Advanced Theory of Consciousness

Carlo Roselli

Abstract

The topic of this article is *consciousness* and, in it, I will theorize what consciousness is like and where it arises from. The work began to emerge and develop over time starting from my belief that consciousness is a physical self-referential phenomenon; thus, my attention was focused on the research for a self-referential process. I was confident that I could satisfy my curiosity through the reductionist method adopted by science. Unfortunately, neuroscientists and philosophers of mind realized that the attempts to explain consciousness with this method have all proved inconclusive. For this reason, they are now trying to address the problem of consciousness with non reductionist methods. As for me, I have always remained faithful to reductionism, but with the conviction that quantum mechanics, even though capable of making predictions with an extraordinary degree of accuracy, is a theory founded on wrong concepts. Thus, surprisingly, I have found a solution to the mystery of consciousness, perceiving a way to explain what it is like at its fundamental level in the field of quantum mechanics and, particularly, in one of its counterintuitive and generally less debated aspects among physicists today, but which aroused great interest in me: I am referring to the spin of the electron that will be described in this paper as a self-interacting process. This paper will also offer a rational explanation of the results obtainable in all experiments for measuring the spin of electrons through Stern-Gerlach magnets. In addition, my theory of consciousness is susceptible to experimental control.

Keywords: *consciousness connected to the electron spin*, *consciousness and quantum mechanics*, *physical self-interacting systems*, *elementary quanta of consciousness*, *what is consciousness like*, *pan-experientialism, the only way to solve the mystery of consciousness*.

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Introduction

We would like to know what consciousness is, what it is like and where it springs from. But above all, we would like to know whether the myriads of entities we perceive, including beings that behave just like us, exist outside there our mind and independently of it.

If we intend to answer this question by keeping away from careless statements, we will come to the conclusion that, although it cannot be ruled out that something else exists beyond our mental world, there is nothing else in addition to the flow of our experiences that is equally unquestionably real.

> Logic alone cannot extract anyone from his sensitive world, nor can it force us to recognize the independent existence of our fellow men.[1]

Indeed, we could take into account solipsism; but the possible solipsistic philosopher would consider the idea of disseminating his own beliefs absolutely meaningless.

In the history of human beings it may well be that someone was a convinced solipsist, but there is no trace of any modern philosopher, starting with Descartes, Locke and Hume, who was. Still, it should also be noted that none of the philosophers who have entered history could ever have dismissed solipsism hastily, and for obvious reasons: although a real world, inclusive of beings who give us the vivid impression of behaving just like us, seems to exist out there, it is in no way possible for us to have direct knowledge of it and, therefore, we cannot prove its objective existence with logical means.

In fact, how could we make sure that, for example, there is a chair out there? Could a simple glance convince us, perhaps supported by a well-aimed kick? This, however, would be an answer as dispassionate as it is inconsiderate. Instead, what we should limit ourselves to saying, in order to avoid unjustified assertions, is:

> we know that if we took a look out there to check whether or not we have the impression of seeing a table, we would actually get the right impression about it. As long as we stick to the realm of pure thought, this last statement of ours is in no way equivalent to taking a position for or against the so-called objective realism ".[2]

Of course, it is possible to get out of the narrow isolation of one's mental world and establish a reasonable philosophical basis from which to move towards the construction of a theory of knowledge. But this requires taking a leap through a hypothesis of a metaphysical nature; moreover, such an operation can lead to profoundly different conceptions of reality.

As is well known, the study of light and matter and, finally, the formulation of quantum mechanics (QM), have led the scientific community to take sides on two main philosophical positions, both epistemological and ontological, regarding the way of conceiving the world.

In a large majority, antirealism (positivism or subjectivism) has been imposed, a vision of nature contained in the Copenhagen interpretation of QM, which limits itself to assuming as real only the acts of observation and the operations of measurement by the subjects endowed with sensory and intellectual perceptions. Their most thoughtful supporters hold to Occam's razor principle, believing that further assumptions are unnecessary to their scientific conception of reality.

