is passive in the exchange of one *elmgrain*.

c. On a speculative basis, the value $[h\nu/c^2]$ can be considered like the *inertial* mass of the photon, which includes some very large relativistic correction coefficient. In contrast, the aforementioned observational upper estimates for μ could (maybe) refer to the *rest* mass of the photon, which can be tiny, while the relativistic correction factor should result very large. On the other hand, if μ is null, which is the present generally agreed assumption in the literature, i.e. if a miniphoton is an *elmgrain*, it makes nonsense considering its rest mass, and its rest *emp* should be just $[h\nu/c^2]$. Therefore, every specific experiment aimed at estimating an upper limit for μ ought to be critically reconsidered in terms of the logical content of its underlying assumptions. At present, no other explanation seems to be possible for such paradoxical difference between μ and $[h\nu/c^2]$.

In the ultimate analysis, an intrinsic basic difference exists between the *elmgrains* and every particle of the α-world or every antiparticle of the γ-world. We must conclude, therefore, that we cannot liken to any other particle or antiparticle the *elmgrains*, whatever they are, as they represent, altogether with the β-world, an asymptotic feature of natural reality, and the "brane" between our world and the antiworld.

If miniphotons are not *elmgrains*, we must speculate that some *elmgrains* must exist, e.g. (maybe) minigravitons. Therefore, it appears crucial being capable of detecting - even only indirectly - the effects of such *elmgrains*, which are to be considered like "carriers" of the β-world, and which move at the asymptotic speed *c*. We strictly need for some unprecedented observational evidence. The best way of measuring the precise speed of light should be in being capable of detecting altogether the effects of light and of such faster *elmgrains*. This is the concern of section 11.

On the other hand, we should be aware of the fact that, eventually, we could be strictly forbidden from any direct observation of effects that occur within the β-world. If such hypothesis is correct, we do observe photons just because they partake into the α-world, while we (perhaps) are forbidden from observing the real *elmgrains*, such as maybe the minigravitons, etc.

For the sake of completeness, let us briefly mention the consequences of the assumption that the speed of light is less than *c*. Let us consider only two specific items, i.e. unit definition (see section 2) and the Feynman/Dirac concern about the competing role of negative energy *vs.* time arrow reversal (see section 5).

Concerning *unit definition*, let us repeat the former argument, and define the time unit by means of one given reference spectral line. Two possibilities have to be considered.

One case occurs when the light speed ($<c$) can be assumed to be *strictly identical* for both Alice and Bob. The length unit can be defined with no change with respect to the former procedure, simply by putting within formulas the actual speed of light instead of *c*.

The other case history occurs whenever the light speeds $\mathbf{v}_A$ and $\mathbf{v}_B$, respectively, are different for Alice and Bob, i.e. when $\mathbf{v}_A \neq \mathbf{v}_B$. In such a case, in principle both Alice and Bob ought to carry out their respective transformation of the inertial mass of the miniphoton into its rest mass, upon considering their $\mathbf{v}_A$ and $\mathbf{v}_B$. The definition of units ought to follow accordingly. Some warning, however, is needed. The velocity vector of a miniphoton, which is a massive particle, must be summed with the $\mathbf{v}$ vector of the observer, (although the modulus of such vector sum shall never exceed *c*, due to the increasing weigh of the inertial mass). Hence, in general it is possible, or even likely, that $\mathbf{v}_A$ and $\mathbf{v}_B$ are different. The relativistic correction factor, however, is very large, and its *percent* variation when substituting $\mathbf{v}_A$ with $\mathbf{v}_B$ is negligible. Hence, one can assume that $\mathbf{v}_A$ and $\mathbf{v}_B$ are *approximately* identical, and the problem is solved. On the other hand, in order to estimate the actual difference between $\mathbf{v}_A$ and $\mathbf{v}_B$, we should be capable of measuring, at least, either the difference between $\mathbf{v}_A$ and *c*, or between $\mathbf{v}_B$ and *c*, because a simple consideration of $\mathbf{v}_A$ and $\mathbf{v}_B$ alone can provide no estimate for *c*, at least as long as we cannot detect some *elmgrains*.

Concerning the *Feynman/Dirac item*, either *(i)* one considers that the α-world and the γ-world are characterised by opposite time arrows, or *(ii)* one supposes that both the α-world and γ-world have the same time arrow, while their respective space axes are all reversed, thus implying a change of parity of 3D space, and the γ-world has negative energy states. In addition, such two possibilities do not exhaust all possible choices (see section 5).

The arbitrary character of such choice can be highlighted as follows. Consider the *QAT* graphs; e.g. consider the interaction between a proton and an antiproton that generates a couple of electron/positron or of any other particle/antiparticle. The Feynman graphs of higher order have an increasing number of knots, and

a miniphoton is the unique needed "carrier" for exploiting such interaction.[8] Consider the way the identical phenomenon is observed from the α-world, or from the β-world, or from the γ-world.

