The Spacetime Model ®

Part 4/5

Electromagnetism

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In 2006, this theory was addressed to more than 7000 physicists worldwide by e-mail. Several paper copies were sent in October 2006 to the most important Academics of Science and Committees of Foundations for Research.

This theory was also published on November, 30, 2006, on 28 different web sites. It is also referenced on many sites such as Google, Google Books, Yahoo, DMOZ... Since 2006, more than 300,000 Internet Users (about 230,000 Physicists) have read it.

Important note

This paper attempts to explain some enigmas of modern physics. In this regard, some parts are speculations, but Science can only advance through speculative theories.

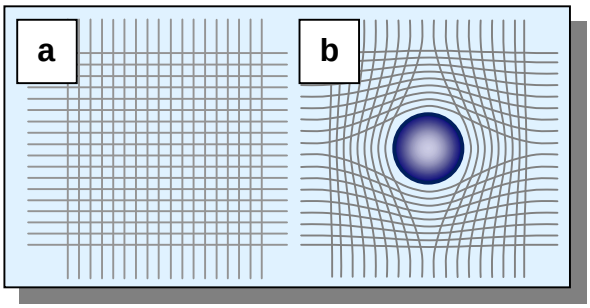
To date, the Spacetime Model, is nothing but a theory. Despite the fact that this theory is logical, coherent, and makes sense, the reader must be careful, bearing in mind that the Spacetime Model has not yet validated by experimentation.

Before reading…

To fully understand this part, the reader must be familiar with the deductions and results developed in previous parts. These results are summarized below:

The curvature of spacetime

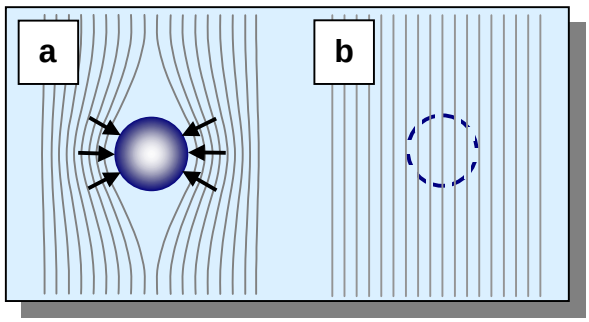
Lets consider a flat spacetime (a). It could be logical to consider that it is the volume, not the mass, that curves spacetime (b).



Einstein Field Equations and experimentations show that it is the mass, not the volume, that deforms spacetime… The solution to this enigma is given below.

Closed and open volumes

All volumes have not the same behaviour regarding spacetime. In reality, we have three classes of volumes:



a/ Volumes with mass, or "Closed volumes" such as elementary particles. Their internal spacetime "pushes" the surrounding spacetime to make room. Thus, "closed volumes" produce a convex curvature of spacetime. Since the latter has properties of elasticity (Einstein), it exerts a pressure on the surface of these volumes. As a result, a "mass effect" appears, i.e. an effect having all the characteristics of mass. The mass component [M] can be extracted from the pressure [M/LT^2] by simple mathematical operations. This conducts to a 4D expression of the mass as M = f(x,y,z,t).

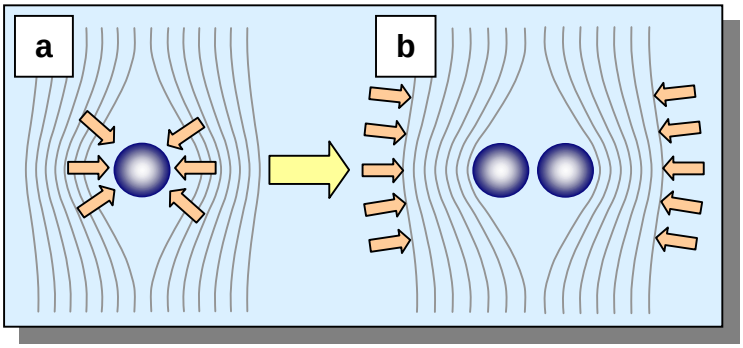
b/ Massless volumes, or "Open volumes". It is a vacuum but sometimes found in various forms such as the volumes of orbitals of atoms. These volumes exist but they are "porous" regarding spacetime. More exactly, they are subject to variations of spacetime but they don't curve spacetime themselves. Therefore, open volumes are massless since no curvature means no mass (Einstein).

c/ Apparent volumes are combinations of closed and open volumes. In atoms for example, the nucleus is a closed volume which has mass, whereas orbitals are massless open volumes. The proportion of closed/open volumes, i.e. volumes with/without mass, varies from one atom to another, from one molecule to another, from one object to another... This is why we feel that mass and volume are two different quantities. This is an illusion. It is the proportion of closed/open volumes that varies from one object to another, which gives us this feeling.

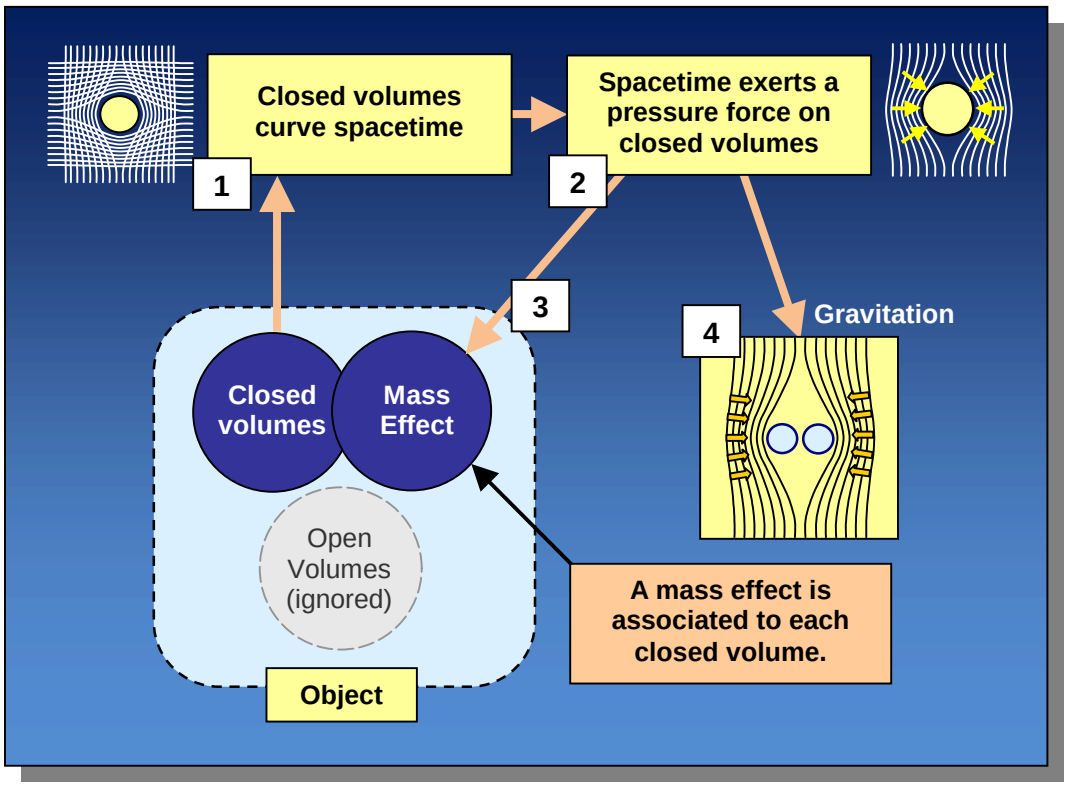
Mass and Gravitation

Two closed volumes inserted into spacetime curve it. Since spacetime is elastic, its curvature produces pressures on these two volumes. So:

Gravitation is not an attractive force between masses but a pressure force exerted by spacetime on closed volumes that tends to bring them closer to each other



As shown in this figure, mass and gravity are the same phenomenon



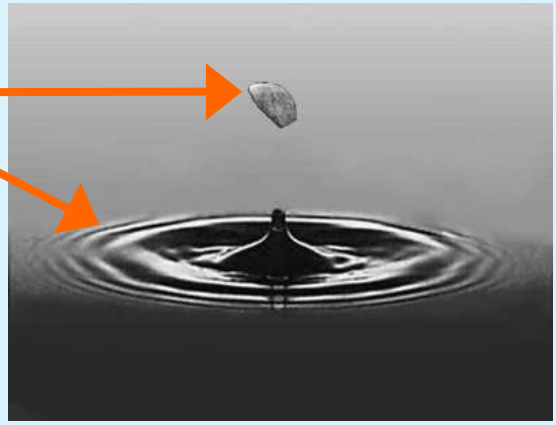
Note: Part 1 also shows that the Higgs Field is nothing but Spacetime.

The Wave-Particle Duality

The following two figures fully explain the wave-particle duality.

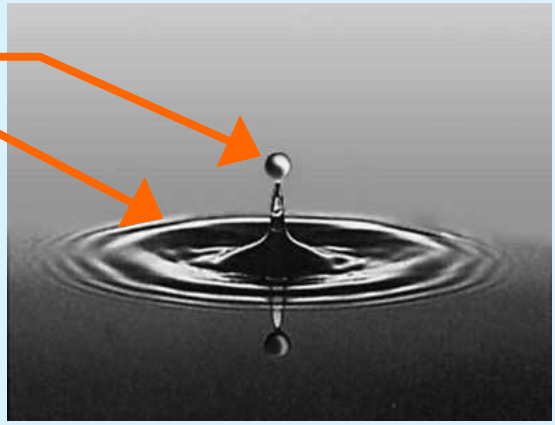
Example 1
A stone
and a water wave
*are of **different matter**.*

In that case, the wave-particle duality can't be explained. It is an enigma.



Example 2
A drop of water (corpuscle)
and a water wave
*are of **identical matter**.*
Water has either a corpuscle behavior or a wave behavior.

In this particular situation, wave-particle duality is explained with logic and consistency.



Particle	wood	stone	metal	**water**	glass	plastic	carbon
Wave	water	water	water	**water**	water	water	water
Medium	air	water	water	**water**	water	water	air
Duality ?	**No**	**No**	**No**	**YES**	**No**	**No**	**No**

Impossibility

Impossibility

Duality is fully explained
in this particular case

Wave – particle duality appears only in the very particular situation where the wave, the particle and the medium are of identical matter

The constitution of particles

Part 1 explains that mass and gravity also come from spacetime. Parts 2 and this part cover explanation of EM waves, which are nothing but spacetime vibrations, different than those due to gravitational waves. Linking this discovery, the wave-particle duality explanation, and experimentations such as the 511 KeV production from e+e- annihilations, we deduce that matter and waves, including De Broglie waves, are made of spacetime. More exactly, what we call "matter" is areas of low (electrons) and high (positrons) densities of spacetime. So:

Waves	=	**Matter**
(Spacetime variations)		*(Spacetime areas)*

The "sCells"

It would seem that the global spacetime of the universe is divided into quanta called "Space-timeCells" or "sCells", which are nothing but neutral electrons. Therefore, sCells could have a closed volume equivalent to 511 KeV but, like neutrinos, they can't be detected.

In particular, sCells explain with logic and good sense the constitution of quarks and show where is located the antimatter in the Universe.

The "Distributed Charge" Model

The explanation of wave-particle duality leads to an important deduction: electrons are not moving around the nucleus as a punctual particle but as a sort of "cloud of charge". Indeed, the charge of the electron is distributed into the sCells surrounding the nucleus. Schrödinger's probability concept must be replaced by a more realistic concept called "Distributed Charge Model". However, quantum mechanics formulas as Schrödinger Equation are not modified by this new approach. It is only an explanation of the phenomenon.

The table of contents is located at the end of this document

1. EM Radiations

EM radiations are mathematically described with a high degree of accuracy, but the principle of EM radiations is still unknown. In this chapter, we will try to understand why the speed of light is constant, and we provide three well-known applications concerning chapter 2 of Part 2.

The reader is invited to read Chapter 2 of Part 2 before reading this part because some sections have been here duplicated for teaching purposes.

1.1 Separation of media

The problem of velocity additions suggests that we are in the presence of two distinct media which are overlaid (fig. 1-1):

1 - "Apparent medium"

This is the visible medium that carries out the experimentations, and from where the EM wave is emitted. For example, in Fizeau's experimentation, this medium is water, and in Michelson's, it is the Earth's atmosphere moved by the Earth itself.

2 - "Real medium"

EM waves are propagated in a "real medium". For example, this *"Real Medium"* could be the De Broglie "Neutrinos Sea".

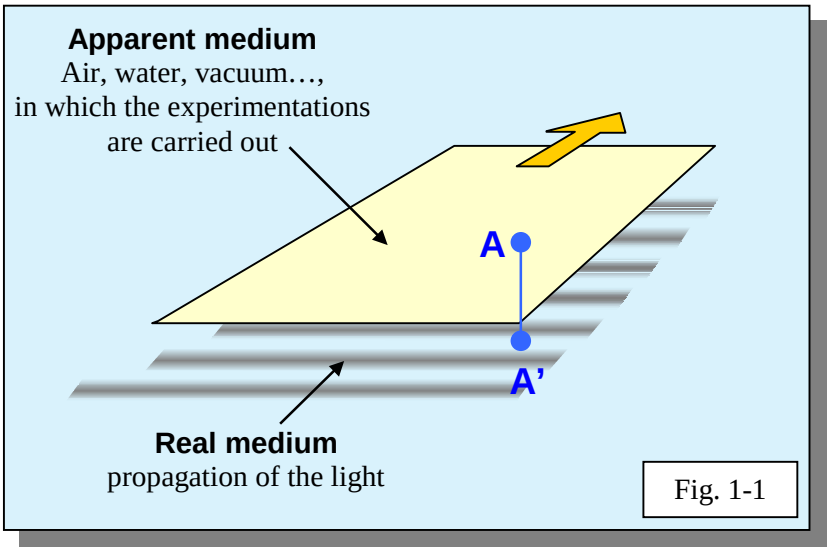


Fig. 1-1

1.2 Properties of the "Real medium"

The *"real medium"*, if it exists, must have at least the following two properties:

1 - To be present everywhere

Since EM waves are propagated everywhere, the *"real medium"* must also be present everywhere, in air, in water, and even in a vacuum[1].

2 - To have propagation properties

We know that any wave needs a propagation medium. Since spacetime has the properties of elasticity (Einstein), it could be a propagation medium.

Therefore, spacetime[2] is an excellent candidate to support EM waves.

Important note

Gravity and EM waves do not curve spacetime in the same manner. Please read Parts 1, 2 and 3. Here, the structure of spacetime has been deliberated simplified for pedagogical purposes.

1.3 Constant speed of light

Let's imagine the emission of a beam, L, from a laser diode (fig. 1-2). The diode, A, is fixed on a motionless *"apparent medium"*. The beam reaches the point L via the real medium: A → A' → L' → L.