This interpretation is opposed by that of objective realism. Their followers think that, once the metaphysical leap has been decided, we might as well make it bigger and assume that, in the face of a multiplicity of conscious and intelligent subjects able to communicate with each other, there is also a physical world located outside the minds. regardless of whether you observe it or not. They believe that such a perspective is, in terms of scientific progress, far more reasonable and fruitful than that of the antirealists who, assuming QM as a complete theory, would have no significant opportunity to broaden the horizons of knowledge.

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[1] Max Planck, *Wege zur physikalischen Erkenntnis*, Zit. Kapitel 8, Publisher, S. Hirzel (1933).

[2] My translation of part of the reasoning that the French theoretical physicist Bernard d'Espagnat introduces in his topic entitled "A note on measurement" - Phys. Lett. A275 (2000) 373.

From now on I will adopt the point of view of objective realism and my own particular form of monism,[3] which will allow me to distance myself from all known forms of idealism and materialism, and which I will try to expose later, as I hope, in an understandable way.

2. ***Theories related to the mind-body problem***

Dualistic theories are based on the hypothesis that mind and body are two fundamental kinds of entities or principles. Today there are essentially three main forms of dualism: a) - the dualism of substances (or strong dualism), on the basis of which the body and the mind are different substances, the first material, the second immaterial and characterized by equally immaterial states, in other words a substance that thinks; b) – the dualism of properties, which admits the existence of only one kind of substance which nevertheless possesses both physical and mental fundamental properties, the latter not reducible to physics, as if to say that there are physical entities which also have non-physical properties; c) – the dualism of predicates,[4] according to which the predicates referring to the mental world are not reducible to the predicates of the physical world and are considered indispensable for the description of a causally closed world.

Monism[5] is opposed to dualistic theories and it is articulated in three distinct conceptions: 1), idealist monism (mentalism, or simply idealism), which assumes the existence of only mental reality, where what we call "matter" is nothing else that a manifestation of it; 2), double aspect monism, according to which material and mental phenomena are only two aspects, or attributes, of the same reality; 3) materialist monism (or materialism), which today represents the most widespread philosophical position and which maintains that all phenomena of reality, including mental phenomena, can be traced back to the exclusive behavior of a single substance of a material kind, so that the mental world is held to be a product of material processes. From materialism came physicalism, according to which mental states are only physical states of the brain.

For over fifty years, the dualism of substances has been abandoned by most scientists, who preferred to engage in the search for a possible material description of mental phenomena.The reason lies in the fact that strong dualism implies a problem that cannot be tackled on a scientific level. In fact, it is completely incomprehensible how two ontologically distinct substances can influence each other. Thus the study of the mind and its external manifestations dependent on neurophysiology, or the study of the physical or neural processes that take place in the brain, has been affirming. Its goal is to found the "science of behavior".

3. Behaviorism and cognitive sciences

Behaviorism initially developed in the United States in the 1940s, and then spread to Europe as well. His investigation is aimed at understanding how neural processes are related to specific behaviors of living beings equipped with a highly evolved perceptual and intellectual apparatus and, therefore, above all of human beings, who are also equipped with a sophisticated language.

In the course of investigations of an experimental nature, the "cognitivist" hypothesis came to impose itself, on the basis of which, in humans, mental processes responsible for rather complex functions should be triggered, such as for example memory, associations of ideas, the ability to access own inner states and their reportability, that is. the possibility of making them available

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[3] My personal monism is detailed in my article entitled "La Coscienza", available online.

[4] This form of dualism is also called "intensional conceptual dualism". Although the predicates referring to the mental and those referring to the physical are linguistically and phenomenologically distinct, it cannot be excluded that there is a correspondence between the extensions of the psychological and physical predicates.