Alice detects everything while she is embedded within her 4D spacetime, with standard time arrow. She shall see the β-world as inhabited by *elmgrains*, which are eventually undetectable, although she speculates that they move at the asymptotic speed *c*. She will like (perhaps) considering the antiproton as embedded in a space with *the same* time arrow as the proton, although she must state that the antiproton has a *negative* energy. That is, she prefers keeping invariant the time arrow, although she must admit the existence of negative energy states. In contrast, according to the viewpoint here adopted, such proton and antiproton, as observed by Deborah, generate a couple of photons of parity opposite to each other - notwithstanding, as a standard, they are presently interpreted by Alice as being one unique photon, rather than two photons; but this makes little difference, as such photons are not seen directly, and their evidence relies on the energy balance of the interaction proton/antiproton, by which the existence of one photon alone, rather than of a couple of photons of opposite parity, is just a matter of an assumption. Even in such case, however, every photon of either parity is a particle of the α-world, as it has a non-vanishing mass. But the two photons must sometimes combine and give one *elmgrain* (maybe, a minigraviton?) that later "exhales" into a symmetric pattern of α-world and γ-world. Such "exhalation" is manifested as a generation of a new couple of miniphotons of opposite parity, or of a couple particle/antiparticle, and so on. Therefore, Deborah will like considering the proton and the antiproton like complex conjugate expressions of a complex world, where her β-world is the real part, or the parent world, from which matter and antimatter eventually "exhale", for "later" returning back into their parent β-world, etc. That is, owing to symmetry reasons, i.e. owing to the search for a "beautiful" theory, Deborah shall prefer and avoid making any reference to states of negative energy.

Symmetrically, Frank will like considering only a reversed time arrow, where his normal conditions shall be negative energy, and he will like considering the α-world as a "curious" world with positive energy.

Summarizing, the Feynman/Dirac dichotomy is just a matter of choosing a viewpoint, which can eventually appear more or less "simple" and "beautiful" to different observers, depending on their location in either the α-world, or in the β-world, or in the γ-world.

10 – An axiomatic formulation

Consider the nice garden mentioned in section 1, with a pond, a fish, etc., and the "blindness" of the humans. Nature is objectively composed of the α-, β-, and γ-worlds, which are *real actually existing* features of natural reality. Owing to the central role of the β-world, let us first consider the way the "garden" is perceived by Deborah.

As far as Alice and Frank are concerned, they cannot asses even the dimension of the Deborah's β-world, where they cannot define a straight line, they cannot recognise coordinate axes, or measure lengths along them, or assess any individuality, etc. They are "blind". However, all such information is perceived by Deborah, who is timeless. She knows the dimension of her space (for simplicity, let us say that it is likely that the β-world is 3D); she knows coordinates axes; she can measure coordinates; and she can recognise individualities. She defines the "existence" of "something" by identifying it with one "*virtus*", i.e. with its *emp* content. Owing to the finite principle, all what exists must be expressed in the form of suitable *elmgrains* that determine, within the β-world, the interaction of every two (or more) specific individual objects through the *QAT* process. However, we do not know the physical nature of such *elmgrains*, and we cannot detect such interactions occurring between entities that we cannot recognise within the β-world. But Deborah can detect all this.

Deborah knows that every *elmgrain* has at least two intrinsic "*virtutes*". One is a scalar, and it is the aforementioned *emp* content. The other is a vector, hence - up to our understanding - it is presumably 3D, and it is called "*generalised momentum*" (see section 1). It should be stressed that such definition of "*momentum*" is formal and axiomatic, independent of the fact that no time exists within the β-world, hence no speed and no relation between momentum and dynamics (as dynamics *per se* cannot be even defined).

[8] Let us stress that Feynman graphs with a large number of knots are possible, although their contribution is physically less probable. That is, we should consider a *finite sum* of terms, rather than a *series*. This fact gets rid of the paradox of renormalisation theory, and such achievement is shared also by string theory, as it rejects infinitesimal quantities.

Such "*momentum*" can be likened e.g. to some kind of intrinsic property or quantum number, such as e.g. the spin of a particle, or its magnetic moment, etc.

In addition, Deborah knows, or she assumes, that whenever, for whatever reason, a scattering occurs between every two objects, the total *emp* and the total "*momentum*" of the system must be conserved. In addition, whenever some aggregate of *emp* is attained, which is above some threshold, it shall be much unstable. The result is that that such excess concentration of *emp* shall eventually give rise to the formation of a couple particle/antiparticle. At such stage of the phenomenon, such process can be finally observed also by Alice and by Frank, who shall be happy of being no more fully "blind".