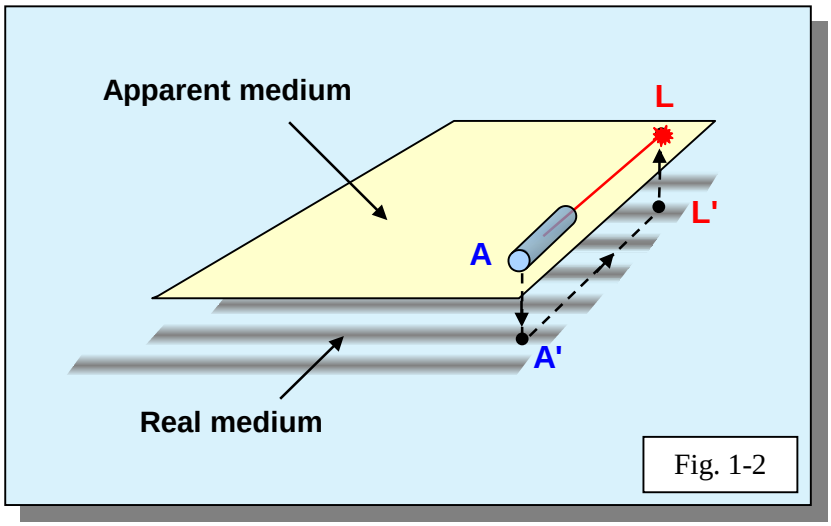


Fig. 1-2

Now let's consider that the apparent medium is moving with the velocity "V" (Fig. 1-3). An external observer, such as Fizeau or Michelson in 1900's, could think that the speed of the

[1] The real medium is not what we called the "aether". To avoid any confusion, we will use the term "real medium" instead of aether.

[2] The spacetime of the universe, sometimes called "global spacetime structure", is the one that was created about 13.7 billion years ago, and not the local spacetime of special relativity. So, in this document, the word "spacetime" will always refer to "global spacetime structure of the universe", as in Friedmann-Robertson-Walker Definition.

apparent medium V is added to the speed of light. In reality, the speed of light from A' to L' will be constant, whatever the speed of the apparent medium V.

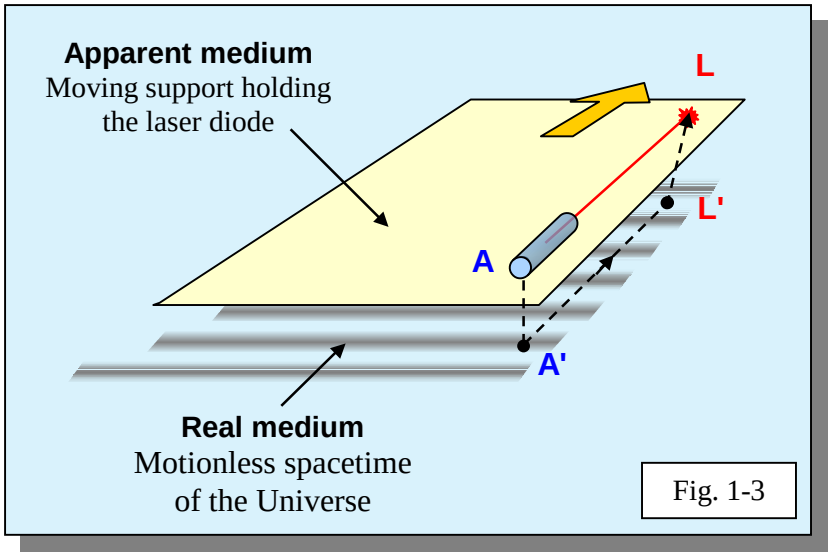


Fig. 1-3

Indeed, since the light is propagated in the *real medium*, its speed depends only on the nature of this medium, and nothing else. In reality, the permittivity of free space ε_0 is not a "vacuum permittivity" but rather a "spacetime permittivity", a physical constant that defines the spacetime propagation characteristics, as the "spacetime permeability" μ_0.

1.4 Case of two reference spaces

Fig. 1-4 shows a photon which is emitted from an apparent medium A to another apparent medium B. The two apparent media are moving in the opposite direction[1]. In this case, no one can explain why the speed of this photon is constant.

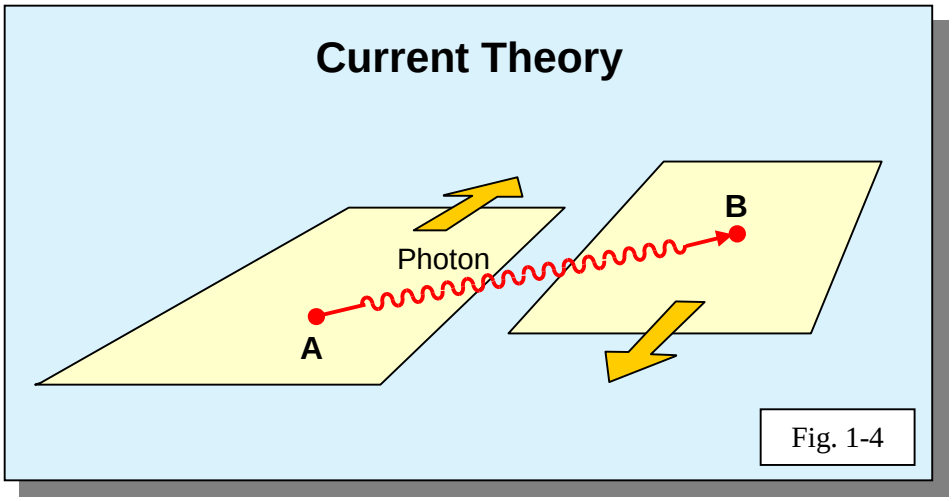


Fig. 1-4

[1] We should not have any confusion between the word “motionless” used in the context of the global universe, which is correct, and the same word used in Special Relativity, which is not relevant in that study.

Fig. 1-5 shows the proposed theory. The light is not propagated in the apparent medium, which supports the sources of light A and B, but in the real medium, which is global spacetime of the universe. EM radiations do not consist of photons but of EM waves. As a result, the constant speed of light is easily understood. The velocity of light is a function of the real medium characteristics, i.e. spacetime permittivity ε_0, and spacetime permeability μ_0. Thus, the speed of light is always 300 000 km/s, whatever the relative velocity of the two apparent media from where the light is emitted.

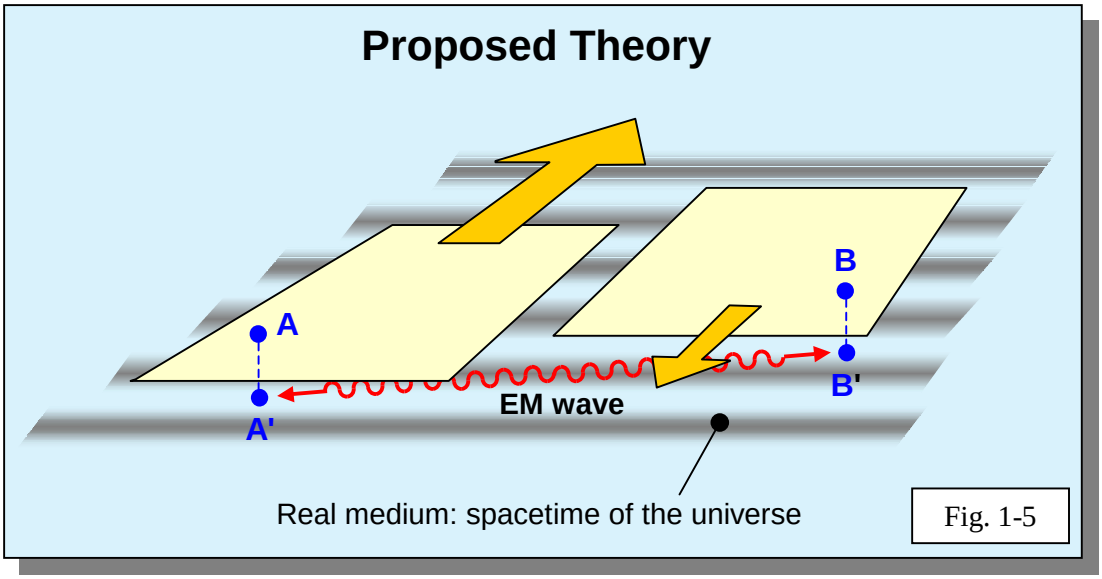


Fig. 1-5

1.5 Atoms

Fig. 1-6 explains what happens when an EM wave goes from an atom "A" to another atom "B". Here, the same principle as above may be used to solve the enigma of the speed of light. According to the wave-particle duality, the light doesn't move as a photon but as an EM wave.

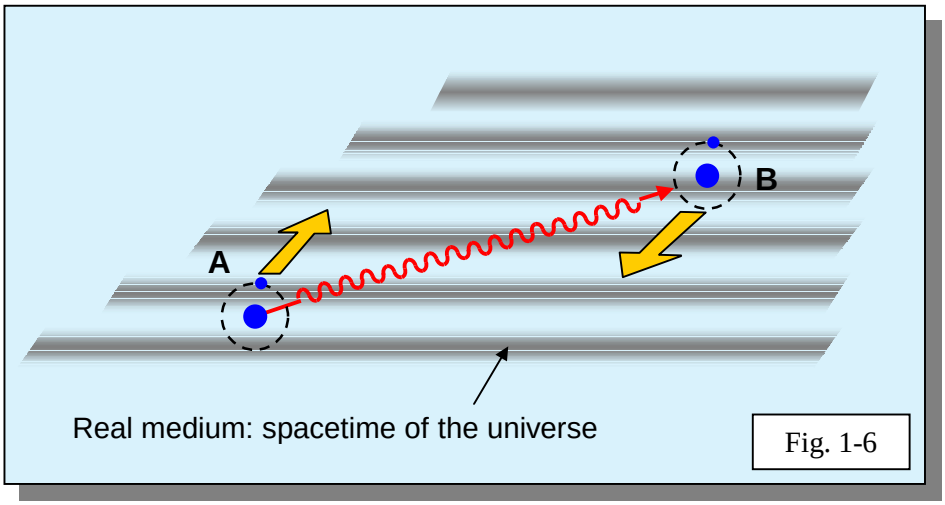


Fig. 1-6

1.6 Conclusions

- EM waves are emitted from an *apparent medium* but are propagated by the *real medium,* which is global spacetime of the universe.
- In this *real medium*, the speed of light is 300 000 km/s. Its invariant velocity is only a function of the permittivity ε_0 and the permeability of spacetime μ_0

Therefore, although it amounts to the same thing, it would be more accurate to write:

"The speed of light is 300 000 km/s in spacetime [1] *"*

rather than:

"The speed of light is 300 000 km/s in a vacuum"

1.7 Application 1: Displacement of charged particles

By no means, can a moving charged particle emit other particles called "photons". In the same way, a stone falling into water cannot emit tiny stones in all directions.

The photon concept (chapter 3), from this point of view, does not make sense. Reality is much simpler. With the image of a stone falling into the water, the displacement of a particle produces movements in spacetime (fig. 1-7). From a mathematical point of view, these spacetime perturbations are "EM waves" but have all the characteristics of photons, as explained further.

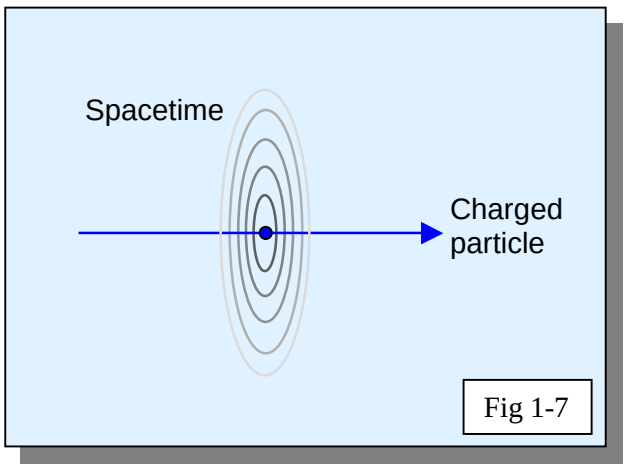


Fig 1-7

[1] Under certain conditions, EM waves may move at a speed different than 300 000 km/s. For example, using Bose Einstein condensats made up with sodium atoms at -273.15°, Lene Vestergaard Hau, from Harvard University, USA, slowed down EM waves to 17 m/s. In the same way, EPR also is an exception to the theory. The Spacetime Model partially covers these exceptions, particularly in Part 1 "Mass and Gravity".

1.8 Application 2: Changes of orbitals

In the same way, there is no emission of photons when an electron moves from a higher to a lower orbital (fig. 1-8). This point of view does not make sense scientifically.

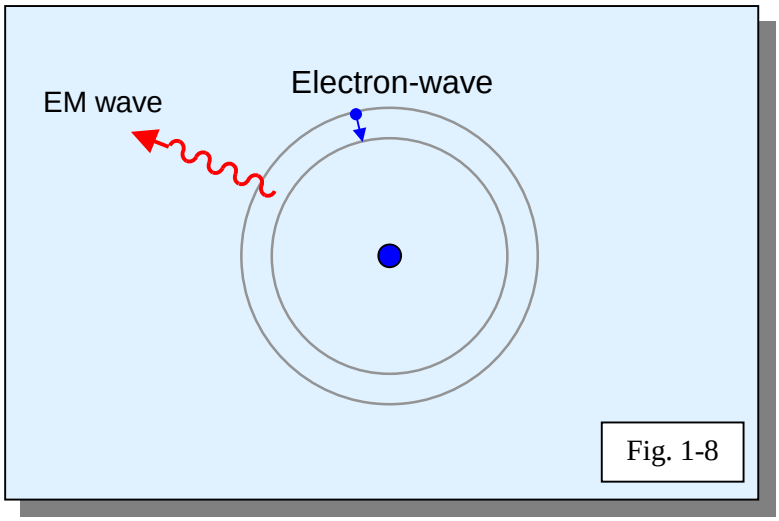


Fig. 1-8

The explanation of the EM radiation emitted during a change of orbital follows the same principle as the precedent.

Contrary to a preconceived idea, the electron does not move as a particle on the orbital but rather as a wave.

The passage of the electron in its wave form from an orbital to another of less energy creates movements in spacetime, like whirpools or eddies in water. These movements are EM waves or, to be more precise, "quantified EM waves". These subjects are covered deeply in the following chapters.

1.9 Application 3: The Δq/Δt

As we know, a motionless stone in water doesn't produce water movements. A stone begins to make eddies only when it moves.

We have the same phenomenon in spacetime. A motionless electron doesn't create any perturbation, or wave. It does when it moves.

Therefore, we have a perfect match between this common phenomenon on Earth and electromagnetism (Δq/Δt). This simple example clearly shows that the photon concept, despite the fact it has been used since 1905, is inconsistent. A more credible explanation is provided further in this part.

Moreover, this phenomenon is in perfect accordance with the wave-particle duality (see chapter 1 of Part 2).

2 Electromagnetism

Everyone knows the electromagnetism (EM) force but no one can clearly explain its principle. This chapter examines the EM force using the electron, but the following explanations can be extended to other charged particles.

2.1 The electron

The volume of the electron is measured with remarkable accuracy: 510.998918 KeV. Therefore, its borders are very precise and clearly defined. Indeed, the electron and positron are not those particles that were described in Part 2 “Constitution of Matter” as figure 2-1A shows. They are, rather, particles illustrated in figure 2-1B.