[5] We recall that Spinoza, in his Acosmico, supports the point of view of monism, affirming that mind and body are two aspects of a single necessary, self-sufficient and ontologically indefinable substance. This substance is identified by him in the concept of Deus sive natura, whose attributes are extension and thought, and from it all the phenomena of the universe descend following a deterministic and teleological path. We also recall how Einstein approaches Spinoza's idea of God, sharing his attributes of extension and thought, but distancing himself from his pantheistic (or immanentist) conception. Einstein's God is in fact interpreted as an entity that transcends cosmic reality and yet pervades it everywhere.

through verbal reports. All these functions seem to be related to something much more complex than pure and simple behaviors.

Cognitivism thus becomes the new scientific approach to the study of the relationships between the complicated neural activity of the brain and the various cognitive functions. Through an increasingly elaborate experimental activity, many of these functions manage to find a scientific explanation thanks to the use of a constantly evolving technology and the use of particular non-invasive methods, such as Magnetoencephalography, Magnetic Resonance Mapping (MRI, from the French "Imagerie par Résonance Magnétique") and Positon Emission Tomography (PET).

The acquired results lead scietists to convince themselves that in a more or less distant future the entire variety of neurophysiological and cognitive functions will be explained. However, there is one aspect of mental activity that cognitivism, for a long period of time, has completely kept out of its investigative program: consciousness, that is *first person experience*.

The initial proposals aimed at laying the foundations for a science of consciousness date back to just over a couple of decades ago. However, these are extremely ambitious challenges in which several philosophers of mind and neuroscientists are engaged, generally attested on underlying premises in conflict with each other, and only slightly different in some of them, but for now none of the premises is able to boast a promising theoretical setting. This is due to the presence of a difficulty, consisting in the search for a correlation between the functional mechanisms triggered by the neural activity of the human brain and the conscious experience, i.e. the phenomenon which allows the owner of that brain to notice specific effects , to suffer them from his exclusive point of view.

The American philosopher Thomas Nagel (1937), in his reflections on the phenomenon of conscious experience, argues that

> it is a widespread phenomenon. It can be observed at different levels of animal life, even if we cannot be sure of it with regard to the simplest organisms [...]. There is no doubt that it exists in innumerable forms totally unimaginable to us, on other planets and in solar systems throughout the universe. But regardless of the variety of forms it might take, the very fact that an organism has conscious experience means, in essence, that it feels like something to be that organism.[6]

Furthermore, Nagel specifies that

> basically an organism experiences conscious mental states if and only if one feels something to be that organism [...]. We could call all this the subjective character of experience: this remains elusive for the typical reductionist analyzes of the mental developed in recent years [...]. The subjective character of the experience cannot in fact be analyzed in terms of any explanatory system of functional or intentional states, since these same states could also be attributed to a robot or an automaton that behaved like humans, despite having no subjective experience..[7]

If we are determined to explain the phenomenon of consciousness, we will have to discover the existence of a self-referential physical system. If such a system does not exist, consciousness is not explainable. If it exists and we look for it at the level of classical physics, we will not find it and we will not even be able to imagine it; thus, all we have to do is investigate the quantum world.

To give a scientific answer to where consciousness is and what it is like, a theory of consciousness would be needed. But to date there is no such a theory and not even a widely shared outline to pave the way towards a plausible understanding of it, so that many scientists of the mental world, some

[6] T. Nagel, *What Is It Like to Be a Bat?* Philosophical Reviews USA, 1974.
[7] Idem..

of whom are referred to as "mysterians",[8] are convinced that an answer to why and how cosmic reality contemplating the phenomenon of conscious experience is absolutely inaccessible to the human intellect.