Such generation of a couple particle/antiparticle recalls, in fact, a slingshot process, which (instead of occurring within an atom monad; section 1) occurs through the exhalation of a time axis and of an antitime axis. A particle and an antiparticle thus appear to Deborah like some kind of "degraded" objects that, according to Alice and Frank, move at a much lower speed compared to the asymptotic speed of the objects that A and F interpret as partaking into the β-world. Such "degraded" objects experience dynamics and antidynamics, respectively, and interact with other objects through the *QAT* mechanism. They exchange minigranules, which are either the same *elmgrains* or maybe some other minigranules, i.e. miniphotons or minigravitons or others. Whenever one such "degraded" object captures or releases either one such minigranule, its *emp* content and its momentum change accordingly, by some finite and discrete (non-continuous) mini-amount. In this way, such "degraded" objects can eventually increase their respective *emp* content, by adding some discrete amount of *emp*. We call "kinetic energy" the total amount of such additional *emp*. In addition, the former original *emp*, which was referred to the *absolute frame* of reference represented by the β-world, is associated with what we call "rest mass" (after dividing *emp* by c^2 , which is just a matter of an arbitrary change of units). In contrast, the observed *emp* content, after being modified by subsequent *QAT* interactions by minigranules etc., is associated with what we call "inertial mass". In fact, whenever one particle, or one antiparticle, within its α- or γ-world, respectively, enters into some new interaction by capturing or releasing one minigranule, it enters into the balance of the dynamics of the system with its actual *total* contents of *emp* and of momentum. That is, the generation of the time axis and of the antitime axis implies a "degrading" of the former *emp*, which existed in the β-world. But, such "degraded" objects search for approaching the β-world by "capturing" minigranules in order to increase their *emp* content and momentum, almost like in the case that their ultimate aspiration is after returning into the β-world.

Consider the slingshot process that occurs within an atom monad, i.e. consider the way Alice or Frank observes an excited atom, which releases its light spectrum. The atom contains a cloud of electrons, which are structured in some way. Such structure, however, is unknown to Alice, as such knowledge should require knowing hidden parameters. The interaction between different electrons within such cloud occurs through the exchange of miniphotons in terms of Feynman graphs. In any case, whenever the system attains some *emp* concentration that results above some threshold, it becomes unstable, and it releases some extra amount of *emp*, which is finally manifested like a volley of miniphotons. Alice and Frank, however, can have only a "thermodynamic" knowledge of such phenomenon, which is empirically expressed by spectroscopy and by the Schrödinger's equation, while they can have no knowledge about the hidden parameters of the atom monad.

Such entire theoretical scheme is "beautiful", although a few points ought to be clarified. We cannot know whether only one kind of *elmgrains* is necessary, or rather several different kinds. Is the miniphoton one kind of such *elmgrains*, or not? Does it move at some speed smaller than the speed of real *elmgrains*? Several other eventual kinds of minigranules can be presumably inferred, by carrying out a suitable analysis of the zoo of the interactions of elementary particles, and of their apparent regularities, etc. Such problem is not here tackled. A different investigation deals with the search for astronomical evidence, which should hopefully give the observational proof of the different propagation speed of photons, compared to some other speculated minigranules, such as, perhaps, minigravitons. This is the concern of section 11.

11 - Measuring the speed difference of gravitons and photons

Let us refer to the natural laboratory represented by our visible universe. We must envisage some phenomenon, and detect it either by its gravitational effects, or by its e.m. effects i.e. observed by means of the e.m. radiation that it releases.

Several different kinds of catastrophic celestial events are recognised and investigated by astrophysicists. Their optical observation by telescopes is available. According to the general feeling, all of

them, or only a few of them, could be responsible, perhaps, for releasing some anomalous gravitational signal, which should be detected in the form either of gravitons, or of gravitational waves - which, according to the present interpretation, ought to be volleys of minigravitons.

The search for the detection of gravitational waves and/or of gravitons is one of the present most advanced frontiers of physics (projects *LIGO, VIRGO, GEO 600, TAMA300, AIGO, LISA*, …). Since it is generally believed that the scale size of a graviton ought to be larger than the entire Earth or even than the entire solar system, the most reliable way of getting rid of every spurious effect is by seeking a correlation between the signals recorded by gravitational observatories located on the Earth's surface very far away from each other. In general, one should suitably consider the possibility that every one given such event could be associated with some physical effects other than the speculated celestial catastrophe. That is, the optical e.m. evidence is fully reliable, as it is derived from space telescopes and it assesses the objective occurrence of some specific phenomenon. In contrast, in principle sometimes the gravitational evidence can be spurious. Therefore, there is need for some large statistics of observations for getting rid of such drawback.