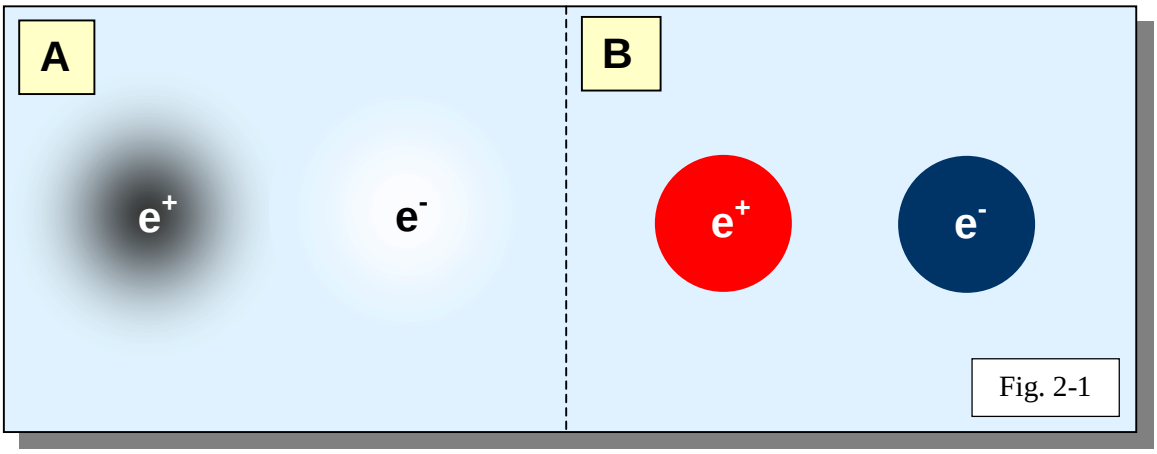


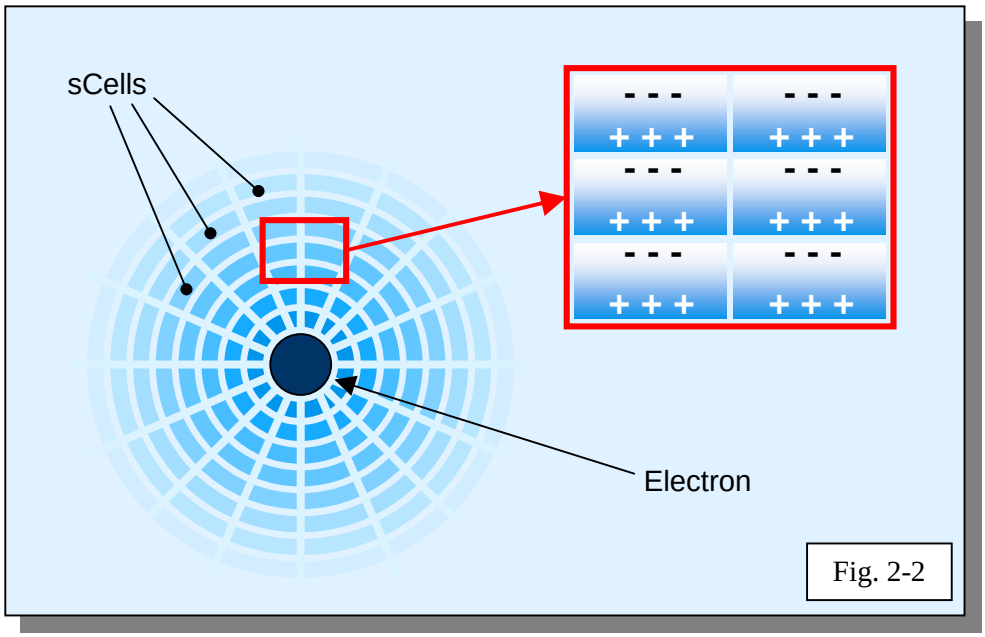
Fig. 2-1

Part 3 “Quarks and Antimatter” explains the possibility that electrons and positrons could be charged sCells whose borders make a volume, or “mass effect”, of 510.998918 KeV (see the introduction in page 3 of this part). Since these borders are very "clean", the propagation of the charge of the electron, i.e. spacetime density as explained in Part 2 “Constitution of Matter”, over its boundary is an enigma. How can the EM field exceed the electron's borders?

The solution seems very simple.

SCells, defined in Part 3, have a homogenous spacetime density that makes their charge neutral. Under an external influence, like near a charge, this homogeneity is disturbed.

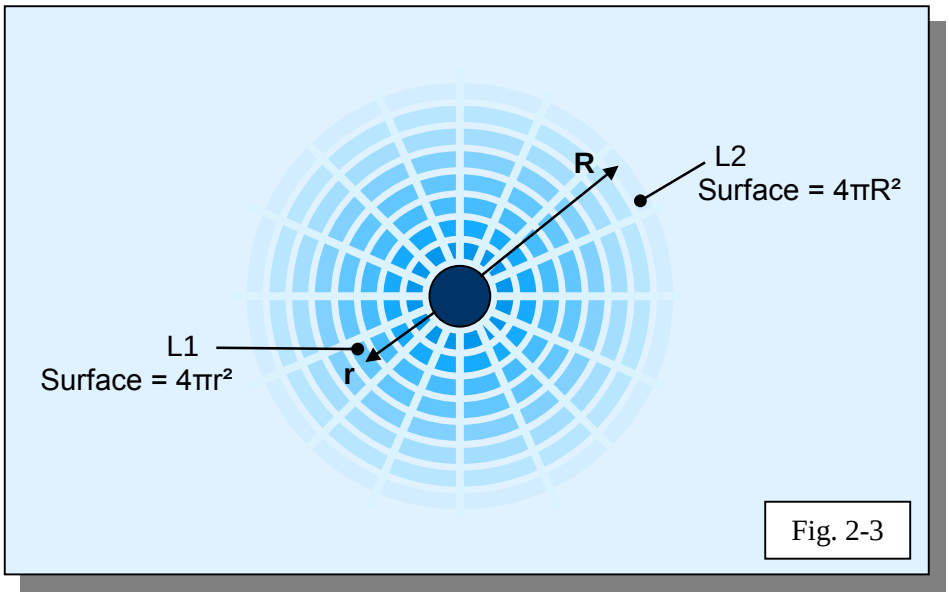
The electric field creates a pressure of spacetime on one side of the sCell, and a depression on its opposite side. Thus, the electric field can be gradually propagated, step-by-step, **inside** the sCell (fig. 2-2). Each sCell acts like an electric dipole.



The representation of this figure is only for teaching purposes. The sCells and electrons have the same closed volume of 511 KeV.

2.2 The 1/d² rule

Let's imagine that on the layer L1 we have 1000 sCells (Fig. 2-3).



On the layer L2 we will have:

$$N = 1000 \times 4\pi R^2/4\pi r^2 = 1000 \times R^2/r^2$$

This simple reasoning shows that the number of sCells is proportional to the surface of the layer. More the layer is far, more the number of sCells is important. This quantity varies as d^2, d being the distance of the layer from the centre.

Since the central charge (here the electron) is divided by the number of sCells, it is easy to demonstrate that the charge is inversely proportional to the distance d and varies as $1/d^2$.

SCells Theory perfectly verify the Coulomb $1/d^2$ rule

2.3 1D polarization of sCells

Let's use polar co-ordinates. The electric polarization seen in the preceding paragraphs is a function of the radius, r, which has only one dimension (1D). At a distance r from the centre, sCells are electrically polarized in an identical manner, regardless of the φ and θ angles. This situation is normal since we are in a spherical symmetry.

Figure 2-4 (left) represents a 3D view of a static electron and six sCells. As explained previously, the density of spacetime into each sCell decreases in $1/r^2$ with the distance "r". Figure 2-4 (right) shows a cross-section of the left view. If the electron doesn't move, it produces only an electric field, which is this one-dimensional polarization.

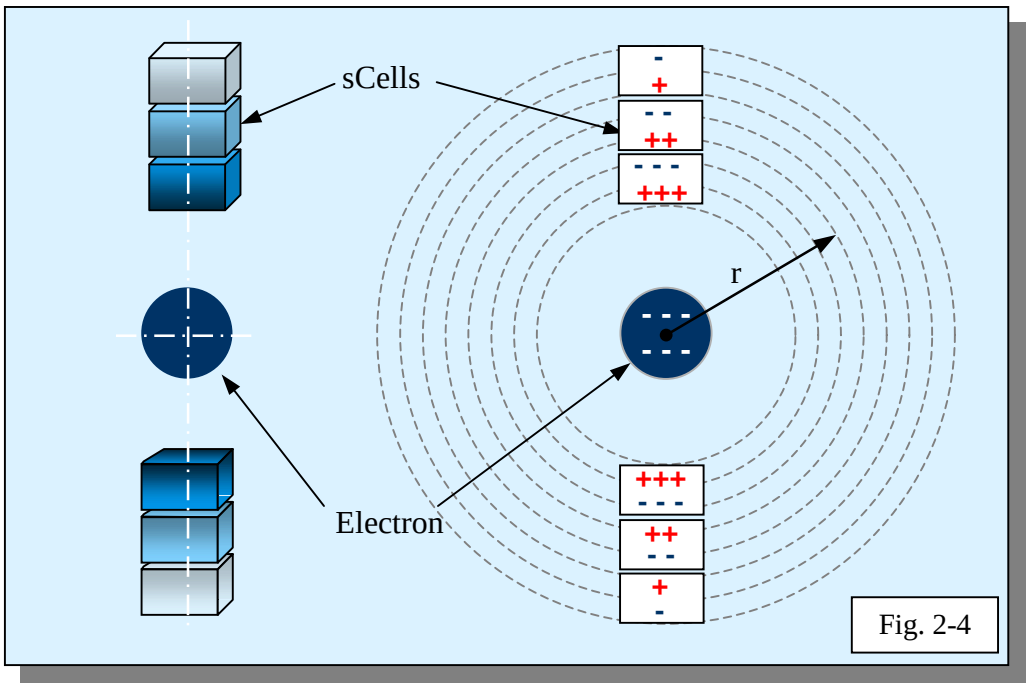


Fig. 2-4

The electric field is a one-dimensional polarization of sCells, which is only a function of the "r" radius

This explanation is in accordance with our knowledge of the electric field. Indeed, as we know, if the electron is static, the magnetic field doesn't exist.

2.4 3D polarization of sCells

We know that:

- Electromagnetism appears only if the charged particle is moving,
- The electric field and the magnetic field are two different effects of a common phenomenon. James Clerk Maxwell demonstrated this in 1872.

These two remarks lead to the following deduction.

The radial co-ordinate is already used by the electric field. We can, therefore, deduce that the magnetic field, which appears only if the electron is moving, uses the remaining co-ordinates: angles θ or/and φ. This point of view is exactly what the experimentation proves. Indeed, to describe magnetism, we need vectors perpendicular to each other, whereas only one vector is necessary to define the electric field. In schools, this principle is known as the "three fingers rule".

2.5 Principle of magnetism

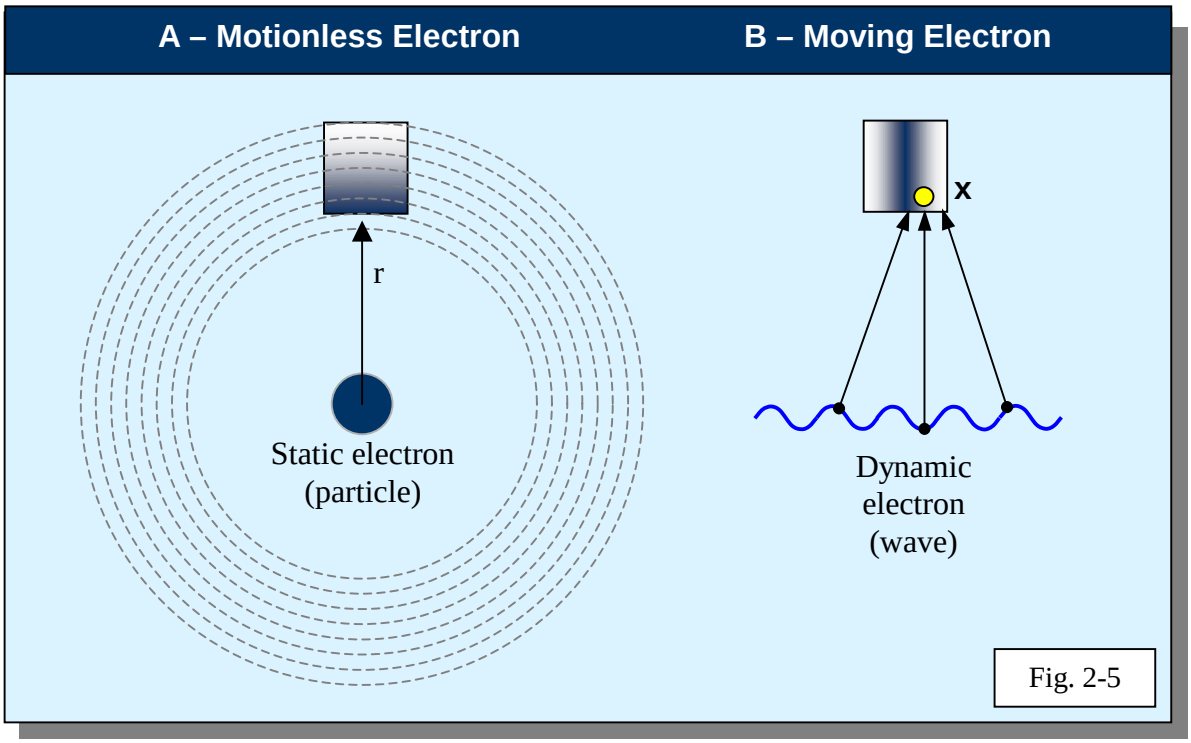
Why does this polarization appear only in the particular situation when the electron is moving?

Here is a suggestion to solve this enigma. We have the following alternative:

- **Motionless electron**

  A motionless electron is simply a charged sCell. It has a spherical symmetry. The electric field is propagated from sCells to sCells, as shown in fig. 2-2. Each sCell is polarized in only one direction, the "r" radius (fig. 2-5 A). This 1D polarization is confirmed by experimentations. In such a case, the magnetic field doesn't exist.

- **Moving electron.** The third principle of wave-particle duality (Part 2, chapter 1) says: *"When the particle is moving, it becomes a wave"* (fig. 2-5 B). Each sCell is therefore subject to several polarizations produced by different parts of the wave. For example, point "x" receives three different fields, each having different intensities. The result is that all sCells are polarized in 3D (r, φ and θ) instead of 1D (r only) for static electrons. A lateral polarization (φ and θ) is added the radial polarization (r).



In other words, magnetism does not exist as a fundamental force. We have only the Coulomb Force, nothing more. The magnetic field is a kind of "lateral" Coulomb Field. The orientation of the polarization of sCells produces a new phenomenon called "magnetism", but in reality, magnetism, as the Coulomb force, is a polarization of sCells.

We must also note that the particle, when it is motionless, has an electric field (1D), which acts like a monopole since it is a punctual object. On the other hand, the magnetic field (2D/3D) requires dipoles (the wave) to create it. So, **the magnetic monopole can't exist.** This is also proven by experimentation.

Lastly, it is also possible to have a magnetic component without an electric field. This is the case, for example, of permanent magnets. It is only a matter of the polarization of sCells[1].