David J. Chalmers (1966), one of the most authoritative philosophers of the mind and author of various essays, has carried out and is still carrying out a careful reflection on the most disparate theories proposed up to now to try to answer the inescapable questions emerging in the field of neurophysiology and neuroscience:

what is consciousness? Conscious experience is at once the most familiar thing in the world and the most mysterious. There is nothing we know about more directly than consciousness, but it is extraordinarily hard to reconcile it with everything else we know. Why does it exist? What does it do? How could it possibly, arise from lumpy gray matter?[9]

These questions are among the most intriguing and enigmatical in all of science. Chalmers' first concern consists in isolating the set of easy problems connected to the idea of consciousness from the so-called "hard problem". The former are susceptible to a relatively simple scientific explanation, as they can be objectively studied by neuroscience and classified as the performance of neural or computational mechanisms. All in all, these are explanations of specific functions that, according to Chalmers, seem to have to do exclusively with the physical world. On the other hand, the truly difficult problem consists in asking, as Nagel did before him, why the physical processes taking place in the brain are accompanied by conscious experience, i.e. why they can shine, to use my personal expression, with their own light.

I am not denying - says Chalmers - that consciousness arises from the brain. We know, for example, that the subjective experience of vision is closely linked to processes in the visual cortex. It is the link itself that perplexes, however. Remarkably, subjective experience seems to emerge from a physical process. But we have no idea how or why this is.[10]

When asked if neuroscience will be able to open a window towards the understanding of consciousness, Chalmers replies that this could happen under only one condition: that what the American philosopher of mind Joseph Levine defined in 1983 as the "explanatory gap", that is, that a bridge can be built between physical processes and subjective experience. However, on the basis of his scrupulous arguments, Chalmers realizes that all the experimental methods practiced today by neuroscience and cognitive science, as well as all the most modern theoretical proposals in this direction, ranging from the different forms of dualism (with the exception of dualism of substances) to identity theory (also known as 'physicalism'), functionalism and eliminative materialism,[11] to one degree or another fail in their task. None of them is in fact able to explain from which property or physical law conscious experience originates.

The hope of bridging the explanatory gap will require a new theory based on significant discoveries that could come from the field of neurophysiology or from the study of algorithmic processes or, much more reasonably, from the discovery of something new at the level of quantum physics. Furthermore, the possible solution of some of the well-known mysteries of the latter would be of great help.

The new theory, in the hypothesis that it is prepared, will hardly be subjected to experimental tests and will therefore be based on conjectural procedures. In any case, to hope for its convincing

[8] Mysteians are philosophers of mind who preach the amazement of experiencing one's own existence and who regard consciousness as an irreducible phenomenon.

[9] Chalmers D.J., *The Conscious mind*, Oxford-New York, Oxford University Press., 1996, p. 3.

[10] Chalmers, *The Puzzle of Conscious Mind*, Department of Philosophy, University of Arizona, Tucson, AZ 85721, chalmers@arizona.edu.

[11] Eliminative materialism or, more simply, eliminativism holds that the mind should be studied like any other physical phenomenon. Its supporters assume that the mind is the product of two essential aspects, behavior and the brain; with this they exclude any sort of derivation of the mind from metaphysics; functionalism established that a mind is a set of states essentially causally related to sensory inputs, behavioral outputs, and one another.

elaboration, it will certainly be necessary to rethink the scientific method adopted so far for the formulation of physical theories.

Therefore, as I believe, one will essentially have to rely on the fecundity of the imagination and count on the possibility of intuiting new fundamental properties, or what Chalmers calls the "additional ingredient". He, believing that conscious experience must depend on physical processes but that this dependence cannot be derived only from physical laws, states that

> The new basic principles postulated by a non-reductionist theory give us the extra ingredient we need to build an explanatory bridge. Of course, by viewing experience as fundamental, there is a sense in which this approach does not tell us why there is experience in the first place. But the same goes for any fundamental theory. Nothing in physics tells us why matter exists in the first place, but we don't consider that a fact that gets in the way of theories of matter. Some elements of the world must be considered fundamental in any scientific theory.[12]

Chalmers, starting from a philosophical position called "naturalistic dualism",[13] believes that certain criteria adopted to build physical theories, in particular those based on principles of simplicity and elegance and such as to suggest the existence of fundamental laws, can be equally valid for a theory of consciousness. The principles that unify physical and experiential processes will have to be conceived as explanatory fundamental, i.e. not derivable from physical laws.