We can consider the whole planet Earth as one unique possible gravitational antenna. We can tentatively identify the occurrence of some earthquake, having some magnitude above some threshold, as evidence of a phenomenon that releases some large amount of potential elastic energy, and that maybe was triggered by some impinging graviton or gravitational wave, etc. For sure, it is generally believed that some earthquakes (if not all of them) require no external trigger. We need only for assuming that some non-vanishing fraction of earthquakes is eventually triggered by a gravitational signal impinging from space. If such assumption is correct, we should find statistically significant evidence. If it is manifestly wrong, we should find a proof for this. In any case, the needed data handling is quite straightforward, simple, and univocal, as follows.

Call t_1 the time instant of the astronomical observation of a celestial catastrophe. In general, its error bar can be of the order of, say, *~ 1 day* (or sometimes even less). Astrophysicists claim that they afford in estimating the distance D of such celestial objects – or at least for some fraction of them. In general, D is known with some relevant uncertainty. The error bar of D is likely to be the largest source of error in the following analysis.

If the speed of light is v_1 , the time lag $[D/v_1]$ is spent by the optical signal for reaching the Earth. Call t_2 the time instant of the observation of a presumed effect triggered by a gravitational signal. If the speed of the gravitational signal is v_2 , the time spent by the gravitational signal for reaching the Earth is $[D/v_2]$. Therefore it is

$$\Delta t = t_1 - t_2 = [D/v_1] - [D/v_2] \qquad [\Delta t/D] = [1/v_1] - [1/v_2] \qquad (9a,b)$$

Operatively, let us start from a data log of celestial catastrophes, including either one, or a few, given kinds of events. Let us use a catalogue of the earthquakes that occurred all over the world *during some long time span*, and that have magnitude above some pre-chosen and arbitrary given threshold. Choose just one given such celestial event alone, associated with a celestial object that is believed being at some distance D. Tentatively consider *every* earthquake, of the *entire* seismic catalogue, as one single physical fact to be possibly associated with such unique and pre-chosen celestial catastrophe. By such assumption let us compute Δt, which, in general, can result either positive or negative. Evaluate $[\Delta t/D]$ and put one corresponding box within a histogram. Repeat the same procedure for *every one* given and the same pre-chosen celestial catastrophe, and repeat it for *all* earthquakes of the *entire* seismic catalogue. Draw the corresponding total histogram. Repeat the same procedure for *every* celestial catastrophe, and *superpose* all results into *one unique* histogram. If the effect that we are seeking is correct and physical, such final histogram ought to display a peak corresponding to some given $\Delta t/D$, either positive or negative, depending on what signal is comparatively faster or slower. Finally, from (9b) evaluate v_2 when v_1 is supposed known. For instance, if gravitons are faster than photons, their relative speed difference can be evaluated. The remaining arbitrariness shall therefore be in assuming that gravitons (e.g.) are *elmgrains*, rather than photons. If photons result to move faster than gravitons, we should speculate that photons are *elmgrains*, unlike gravitons, etc.

The concrete concern is about error bars, as we have to assess what peak of the histogram can be considered as statistically significant. This can be achieved as follows. For simplicity and with no loss of generality, let us consider the data base of the celestial events (although the same can be symmetrically repeated by making reference to the seismic data base). Arbitrarily change the set of the time instants of *every* event, and redefine such set by mixing in some random way the identical given physical time instants. That is, this amounts to mixing in a random way the D values of the set. Compute the histogram as above.

Repeat such procedure several times, e.g. say *1000* times, and get a corresponding set of *1000* such histograms. Compute the average histogram, which is the formal average of such *1000* random histograms, and its standard error bar computed at every abscissa of such average histogram. Such error bar is to be used for inspecting the original actual observational histogram, and for deciding what peak is eventually statistically significant.

An important physical aspect ought to be stressed. The distance *D* can be very large (e.g. of the order of the diameter of the Milky Way, i.e. ~ *100,000 LY*, or even much larger). In addition, Δt can be either very small or very large (e.g. it can be even centuries or millennia, or much longer), depending on the difference between v_1 and v_2 , which is essentially *a priori* unknown. In any case, if we want to get observational evidence by means of a seismic catalogue that can span only a few centuries, such difference between v_1 and v_2 should be some very tiny percent of either v_1 or v_2 . Therefore, we should request that the seismic catalogue ought to span the longest possible available time interval. Even catalogues of historical earthquakes can be useful, notwithstanding they are eventually incomplete and uneven. Similarly, one can even include historical catalogues of ancient supernovae, etc.

If such analysis (in progress) will hopefully result successful, it could be the first observational evidence of the effect of gravitons impinging on the Earth; if not, in the fact that it is found that v_1 and v_2 result apparently identical, it will be possible evaluating an upper limit for the $]v_1 - v_2]$. If the speed of light results actually $<c$, it will be possible to compute the relativistic factor relating rest mass and inertial mass of the miniphoton, resulting into an experimental measurement for high value of $\beta = v/c$.

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