[1] The current document doesn't cover completely so vast a subject.

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3 Spin (proposal)

Since its discovery in 1925, spin remains a mystery. No one knows exactly what is spin. The current definition, "quantum quantity", doesn't explain the origin and the real nature of spin.

In physics, we have more than 50 unsolved enigmas. Spin is one of the greatest of these enigmas. Here we try to understand what really is spin, with logic and good sense, but our conclusions are very speculative. It is obvious that Science will make a great step ahead the day that it can explain spin.

3.1 Definition

In quantum mechanics and particle physics, spin is a fundamental characteristic property of elementary particles, composite particles (hadrons), and atomic nuclei[1]. All elementary particles of a given kind have the same spin quantum number, an important part of the (quantum) state of a particle.

When combined with the spin-statistics theorem, the spin of electrons results in the Pauli exclusion principle, which in turn underlies the periodic table of chemical elements. The spin direction (also called spin for short) of a particle is an important intrinsic degree of freedom.

Wolfgang Pauli was the first to propose the concept of spin, but he did not name it. In 1925, Ralph Kronig, George Uhlenbeck, and Samuel Goudsmit suggested a physical interpretation of particles spinning around their own axis. The mathematical theory was worked out in depth by Pauli in 1927. When Paul Dirac derived his relativistic quantum mechanics in 1928, electron spin was an essential part of it.

There are two types of angular momentum in quantum mechanics: Orbital angular momentum, which is a generalization of angular momentum in classical mechanics ($L=r\times p$), and spin, which has no analogue in classical mechanics. Since spin is a type of angular momentum, it has the same dimensions: J•s in SI units. In practice, however, SI units are never used to describe spin. Instead, it is written as a multiple of the reduced Planck constant ħ. In natural units, the ħ is omitted, so spin is written as a unitless number.

[1] It is worth noting that the intrinsic property of subatomic particles called *spin* and discussed in this article, is related in some small ways, but is very different from the everyday concept of spin, for example, as used when describing a spinning ball. *Spin*, as used by particle physicists in the quantum world, is a property of subatomic particles, which has certain qualities and obeys certain rules.

3.2 What is spin?

Since spin is not proportional to the charge or to mass, it could be related to another quantity. One of the most adapted quantity is the shape of the wave when the particle is moving (see Part 2: Wave-Particle Duality). Here we explain the idea.

In figure 3-1, the two particles, an electron and a neutrino, go towards the reader. On the left side (A), the two particles are motionless, i.e. in their corpuscular form. The spin doesn't exist. On the right side (B), these two particles are moving as waves, as explained in Part 2. So, the immediate idea is that spin could be a simple ratio (relative to the reduced Planck constant ħ), like |H/L|, the height (H) and length (L) of the wave.

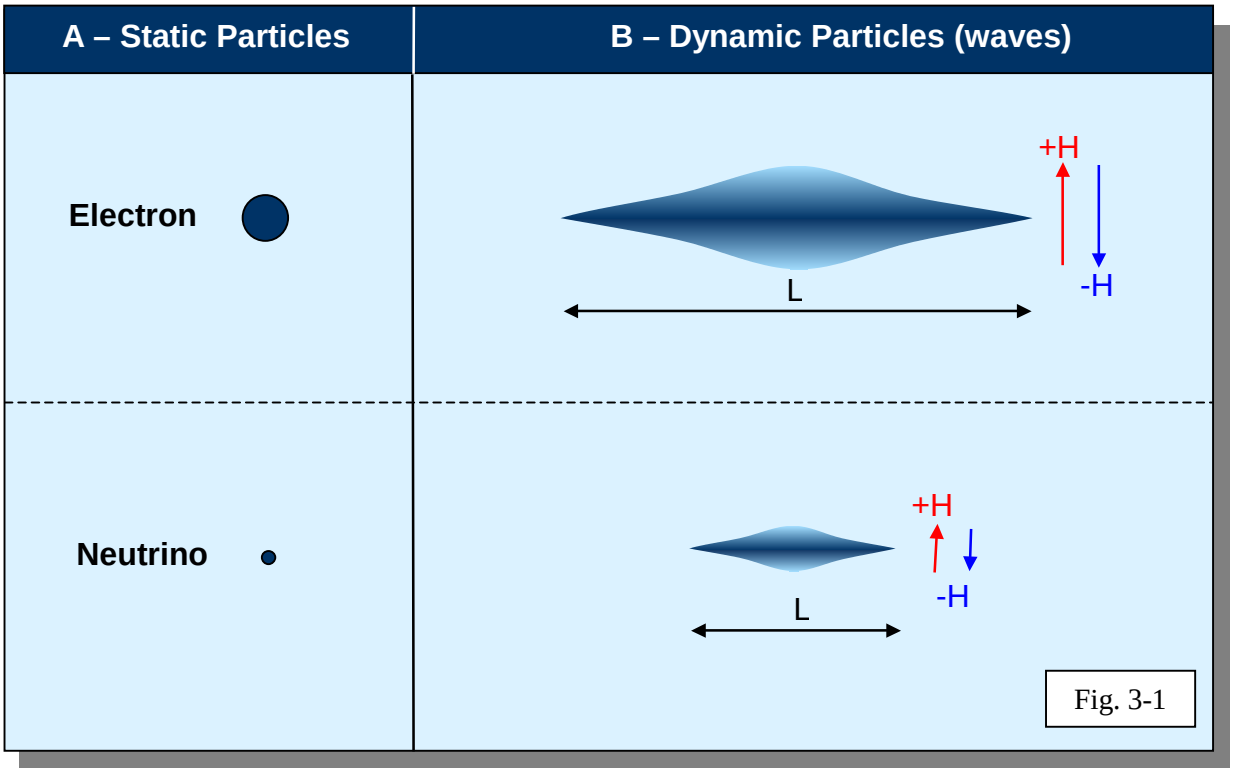


Fig. 3-1

If this point of view is correct, the spin would not be a value attached to any particle but rather a value attached to the movement or to the mode of propagation of the waves. More precisely, the spin would be a direction of polarization of sCells. In that way, we could expect that the projection of spin over a direction gives two values, +H/L and –H/L.

This point of view also means that any motionless particle can't have a spin. In other words, the theory described in this document predicts that **the spin exists only when the particle is moving**, i.e. only when the particle is in its waveform. However, if the particle is moving at low speed, its form is between a corpuscle and a wave and we could have intermediate states, such as those of gluons (crisis of the proton). In such a case, the spin could have a different value, for example 1/4 instead of 1/2 (this suggestion must be considered with great care).

This approach may be illustrated by the following examples (fig. 3-2).

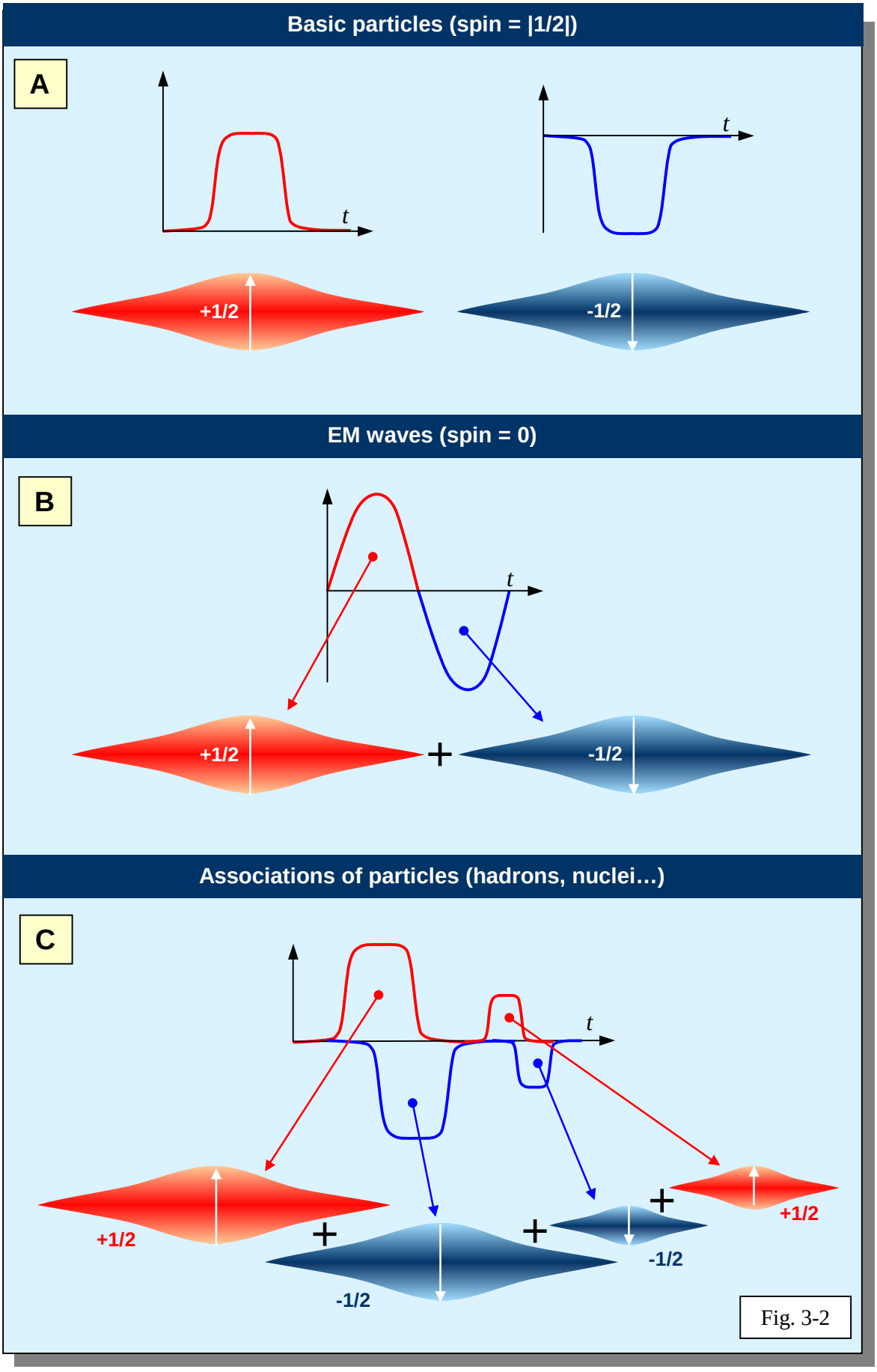

Basic particles (spin = |1/2|)
A
t
t
+1/2
-1/2
EM waves (spin = 0)
B
t
+1/2
+
-1/2
Associations of particles (hadrons, nuclei…)
C
t
+1/2
+
-1/2
+
+
+1/2
-1/2

Fig. 3-2

Three cases must be considered:

Case A: Basic particles. The spin is 1/2 in absolute value. The projection of the spin over an axis depends of the polarization of sCells.

Case B: EM waves (bipolar polarization). The spin of a half-period cancels each other.

Case C: In some cases, we have generally a set of half-periods. For example, a nucleus is moving as a complex set of waves (quarks, electrons…) and their individual spins can be added or cancelled. This also depends on the overlap of the individual waves.

3.3 A first confirmation

The point of view here described seems already be confirmed by at least one experiment: the Bose-Einstein Condensat. For example, Helium atoms become superfluid at –273°K. At this temperature, Physicists suppose that a superposition of states occurs, but this is only a theory.

This phenomenon has a more simple, logical, and credible explanation.

Since we suppose that spin exists only when the particle is moving, spin must theoretically disappear at –273°K. It means that the Pauli Exclusion would not exist anymore at this temperature. To date, no experimentation has been done in a really absolute 0° temperature but it is probable that orbitals are completely disorganized. For example, instead having the two first "n" layers with 2 and 8 electrons, it is possible to have an unique layer n1 with 10 electrons.

It would be interesting to conduct experimentations in that way.

3.4 Rule of addition of spins

The rule of addition of spins has been devised taking into account the experimentations conducted since 1925. This theory is applied with success in a large majority of cases (hadrons, nuclei…), but extrapolation of this rule to all the components of physics without any reservation is highly debatable for the following reasons:

- **Nature of spin:** It is not possible to create a reliable theory concerning spin since the real nature of this fundamental characteristic property of elementary particles is unknown.

- **Extrapolation of spin:** The rule of addition of spins applies in most cases, but this does not mean that it applies in all cases. Any extrapolation toward the quarks or other particles may produce debatable results since our knowledge of the nature of these components, as our knowledge of the spin, is very poor. To date, no one knows exactly the constitution of quarks, or why their charge is a multiple of 1/3, or while the spin of the proton is not in accordance with this rule of addition or quarks (proton spin

crisis)[1]. More generally, we have an excellent mathematical knowledge of the particle's behaviour but we are still not able to answer the fundamental questions concerning the basic phenomena: What is the charge? mass? gravity? spin?....

- **Overlap of waves:** Moreover, the spin seems to be a function of the overlap of waves. As we know, molecules and atoms are much larger than protons or quarks. When these elements are moving, the overlap of their waves is different. Therefore, we may get erroneous results when extrapolating the rule of addition of spin toward elementary particles since we don't know exactly the wave shape of each particle, which is concerned.

To summarize, to date:

- The real nature of the spin is unknown (the definition of *"quantum value"* doesn't explain the origin of spin),
- The overlap of waves is unknown,
- The wave of a nucleus or atom is much larger than the wave of a quark,
- The nature of spacetime is unknown,
- The nature of electrons, quarks and other particles is unknown…
- Origin of charge is unknown,
- Origin of mass is unknown,
- Origin of gravity is unknown, even this quantity is not related to spin,
- Origin of electrostatic field is unknown,
- Origin of magnetism is unknown,
- The mass of quarks is measured with poor precision, even if mass and spin are two different quantities,
- Spin of the proton doesn't match with the rule of addition (see the foot note about the *"proton spin crisis"*)

…etc…

Under these conditions, is it reasonable to assume that the rule of addition of spins, which is correct in 99% of cases, can be extrapolated to all particles of physics without reservation? [2]

Of course, not. This extrapolation is hazardous in the 1% of remaining cases.

---

[1] The key question is how the nucleon's spin, whose magnitude is 1/2ħ, is carried by its constituent partons (quarks and gluons). It was originally expected before the 1980s that quarks carry all of the nucleon spin, but later experiments contradict this expectation. In the late 1980s, the European Muon Collaboration (EMC) conducted experiments that suggested the spin carried by quarks is not sufficient to account for the total spin of the nucleons. This finding astonished particle physicists at that time, and the problem of where the missing spin lies is sometimes referred to as the "proton spin crisis". Experimental research on these topics has been continued by the Spin Muon Collaboration (SMC) and the COMPASS experiment at CERN, experiments E154 and E155 at SLAC, HERMES at DESY, experiments at JLab and RHIC, and others. Global analysis of data from all major experiments confirmed the original EMC discovery and showed that the quark spin did contribute about 30% to the total spin of the nucleon. A major topic of modern particle physics is to find the missing angular momentum, which is believed to be carried either by gluon spin, or by gluon and quark orbital angular momentum. The gluon spin components are being measured by many experiments. Quark and gluon angular momenta will be studied by measuring so-called generalized parton distributions (GPD) through deeply virtual compton scattering (DVCS) experiments, conducted mainly at JLab. As a result, extrapolating the spin to the protons and quarks at rest is very speculative.