But a theory of experience, although it can benefit from reliable indirect sources, such as the verbal reports of subjects studied with the modern investigation methods of neurophysiopsychology and cognitive science, lacks objective data. It follows that any theory of experience, like all non-empirical theories, will always have a speculative character.

A theory of consciousness, according to Chalmers, should be able to explain how to fill the so-called "explanatory gap" with which Levine, in opposition to the reductionist method, argued that between the physical and conscious experience no explanation given entirely in physical terms can ever account for the emergence of conscious experience.

To fill the explanatory gap, Chalmers suggests that an extra ingredient will be required. In order to understand where such an ingredient capable of shedding light on the mystery of experience lies, various proposals have been put forward. The most interesting claims that it should be at the level of quantum mechanics. But, in asking how physical processes could give rise to experience,

> it would be wonderful - says Chalmers - if reductionist methods could also explain experience.[14] […] There is a temptation to say that all kinds of enigmatic phenomena eventually prove capable of explanation in physical terms. However, each of them would be a problem concerning the observable behavior of physical objects and thus turns into a problem of the explanation of structures and functions[15].

Although conscious experience appears as an intractable problem, Chalmers, showing a certain optimism, refuses to believe that it can never be solved and, therefore, deems it appropriate to reduce it by defining it as "the difficult problem", in the face of which, as already remarked, there are problems so-called "relatively easy", i.e. problems concerning the explanation of cognitive and behavioral functions (the solution of some of these problems could take many or even very many years).

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[12] Given the partial nature of the theories we have in every cognitive field, only the knowledge of the ultimate elements (their ontological foundation, the reason for their existence and their intrinsic and relational properties) could unify them in a complete and self-consistent theory.

[13] Chalmers assumes that mental states supervene "naturally" on physical systems, such as brains; and that mental states are ontologically distinct from and not reducible to physical systems.

[14] Chalmers: *Facing up to the Problem of Consciousness*, Journal of Consciousness Studies, 2, 1995, my translation from Italian book *Cos'è la coscienza?*, Castelvecchi Ed. 2014, p. 39.

[15] idem, p. 41.

Conscious experience still remains a mysterious phenomenon today and, according to several philosophers of mind, it will remain so until the explanatory gap is filled or, equivalently, the *extra ingredient* capable of solving the difficult problem is identified.

There have been several proposals to explain how consciousness can emerge using quantum mechanics, but they have all proved unsuccessful. Among these proposals, the best known is that of Penrose and Hameroff, according to which conscious experience emerges from coherent vibrations in the microtubules found inside brain neurons, but it gives us no insight into why these vibrations should produce the phenomenon of experience.

Someone might also feel attracted by a particular interpretation of quantum mechanics, the one formulated by Eugene Wigner, called "Consciousness causes collapse [of the wave functions] hypothesis", briefly "CCCH", in which consciousness would play an active role. However, this hypothesis, in addition to being of a metaphysical nature rather than an explanation of consciousness, upon careful analysis and the introduction of a particular strategy, turns out to be erroneous (see my article "The Dead-alive Physicist experiment", Foundations of Physics Springer).

Anyway, all the explanations given so far of what consciousness is like are not explanations of how a given process should bring out the phenomenon of conscious experience. Finally, since it seems that consciousness cannot be derived from the physical world or explained in physical terms, philosophers of mind and neuroscientists feel forced to consider approaches based on non-reductionist methods.

This renunciation of reductionism is comprehensible, but sooner or later it will be realized that resorting to non-reductionist methods would lead nowhere.

3. ***My personal way of proceeding towards understanding the phenomenon of consciousness***

As far as I'm concerned, I've never given up chasing answers to fundamental questions, no matter how intractable they may seem, unless they are proven impossible.

My approach to the problem of consciousness is based on the reasonable belief that it is a self-referential physical process and, therefore, if we intend to proceed to an explanation of consciousness we should look for a self-referential physical process. If such a system does not exist, consciousness is not explainable. Assuming it exists, where should we look for it? We certainly cannot find or conceive it at the classical level; so, what remains to be done is to search within the quantum world. Finally, only if it is possible to provide an understandable description of a self-referential physical process we will be able to proceed towards the formulation of a theory of consciousness. Outside of this possibility there are only beautiful words, opinions, conjectures, which however are of no help to understanding what consciousness is like and where it has its roots.

In my investigation I went deep enough to try to extrapolate from the elementary particles of the quantum world unsuspected properties that pushed me to ask questions such as "what could be the genuine behavior of the intrinsic angular momentum (spin) of the electron?". And in this regard I want to mention the Scottish mathematician Ian Stewart who, in addressing the topic of quantum correlations, considers it plausible that, somehow beyond our understanding,

> The electron, however, actually appears to behave as if it were simultaneously rotating around both axes. It's almost as if there were two ghost electrons, one spinning around the north axis and the other around the east axis, and the real electron is a combination of the ghosts [...]. In fact you really need three ghosts, because we haven't added rotation around the top axis yet. In many different types of experiments, this spectral image of an electron has been shown to provide a natural picture of reality[16].

Sharing this reflection, I will find it reasonable to look for a new way of conceiving the spin of the electron (see Appendix 3). Furthermore, considering myself a realist and rejecting as erroneous the hypothesis that consciousness is an emergent phenomenon, I am inclined, unlike Chalmers and Levine before him, to embrace reductionist methods and to support the idea that experience is a

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[16] Ian Stewart, *Does God play dice?* Penguin Books, second ed. 1997, p. 334

physical phenomenon widespread in all levels of reality, ranging from a level of minimum intensity in the quantum field to that of maximum intensity typical, as far as we know, of human beings. In fact, in a realist philosophical perspective there objectively exist, besides me, other human individuals, bats and electrons. So, by knowing what it feels like to be a human and asking *what it is like to be a bat*, we will also be justified in asking what it is like to be an electron.

I will call this philosophical position of mine "pan-experientialism" and, in order to support it in a detailed way, below I will put some of my personal ideas and considerations into play

"In the beginning, the Sphere and the Tetrahedron were united in a single unthinkable, unimaginable Form"

4. ***The enigma of an ambiguous form***

This puzzle, that supports a myth of the Hindu tradition, refers to *Mount Analogue*,[17] the last story by René Daumal, which was fatally interrupted in the middle of a sentence in the fifth chapter.

Curiously, during my research undertaken when I still didn't know the existence of that myth, a friend of mine, who knew my interest in philosophy and science, gave me Daumal's book as a gift., which I read in one sitting and in which I encountered for the first time the above-mentioned enigma. I immediately felt that its solution could be useful to my search for a physical self-referential process, so that I couldn't take my mind off this puzzle. Finally, with the feeling of being close to its solution and after spending a few sleepless nights, I created a rather simple three-dimensional "object" that seems to provide a satisfactory answer to the aforementioned puzzle: an image of sphere and tetrahedron harmoniously confused in a spatial unicum, at the base of which is the curve that I describe below.

Let us consider a regular tetrahedron with unitary side and a sphere with center O in the barycentre of the tetrahedron and radius r = $\frac{\sqrt{2}}{4}$ equal to the distance of O from the midpoint of the side (figure 1). Their intersection is given by the four circles inscribed on the faces of the tetrahedron (figure 2). Indicated with A, B, C, D, E, F the midpoints of the sides of the tetrahedron, on these circles we select the following path: starting from A, in a clockwise direction, we take the arc of 2/3 of the circumference up to the point B (figure 3) and from this, counterclockwise, we take in the consecutive face an equal arc of circumference up to point C. From here we continue, with the same criterion, taking the arc of circumference CD and, finally, the arc DA, thus returning to the starting point.