[2] About spin, the Physics Community thinks that the definition "a quantum value" is sufficient to explain spin. In this chapter we do not pretend to explain spin but at least we would like to have a more rational explanation than *"a quantum value"*. About spin, as in everyday life, we should always bear in mind this remarkable Mark Twain's citation: *"What gets us into trouble is not what we don't know. It's what we know for sure that just ain't so"*.

For all these reasons:

The rule of addition of spins is an hazardous extrapolation in 1% of cases and can't be retained as a valid objection

3.5 Consequences

If this theory about spin is correct, it must have two consequences, which are easily understood examining the previous figures (the second consequence is also covered in Part 2):

- **Spin disappears if the particle or association of particles is motionless**
- **Neutrinos would have a very weak charge**

4 The Photon

In chapter 2, we have considered the wave-like behaviour of EM radiations. Here, we study its particle-like behaviour, i.e. the photon.

4.1 Justification of the photon

The following experimentations seem to confirm the existence of the photon:

- **The Planck Quantum** is a physical reality and not just a mathematical concept. This unit absolutely must be preserved.
- **Experimentations** (photoelectric effect…) also tend to prove that the photon exists. The interpretation of these experimentations is, however, debatable.
- **The EM wave decrease.** This decrease in $1/r^2$ makes it impossible for a wave to exist far from its origin. Only the photon concept would resolve this paradox. This chapter contains a new explanation of this phenomenon.
- **Vacuum propagation.** This enigma is not relevant since EM waves can be propagated in spacetime, and spacetime is present in a vacuum. This problem is covered in chapter 1.

Notes: In 1905, when Einstein explained the PE effect using the Planck Quantum, the atom's internal configuration was unknown. Rutherford thought that the atom was like an "English pudding". In 1905, physicists didn't know that the atom had a nucleus. Einstein thought that the poor efficiency of the PE effect was in relation to the probability that the photon had to meet an electron (in 1905, electron distribution was described as being like raisins in a pudding). Later on, physicists demonstrated that the electron was: 1/ infinitely smaller than the nucleus and, 2/ a huge distance from it, proportionately. This means that the collision probability between a photon, if it exists, and an electron is practically null. However, and paradoxically, the yield was increased to attain more than 99% today with nanotechnologies. This paradox remains a mystery. The cross section calculations and other theories about the photon are highly debatable, not from their mathematical point of view, but, in their interpretation, if we regard the photon as a particle. A wrong reasoning can lead to wrong results. For example, we know three different theories of mass and gravity which are mathematically verified: the Higgs boson, Superstrings (E. Wirren) and the Spacetime Model (Part 1). At least two of these three theories are wrong, despite the fact that they are all three mathematically verified. It means that any theory, which is not fully explained with logic and good sense, must be considered with great care (including the present theory, "the Spacetime Model"). This is the case of theories concerning the photon and the PE yield, because their explanation is not consistent and remains a true mystery.

4.2 Inconsistencies of the photon

- **Its velocity:** The photon's velocity is 300 000 km/s, no more, no less. This is illogical because if the photon is a particle, it may travel at any speed. What would we think of a vehicle moving at only one speed, 100 km/h, no more, no less?
- **Its impossibility to stop:** Why can't the photon stop? In the preceding example, what would we think of a vehicle (a particle), that can't stop? This remark only applies when considering the photon as a particle[1].
- **It's massless**: If the photon is a particle, how does one explain its lack of mass?
- **Its acceleration**: How the photon can be immediately accelerate from 0 km/s to 300000 km/s?
- **The causal principle**: The photon concept continuously violates this principle. Some experimentation needs a particle-like behaviour, such as photo-electric, and other a wave-like behaviour, such as the Young Slits. It is obvious that the photon, once emitted, has not the ability to predict its future. It does not know its own destiny. More precisely, it does not know if the experimenter needs a particle-like behaviour for his experimentation, or a wave-like behaviour. Since the two behaviours do not simultaneously exist, this prediction causes a real scientific problem. It is also a problem of good sense: NO ONE CAN PREDICT THE FUTURE.
- **Its constitution**: What is the constitution of the photon? No one knows…
- **Displacement of a charged particle** (paragraph 1.7): How can a charged particle that is moving emit other particles called "photons"? It is like a stone falling into water emitting tiny stones… This concept is disconcerting.
- **Orbital change of an electron** (paragraph 1.8): In the same way, no one can explain how an electron, moving from one orbital to another, can emit tiny particles called "photons".
- **EPR:** In this experimentation, it would be necessary for the photon to have a kind of thought transference with another photon at a distance of several meters. This view is also disconcerting.
- **Young Slits:** Here too, the photon poses a serious problem of logic and good sense.

These ten inconsistencies - and probably more - mean that the photon concept, despite the fact it has been used since 1905, must be seriously revised.

4.3 Decrease in $1/r^2$

We pointed out that EM waves are propagated gradually in sCells. At a distance "r" from the emission source, it arrives at a moment when the charge contained in a sCell becomes too weak to be propagated in the next adjacent sCell. This limit is, in fact, a quantum. But this is not exceptional since all objects are quantified, in one way or another. In accordance with Max Plank, the quantum is a necessity.

[1] Lene Hau (Harvard University) explains how she stops light in one place then retrieves and speeds it up in a completely separate place. http://www.photonics.com/Article.aspx?AID=28520

The charge, which passes from one sCell to another, must be higher than this quantum. Under this condition, how will an EM wave react when the charge transmitted in the sCells approaches this quantum? There are only two possibilities:

- The charge disappears completely. The EM wave dies.
- The charge remains grouped. In this case, the EM wave ceases to decrease.

The first possibility is not credible because, in Nature, nothing is created, nothing totally disappears. Therefore, the second possibility is more reasonable.

4.4 The "quantified wave"

The various steps of the wave during its travel, from its creation to a distance away, are represented on figure 4-1.

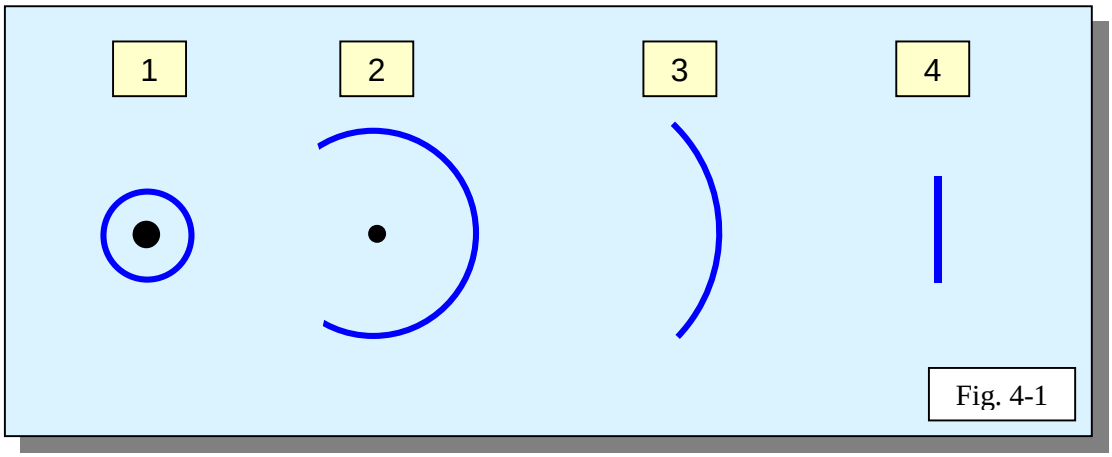


Fig. 4-1

- **Step 1**: The wave is created in a 360° space. Note that the angle is not necessarily 360° and may have any other value.
- **Step 2**: At some distance from its source, the decrease in $1/r^2$ of the EM wave reaches its quantum. The spacetime density of the wave is too weak to continue to decrease while propagating from sCells to sCells. The wave has only one solution: to break at an unspecified place to remain grouped.
- **Step 3**: The distance increases, and the arc of the circle decreases proportionally.
- **Step 4**: The wave is now very far away from its source and its curvature becomes practically a segment or, in quantum mechanics terms, a "wave pack". The EM wave always keeps its wave behaviour while remaining grouped. It can thus travel billions of light-years as a photon would, but as a small "piece of wave" representing the whole wave.

This is what we call a “**quantified wave**”.

So, when we see galaxies, our eyes do not perceive a photon but a "quantified wave". During all its travel, this wave remains grouped[1].

Let's now consider the different phases "emission – propagation – reception" of a quantified wave.

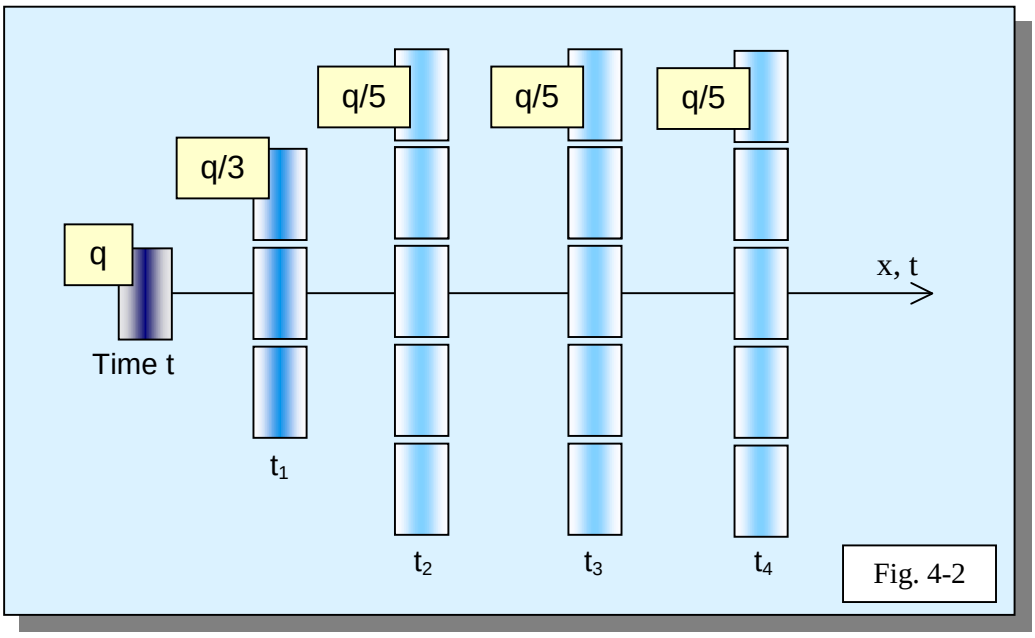
4.5 The emission

EM radiations are always spacetime movements, or EM waves. The photon, as a particle, doesn't exist.

4.6 The propagation

Once emitted, an EM radiation keeps its waveform. Beyond a certain distance, since the charge can't go under the quantum level, there is a possibility that an "ordinary wave" become a "quantified wave".

Figure 4-2 shows an EM wave that is propagated gradually in sCells. The charge is q at the source level, and is divided by 3, then by 5. In figure 3-2, the quantum q/5 is reached at Time t_2. The EM wave doesn't continue decreasing over time t_2.



[1] On earth, we have a similar phenomenon: capillarity.

During its travel, the EM radiation keeps its waveform.
It can, nevertheless, be quantified if the distance requires it.

4.7 The reception

When a part of the wave inside a sCell meets an element, atom or something else, an interaction may take place. The sCell is emptied of its charge. Gradually, it empties all other adjacent sCells forming the wave (fig. 4-3).

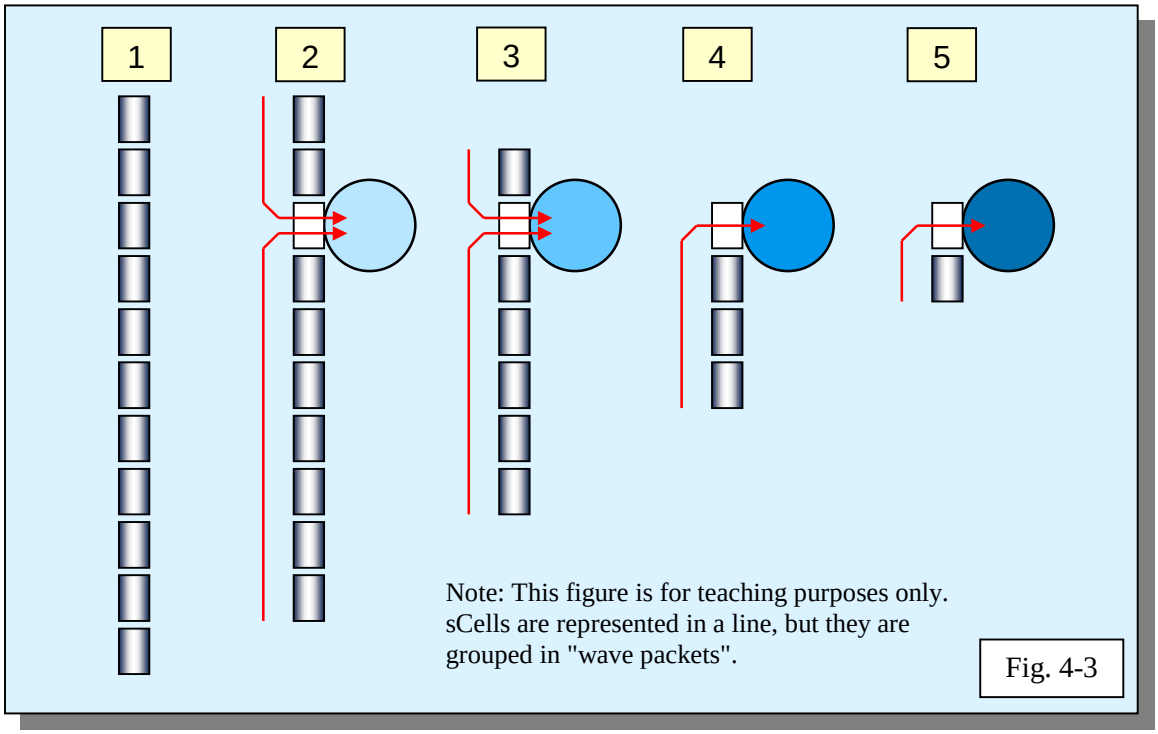


Fig. 4-3

- **Phase 1**: The EM wave propagates normally.
- **Phase 2**: It meets an element that absorbs its energy. The sCell in contact is emptied. This element is not necessarily in the centre and can be anywhere at the front of the wave.
- **Phases 3 and 4**: The EM wave continues to be absorbed by the element. The sCells are gradually emptied, step-by-step, sCell-by-sCell.
- **Phase 5**: The EM wave is almost completely absorbed by the element of interaction.

An identical process exists on Earth (fig. 4-4). The EM wave is replaced by a trickle of water. The particle, which absorbs the wave energy, is replaced by a blotting paper. The trickle of water is absorbed by the blotting paper at the place of interaction, or measurement.