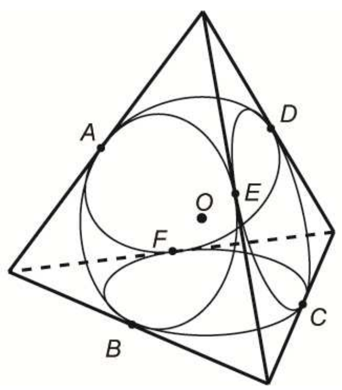


Fig. 1: sphere-tetrahedron relationship

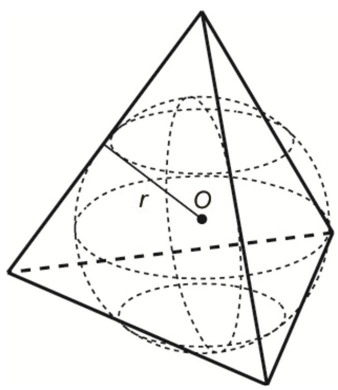


Fig. 2: intersection

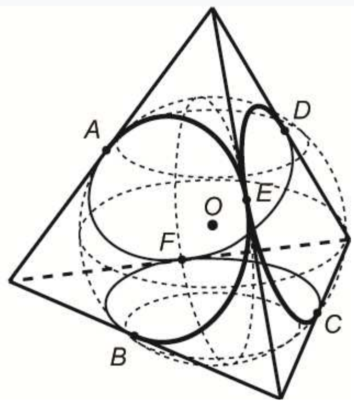


Fig. 3: path *ABCDA*

We call the so obtained spherical curve "Loop Curve$_{2/3}$", briefly $LC_{2/3}$ (figures 3 and 4). Furthermore, we call the center O of the sphere "center of $LC_{2/3}$" (by construction O is equidistant from all points of the curve) and the radius of the sphere "radius of $LC_{2/3}$", while we call the points A, B, C , D, E, F "critical points of $LC_{2/3}$" .

[17] Daumal R., Penguin Books, 1974.

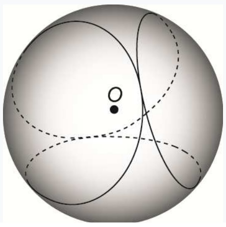


Fig. 4
Loop Curve$_{2/3}$ ($LC_{2/3}$)

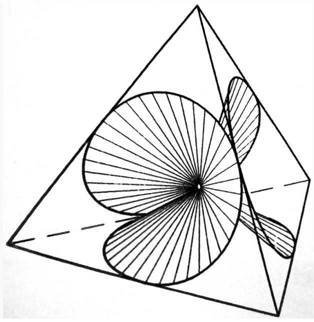


Fig. 5
Loop Surface$_{2/3}$ ($LS_{2/3}$)

By joining the points of $LC_{2/3}$ with its center, we obtain a spherical tetra-polar conical surface with vertex O which we call *Loop Surface*$_{2/3}$, briefly $LS_{2/3}$ (figure 5). The *Loop Volume*$_{2/3}$ ($LV_{2/3}$) will be shown in the following section

5. ***Generation of Loop Volume $LV_{2/3}$***

Let us now see what is obtained from the circle with diameter OP (figure 6) during a quadripolar rotation rq_1 (see Appendix 1) along the curve $LC_{2/3}$ (see Appendix 1, where the equation and all the properties of the curve are described in details).

For clarity, figure 6 includes the 4 axes around which the rotation of the circle along the curve takes place. thus giving rise to a self- referential (self-interactive) process.