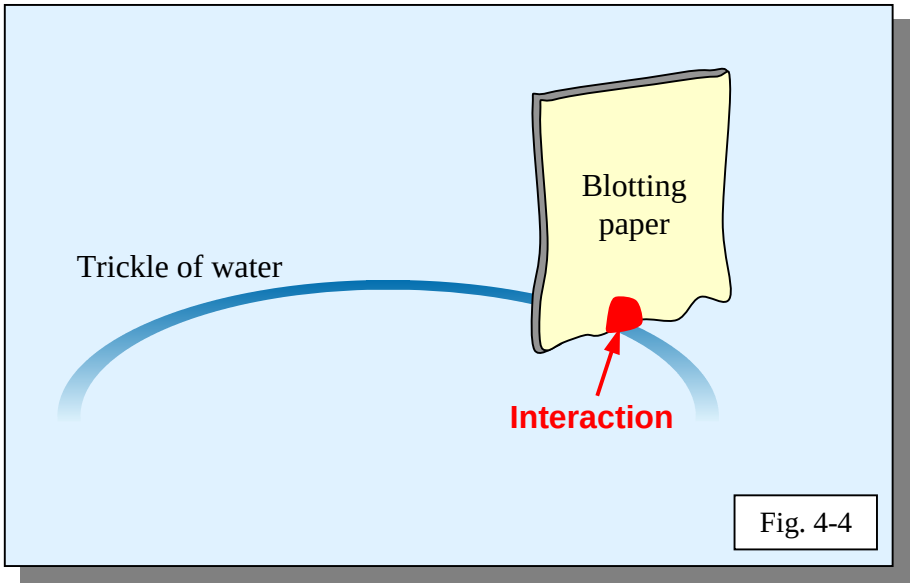


Fig. 4-4

To summarize:

The interaction takes place with a kind of "virtual photon", which is the mathematical expression of an EM wave.

- **This wave may be quantified if the distance requires it.**
- **This wave is absorbed at the place of measurement.**

5 Applications

This chapter covers applications about the photon-wave duality, such as the Young Slits or the EPR.

5.1 Validation of the proposed theory

How can we prove that the photon is the mathematical expression of "quantified waves"?

We already have multiple proofs.

- The constant speed of light, 300 000 km/s, proves that we are in front of a wave and not of a corpuscle. The light can't be accelerated, can't be stopped, has a constant speed… These characteristics are not those of corpuscles.
- Saying that the "mass" of the photon is null is inconsistent. Only a wave has a null mass, not a particle.
- The displacement of a charged particle ($\Delta q/\Delta t$) can't emit tiny particles called "photons". This does not make sense scientifically. If this displacement produces waves, this enigma becomes consistent.
- …. and much more inconsistencies …

If we replace the word "photon" by "quantified wave", we solve all of these inconsistencies, and many more

5.2 The Experimenter

Let's consider that we are in a boat, in the middle of the sea. If the boat starts to pitch, we don't know if it was hit by a stone or by a wave of water.

Likewise, in quantum mechanics, the experimenter is unable to say if he measured a photon (= stone) or an EM wave (= water wave).

The simple fact of measuring the EM wave produces the disappearance of it, giving the illusion of having measured a virtual "photon-like particle"

This phenomenon is quite simple to understand by returning to our blotting paper of fig. 4-4. Putting this blotting paper anywhere on the trickle of water produces the disappearance of it. In spacetime we have the same phenomenon. The experimenter believes that, at the red point of interaction on fig. 4-4, he measures a photon but in reality, he measures a quantified wave.

5.3 Young Slits

To understand this puzzle, it is necessary to forget the photon concept and to consider that the whole experimentation uses only (quantified) waves.

Let's imagine a group of five EM waves (fig. 5-1). These waves pass by two slits. Two detectors, right (R) and left (L), count the number of "photons" passing by each slit.

When a wave reaches an atom of a detector, the energy included in sCells is emptied by a PE effect, Compton Effect, or anything else. The sCells are immediately emptied at the speed of 300,000 km/s. This speed is so high that a wave can't activate two detectors at exactly the same time. In other words, a wave may reach the two detectors at approximately the same time **but activates one, and only one at a time**. A very short Δt (a fraction of pS) is sufficient to make the difference.

However, there is a very slight probability, nearly zero, that the two detectors are activated at the same time. In this case, it is logical to think that the energy of the incoming wave is split. For example, a 511 KeV wave issued from an e+e- annihilation may be detected as two waves of 200 KeV and 311 KeV.

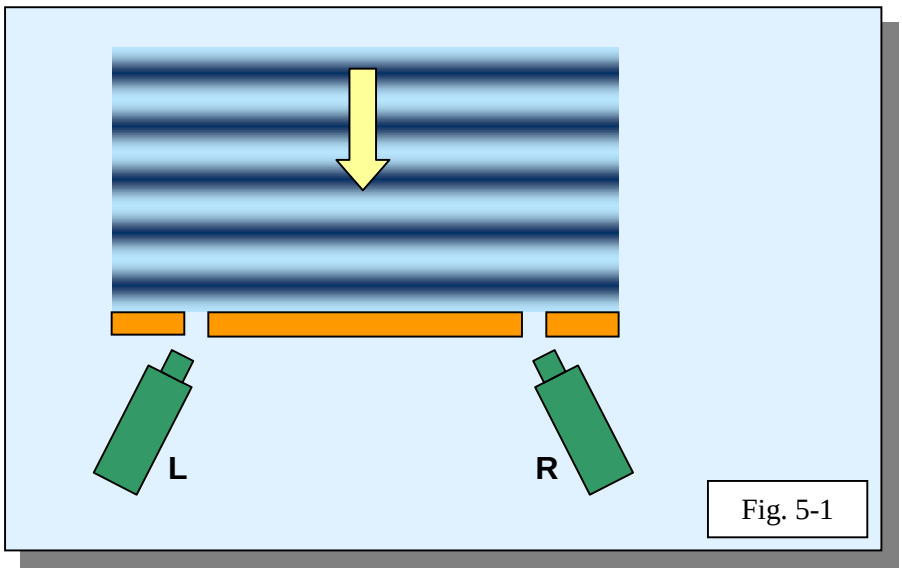


Fig. 5-1

Examining the distribution of the measured waves with a coincidence system must highlight this phenomenon, which could be additional proof that we measure waves, not photons.

To better understand this principle, let's replace the five waves of fig. 5-1 by five trickles of water (in blue) and the two detectors by two blotting papers (fig. 5-2). A trickle would be absorbed by the first blotting paper reached. The first wave is absorbed by the left blotting paper at the red point. The other waves will be absorbed at the green points, due to chance. In any situation, it is obvious that when a trickle has been absorbed by one blotting paper, there is no water left for the second blotting paper to absorb it.

In spacetime, we have an identical phenomenon. *The experimenter thinks he is counting the number of photons whereas he is counting the number of waves absorbed by each detector.* As explained, photons don't exist per se. Photon must be replaced by quantified waves, here the trickles of water. When the quantified wave passes through the two slits, it naturally produces interference fringes that lead to a diffraction pattern (here not represented).

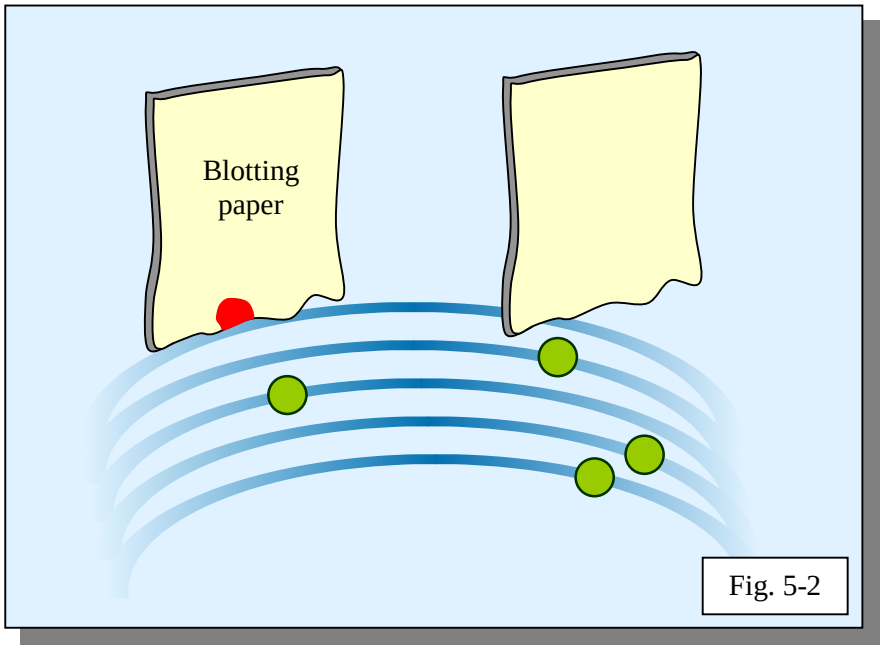


Fig. 5-2

5.4 The Heisenberg Uncertainly Relation

Everyone knows the formulation of the Heisenberg (Nobel Prize – 1932) Relation but no one explains it. In the framework of the proposed theory, its explanation, here with an electron, becomes very simple and gives additional argument in favour of this new theory.

Quantum Mechanics: The electron passes through point A (fig. 5-3) but has a probability to pass through points B or C. This phenomenon does not make sense scientifically, but it is a reality.

Proposed theory: The wave-particle duality (see Part 2 "Constitution of Matter") states: *"When the particle is moving, it becomes a wave"*. Therefore, points A, B and C are all

crossed by the electron-wave. We are facing the same phenomena as the Young Slits[1] explained in the preceding paragraph. As in our example of blotting paper, the wave may be absorbed at point A or, with a lower probability, by points B or C.

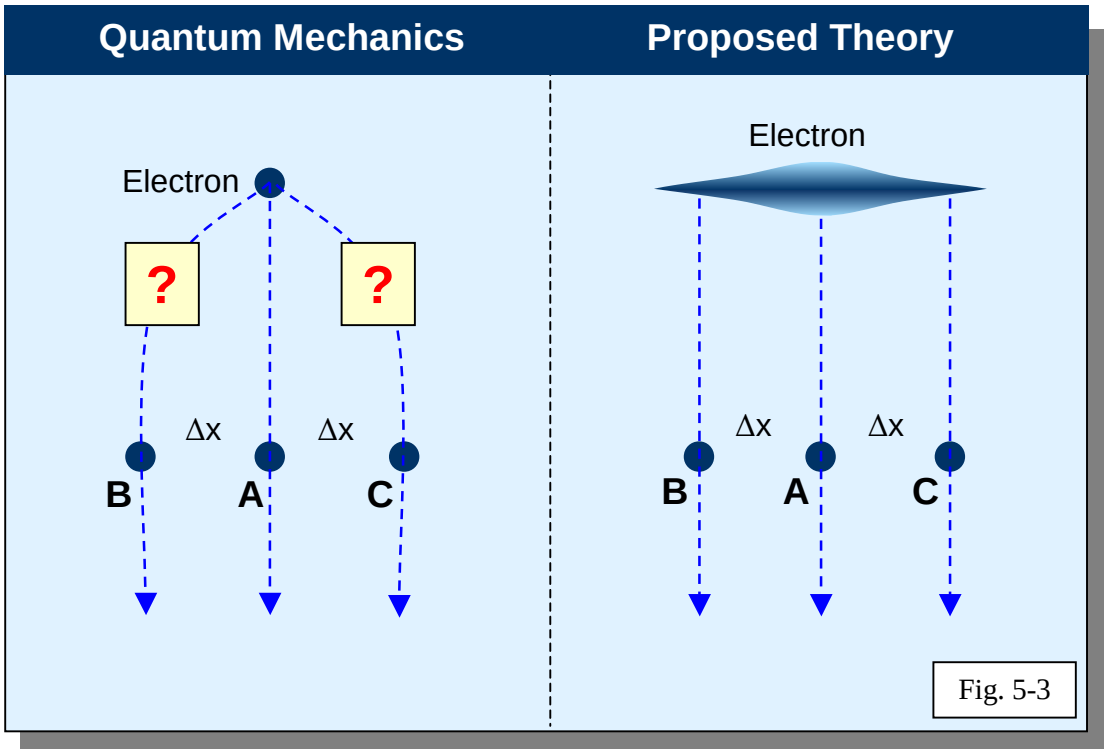


Fig. 5-3

Note: With regard to the Uncertainly Relation, we may suppose that the shape of the wave packet depends on its speed. Taking into account experimentations and the Heisenberg Theory, the immediate deduction is that the wave becomes more conical as its energy increases (Gauss Curve for example). This has no effect on the principle here described. On the other hand, the Heisenberg Relation may have Δp or Δt. The above explanation has been deliberately simplified for teaching purposes.

5.5 EPR (proposal)

The following description of the EPR paradox has been deliberated simplified for teaching purposes. In reality, the measurement is done on spins of particles.

We have a source that emits electron–positron pairs, with the electron sent to destination *x*, (fig. 5-4, next page), and the positron sent to destination *y*. In all cases, if x detects a vertical polarization (blue), y will detect the opposite, i.e. a horizontal polarization (red). In other words, one electron "feels" which axis the other is having its polarization measured along. How does "y" know which way to point if "x" decides (based on information unavailable to "y") to measure "x"? The Copenhagen interpretation rules that say the wave function "collapses" at the time of measurement, so there must be action at a distance (entanglement), or the positron must know more than it's supposed to (hidden variables).

[1] Although it amounts to the same thing, it would be wise to compare the Uncertainly Principle to the Davisson-Germer experimentation rather than to the Young Slits Experimentation.

Trying to understand the EPR mechanism is impossible with good sense with the traditional concept of photon. To understand it, it is necessary to replace photons by quantified waves.

Two waves, "A" and "B", are emitted with a perpendicular polarization of the one compared to the other. These waves are propagated in sCells and are "catalysed" in x and y.

If it has been decided to take the vertical wave "A" (in blue) in point x, it will remain the horizontal wave "B" (in red) for point y, or the converse. Whatever the wave taken in x, it will always remain the complementary wave in y.

If the two measuring instruments, x and y, are isolated by something to avoid interference such as a concrete or a metal wall, the wave still exists because it is propagated in spacetime, and spacetime is present everywhere. However, it must be pointed out that the EM wave may be slowed down or absorbed by molecules of the wall.

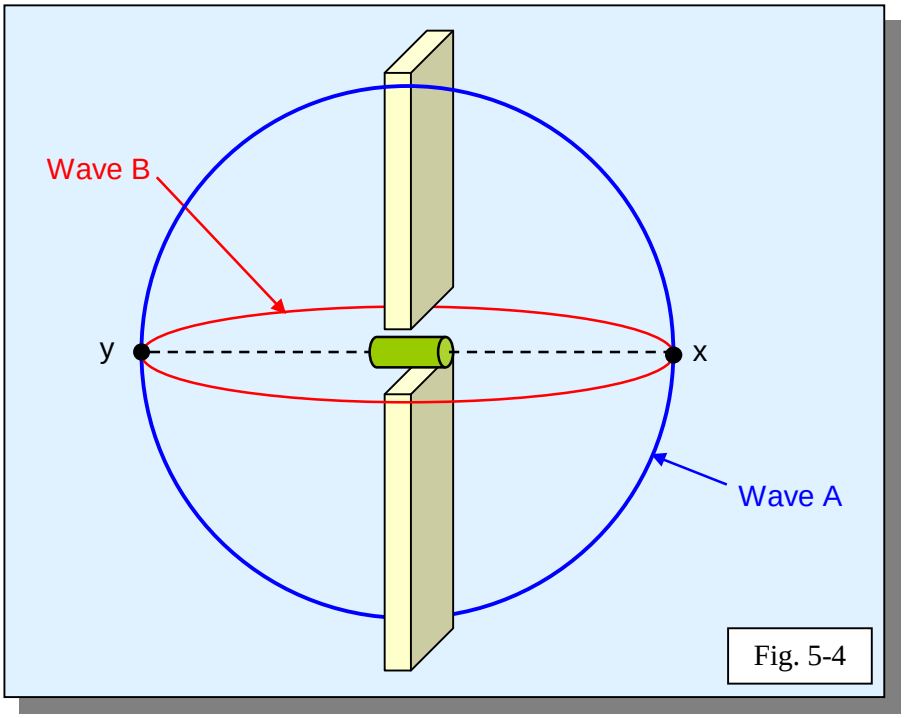


Fig. 5-4

From this point of view, the Spacetime Model predicts that the anomaly of EPR disappears if the two points of measurement, at 180°, are located far from the point of emission. The reason is quite simple. In such a case, traditional EM waves become quantified EM waves and the relation between the two waves disappears.

The anomaly of EPR does not longer exists with quantified waves, if the points of measurements are far from each other.

5.6 Conclusions

The following table compare the photon and the quantified wave concepts.

Problem	Explanation
Planck Quantum	*Replacing the photon by a quantified wave doesn't modify the Planck Quantum. This unit is perfectly logical and must continue to exist.*
Decreased in $1/r^2$	*This problem is solved by the "quantified wave". See section 2.2*
Propagation in a vacuum	*This question becomes meaningless since this problem has been solved in chapter 1.*
Only one velocity, "c"	*The fact that the photon can move at only one speed, c, does not make sense if it is considered as a particle. Indeed, any particle can move at any velocity. Since the photon is a mathematical representation of a wave such as a vector, the question about its speed becomes meaningless.*
The photon acceleration	*When an EM radiation is emitted from a particle moving at a speed of 280.000 km/s, what is the origin of this additional 20.000 Km/S speed? Solution to this enigma lies in (quantified) EM waves.*
Causal principle	*EM radiations are nothing but waves. Since we have no alternative about duality, i.e. a wave is a wave and not a photon, the choice between wave and particle is meaningless. The fact that the photon is interpreted as a mathematical object doesn't conflict with this principle.*
Matter of photon	*Since the photon doesn't exist, this question is meaningless.*
Orbital change	*It is impossible to explain how an electron can emit photons during its orbital change. In reality, the electron produces spacetime movements, i.e. EM (quantified) waves.*
Displacement of a particle	*It is impossible to explain how a charged particle, which is moving, can emit photons. Reality is that a moving particle produces spacetime movements, i.e. EM (quantified) waves.*
e+e- pairs creation and e+e- annihilation	*If the EM radiation is made of photons, the e+e- pair creation, as the e+e- annihilation, is a true mystery (Part 2 "Constitution of Matter"). Only an EM wave, quantified or not, can explain this enigma.*
Young Slits	*This enigma is explained. See § 5.3*
Uncertainly Relation	*This enigma is explained. See § 5.4*
EPR	*This enigma is explained. See § 5.5*

6 Waves and Complements

This chapter gives additional explanations concerning the role of (quantified) waves in the Spacetime Model, taking into account the equality Mass = Closed Volume developed in Part 1.

This chapter is not fundamental and is included primarily for the benefit of non-physicists.

6.1 EM waves: Simplified explanation

Here is a simple experiment explaining the EM wave emission produced by an orbital change in atoms. You can do it yourself in your bathtub. This example highlights that a change of orbital produces waves, not photons.

> *Open your hand beside your lengthened legs and wait until the water is still. Then, suddenly, close your hand. You will immediately feel a wave being propagated on your entire body.*

Closing your hand produces a wave of water, which carries some energy. We have exactly the same phenomenon in spacetime. An orbital change of electron produces a movement in spacetime, which is an EM wave, not a photon.

6.2 EM waves: Detailed explanation

A second example is provided in figure 6-1.

A perforated balloon is immersed into a container filled with water. The holes allow water to infiltrate the balloon. If its volume varies from V1 to V2 or the converse, a wave of water is produced. However, since the balloon is perforated, the quantity of water remains unchanged.

The volume of water doesn't increase or decrease since these movements in water are bipolar (pressure + depression).

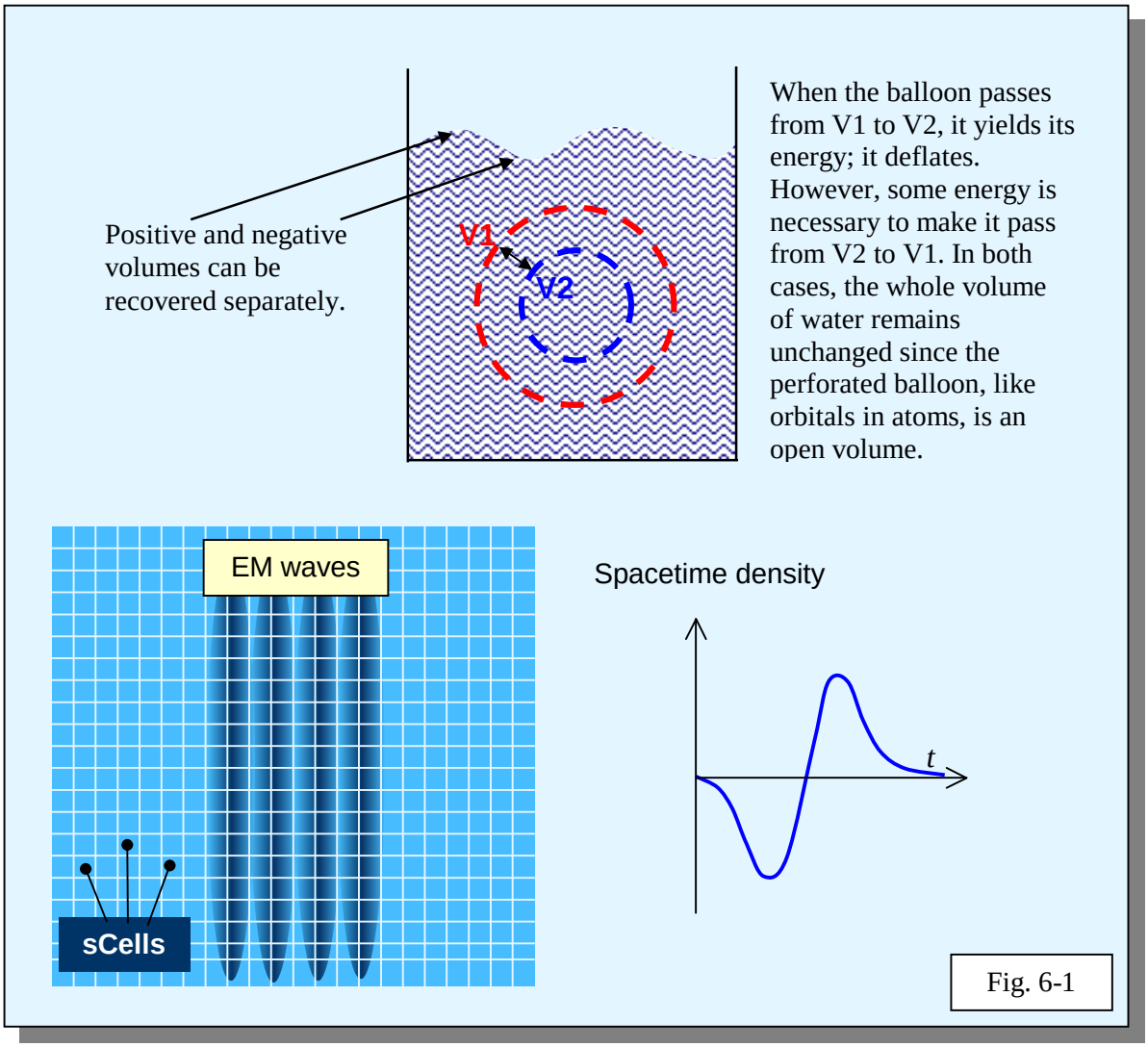


Fig. 6-1

6.3 Matter waves: simplified explanation

A balloon with a volume V1 is immersed into a container filled with water (fig. 6-2). Using a pump "P", a vacuum is made, instantaneously, inside the balloon whose volume becomes V2.

The difference ΔV = V1 – V2 of the balloon volume produces a wave.

When the wave reaches the surface, it is transformed back into a volume of water ΔV identical to the decrease of the balloon's volume ΔV.

This experiment describes exactly how a mass, more exactly a closed volume, can be transformed into a wave, also a volume, and may be transformed back into a mass, which is another volume, and so on.

Mass → waves
Does not make sense

Closed volume (particle) ↔ volume (wave)
Easy to understand, make sense, consistent

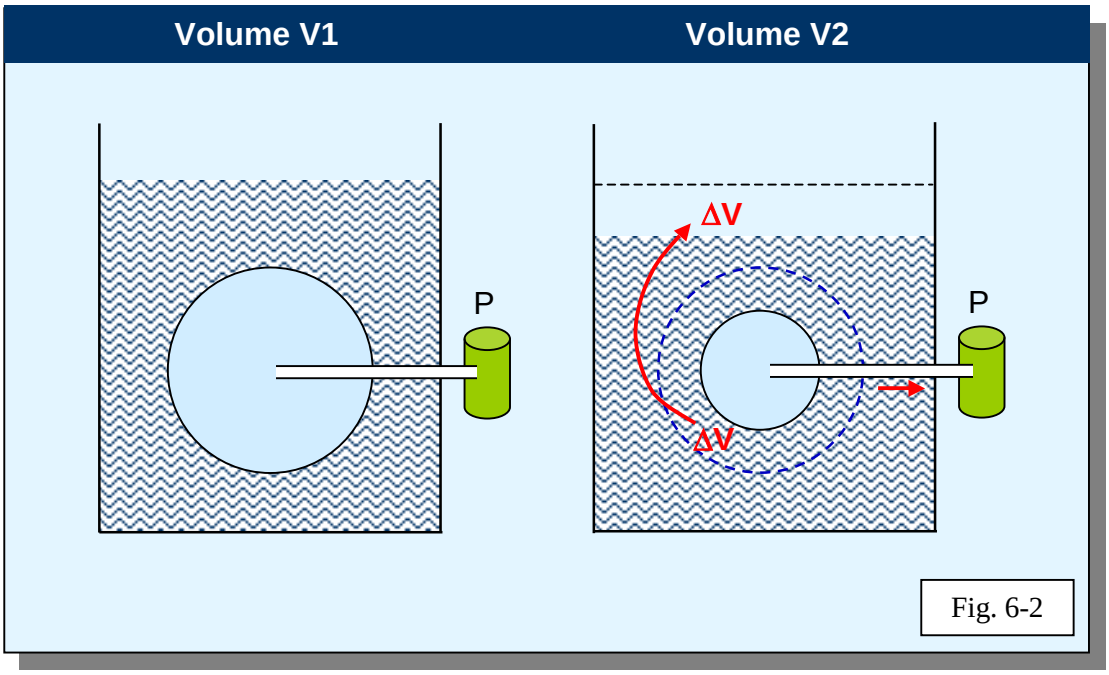


Fig. 6-2

6.4 Matter waves: detailed explanation

The figures 6-3 and 6-4 show negative and positive matter waves. That which is called a “matter-wave” is a moving particle having its charge, or spacetime density, distributed in several sCells.

When a "matter-wave" is moving, each sCell transfers to the other ones some quantity of additional spacetime, in positive or negative charges. These sCells become charged during the period of the wave and act like a "partial" electron or positron.

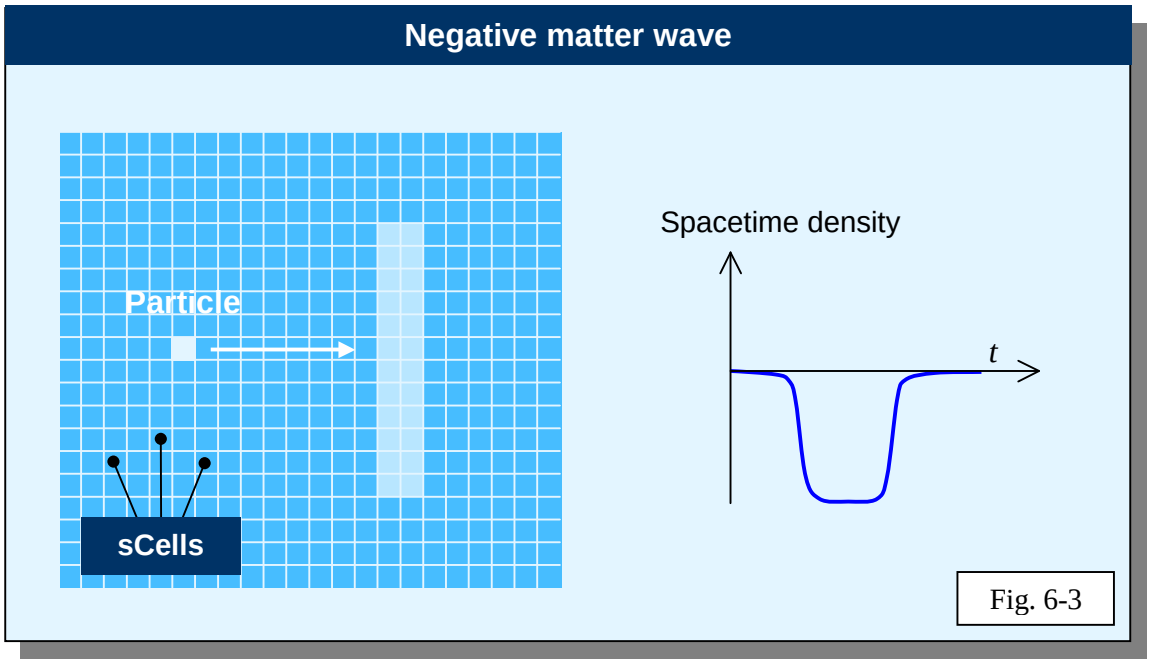
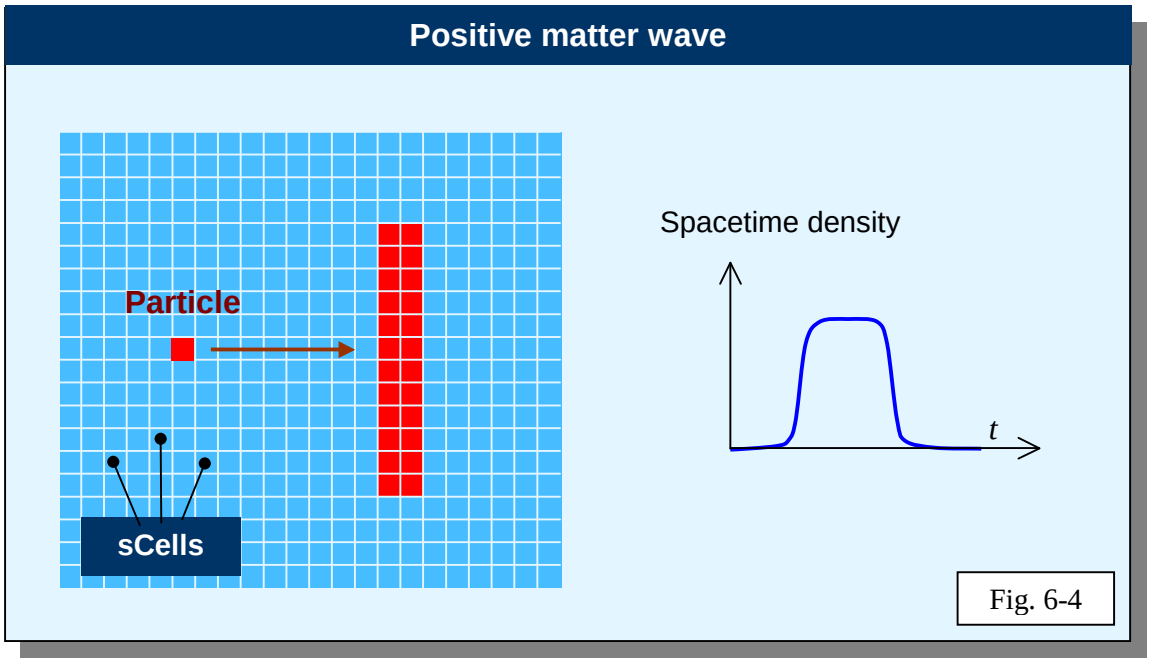


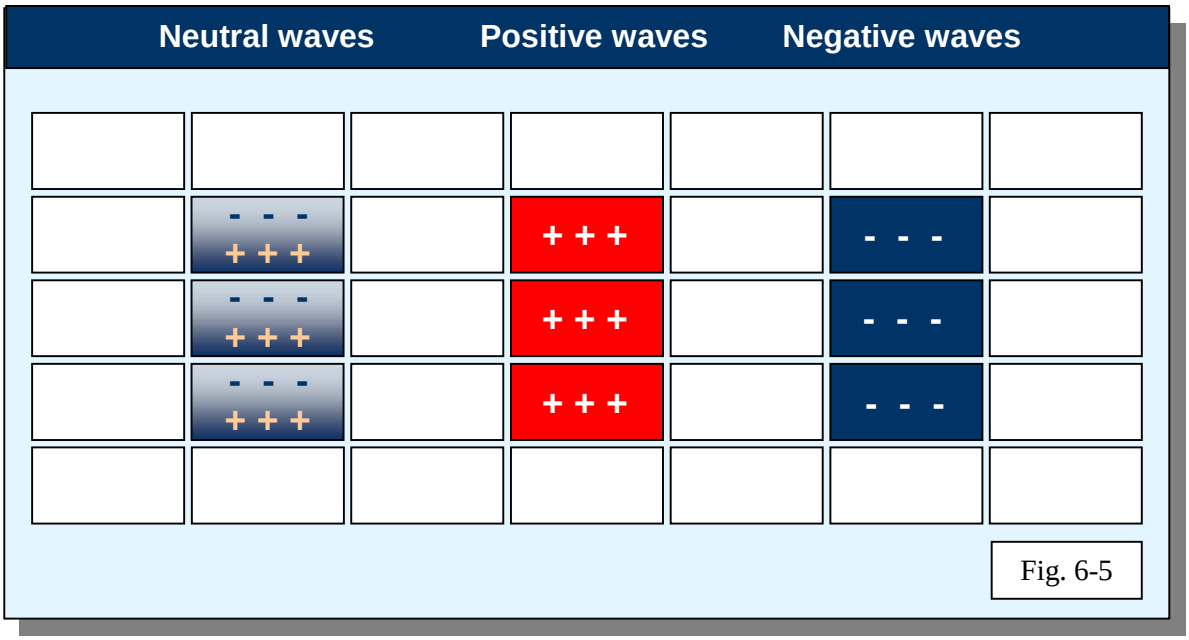
Fig. 6-3



6.5 Differences

The difference between "EM waves" and "matter waves" is only a question of charge. Let's examine the following figure 6-5.

- **EM waves**: The charge is bipolar, with positive and negative alternations. The whole charge of a group of sCells is neutral. The charge is made of positive and negative sCells but is can be distributed inside a sCell, as the figure shows. In reality, no one knows the distribution of charge in a group of sCells. The neutral charge moves gradually inside sCells at a speed of 300.000 Km/s. The charge of a sCell or a group of sCells, which is neutral, remains neutral for the full period. In this case, sCells don't get mass since they don't receive additional charge (+ or -).



- **Matter waves**: Each sCell receives, during a short period of time, an additional charge (+ or -). Since the charge is transmitted from sCells to another sCells, each involved sCell becomes charged and gets mass. Figure 6-5 shows positive and negative charged sCells. The white rectangles represents neutral sCells.

6.6 E = hν

To understand this formula with sCells, according to the equality Mass = Closed Volume, let us consider again the first experiment, which you can carry out yourself.

> *While having your legs lengthened in your bathtub, quickly close your hand. You will note that the wave is more or less pronounced according to the velocity of the movement of your hand.*

This reaction is exactly the same as the quantum phenomenon described by: E=hν or E=h/T. The shorter the period of time (or the more quickly your hand is closed), the greater the energy produced.

6.7 e^+e^- annihilation

This phenomenon is an enigma with regard to its comprehension: *"how can a mass (e+e-) be transformed into two gammas?"*.

We have already explained the e+e- annihilation in Part 2 "Constitution of Matter". We give below another explanation with sCells (fig. 6-6). Let's consider that the electron and positron are both motionless, that is to say, the magnetic component of the EM field does not exist.

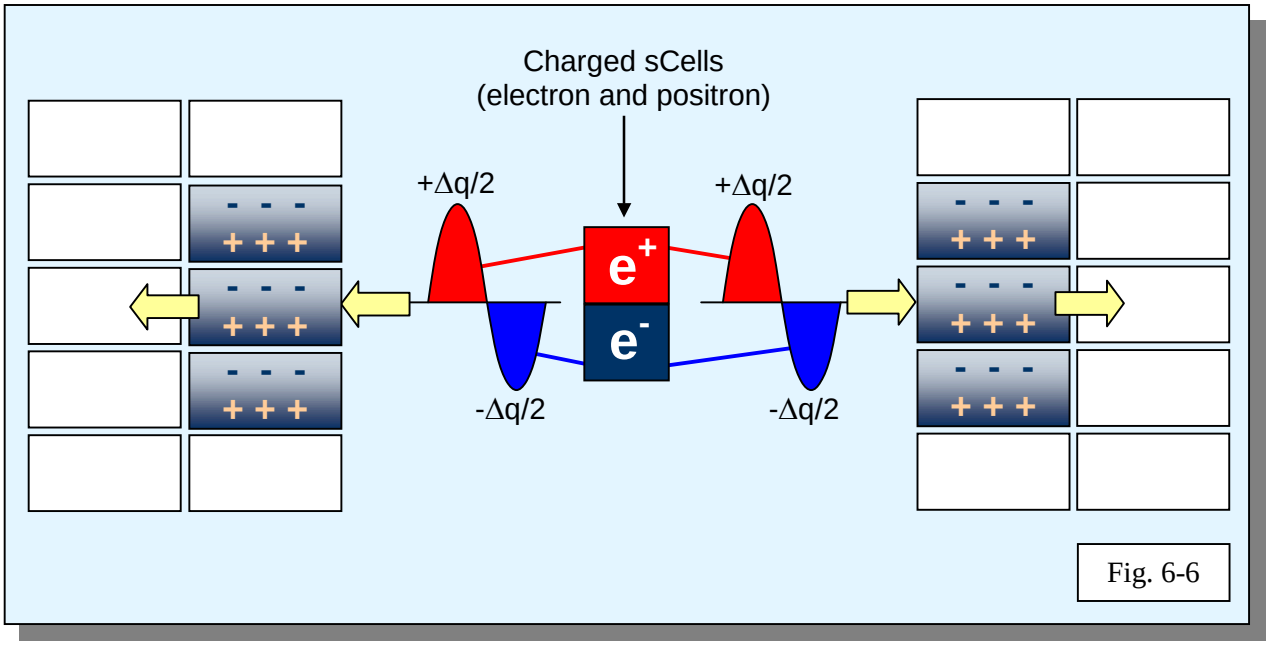


Fig. 6-6

- When an electron meets a positron, the excess spacetime in one particle moves inside the other.
- The annihilation of the two charges is assimilated to a double $\Delta q/\Delta t$. Indeed, the charge of the positron passes from +1 to 0, whereas that of the electron from - 1 to 0.
- The annihilated electron and positron become two ordinary sCells.
- This annihilation produces two movements in spacetime, or EM waves.
- These movements, resulting from the double $\Delta q/\Delta t$, are propagated gradually through adjacent sCells.
- The EM radiation will not be propagated like a photon, but like an EM wave, quantified, if necessary, called a "gamma".
- And finally, as seen in Part 2, if this gamma passes near a nucleus, it may be split into a negative and a positive part, if its energy allows.

All this process of e+e- annihilation is explained with sCells in a simple and logical manner.

6.8 Mass and energy

Before explaining the $E=mc^2$ enigma, it is useful to reconsider the mass - energy equivalence.

It is often stated that Mass = Energy. This is not exact and there is a subtlety to this equation. The dimensional quantity of the mass is [M] while that of energy is $[ML^2/T^2]$.

These two quantities are different and cannot be identified. It is like if we compare apples and nails. So, saying "Matter = Energy" does not make sense scientifically since mass and energy are two different dimensional quantities.

The $E=mc^2$ formula is homogeneous because it has another variable, c^2. This constant has the dimension $[L^2/T^2]$. The product of Mass [M] by c^2 $[L^2/T^2]$ gives indeed a correct value, $[ML^2/T^2]$, which is energy.

In other words, **a mass (or a closed volume) can produce energy, certainly, but never "Matter = Energy"**.

6.9 $E = mc^2$

This formula is fully verified using mathematics and experimentation, but no one is able to explain it using logic and good sense. However, the solution is quite simple within the Spacetime Model. Let us take again the figure 6-2 which, slightly modified, becomes the figure 6-7.

The overall process is as follows. In parenthesis and italics, the equivalent in quantum mechanics is provided:

- **Step 1:** The balloon *(the particle)* is filled with air. It doesn't have any energy.
- **Step 2:** The balloon deflates during a Δt time *("Matter" disappears, like in the e+e- annihilation)*. This decrease in volume produces waves. These waves are moving in water *(in spacetime)* and carry some energy, which is a function of Δt, at the time of the balloon's deflation *(in the same way, the wave energy is E=hν=h/T)*.
- **Step 3:** When the waves reach the surface, they are converted back to a volume *(a gamma may produce back e+e- pairs).*

It is important to note that energy appears ONLY in phase 2, when the volume is in its wave state. When the volume is in a particle state, as in phases 1 and 3, energy doesn't exist or, more exactly, we have "potential energy".

This energy comes from the speed "c" of gammas, which are the result of decays. **Only a movement can produce energy**. A motionless particle only has potential energy. In other words, the $E=mc^2$ formula simply means that energy appears only when the volume of the particle becomes waves, or gammas (fig. 6-7, phase 2).

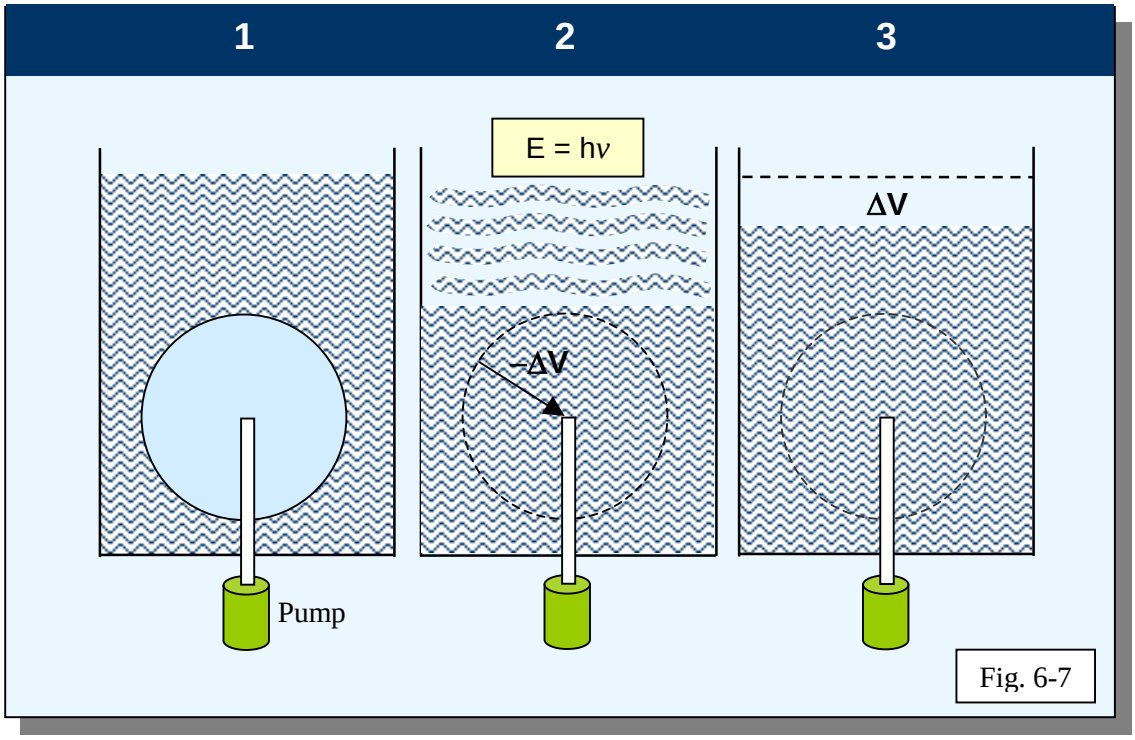


Fig. 6-7

Finally, the $E=mc^2$ formula is very simple to understand if we keep in mind these three points:

- There is a relationship between mass and closed volume (see Part 1).
- The particle may become a wave and the converse, as explained in the Wave-Corpuscle Duality in Part 2. Both, particles and waves, are made up of spacetime.
- Energy is not embedded inside the particle as we think. In our example of fig. 6-7, the balloon doesn't carry energy! A particle is an area of spacetime, nothing more. Energy appears when the particle is destroyed. This area of spacetime becomes a wave, as in the e+e- annihilation. Energy is carried out by these EM waves.

6.10 Conclusions on $E = mc^2$

- **The particle is a closed volume without energy at rest,**
- **When the closed volume disappears, waves are produced. Energy due to their speed "c" appears ($E=h\nu$),**
- **Waves can be transformed back to closed volume, i.e. to particles.**

NOTE: When the particle disappears, as in the e+e- annihilation, it becomes an EM wave (gamma). This is why the term c^2 is present in $E=mc^2$ (deeply explanation with mathematics are provided in Part 1). In this formula, c is not related to the particle itself but comes from the speed of the light. This speed, c, which appears after annihilation, must not be confused with the speed of the particle, v, if the latter is moving. Please also note that this explanation doesn't modify calculations already in place.

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