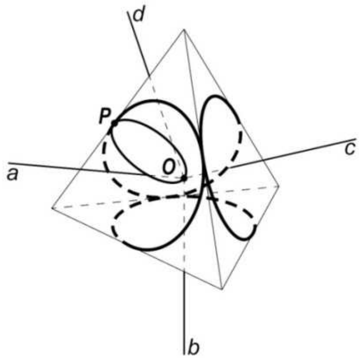
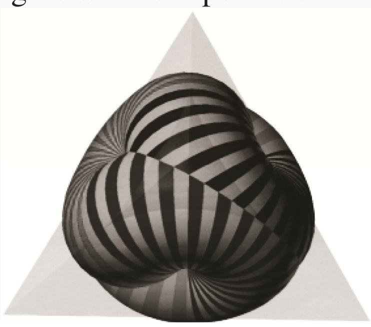
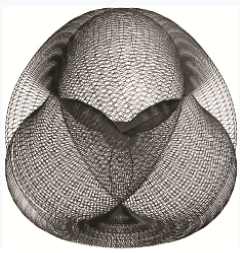


Fig. 6

This circle, moving perpendicular to the curve along its entire length, generates a spheroidal torus-shaped figure with four polarities that we call "Loop Volume$_{2/3}$", briefly $LV_{2/3}$ (figure 7).





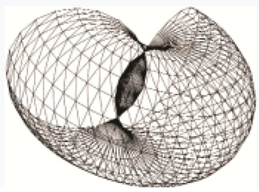


Fig. 7 Fig. 8 Fig. 9

As can be seen, $LV_{2/3}$ is a toroidal surface characterized by four singular points equidistant from each other and each belonging to a spindle cichlid;[18] thus, there are four spindle cichlids, through

[18] This term was introduced by nineteenth century mathematicians in the study of surfaces. A spindle cichlid is characterized by two singular points that resemble the singular point of a double cone. Note that each of the four cichlids in this figure is incomplete as it is generated by a circumference arc that rotates 240° around a chord coinciding with one of the four polar axes of $LC_{2/3}$.

which the surface of $LV_{2/3}$ is connected to its center. We call the four singular points "poles of $LV_{2/3}$". Figure 8, that is a sort of x-ray of figure 7, shows the development of this surface oriented in such a way as to clearly show its four spindle cichlids. Figure 9 best illustrates the shape of one of above cichlids.

Let us now see how a circle perpendicular to the curve $LC_{2/3}$ behaves during an rq_1. For this purpose it will be convenient to redefine the three axes *x*, *y*, *z* into three pairs of complementary semi-axes *x1-x2, y1-y2, z1-z2,* each pair connecting the midpoints of two opposite sides of the tetrahedron, as in figure 10. Starting from point *P* in *x*1, we move the circle along the curve following the direction of the arrow (thus, alternately clockwise and counterclockwise), and we take into consideration only the eight positions (figures 11 *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*) that the circle assumes when it touches the four critical points *A*, *B*, *C*, *D* of the curve and the two points *E*, *F* each counted twice (running the curve along its entire length, the circle passes through each of these last points twice)[19]. It can thus be seen that the plane of the circle (colored in light gray on one side and in dark gray on the opposite side) is rotated by 90° every time it has moved from any of the six semi-axes to the complementary one such as, for example, from *y*1 to *y*2. Furthermore, the plane of the circle is rotated by 180° each time it moves from *z*1 to *z*1 via *z*2, or from *z*2 to *z*2 via *z*1. These observations will lead me to introduce in the next section a new concept called "Monodual System"

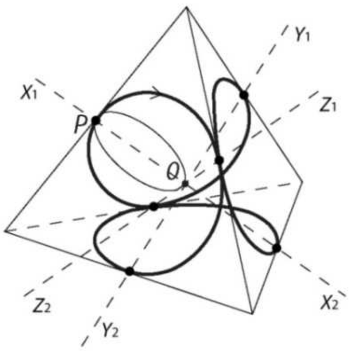
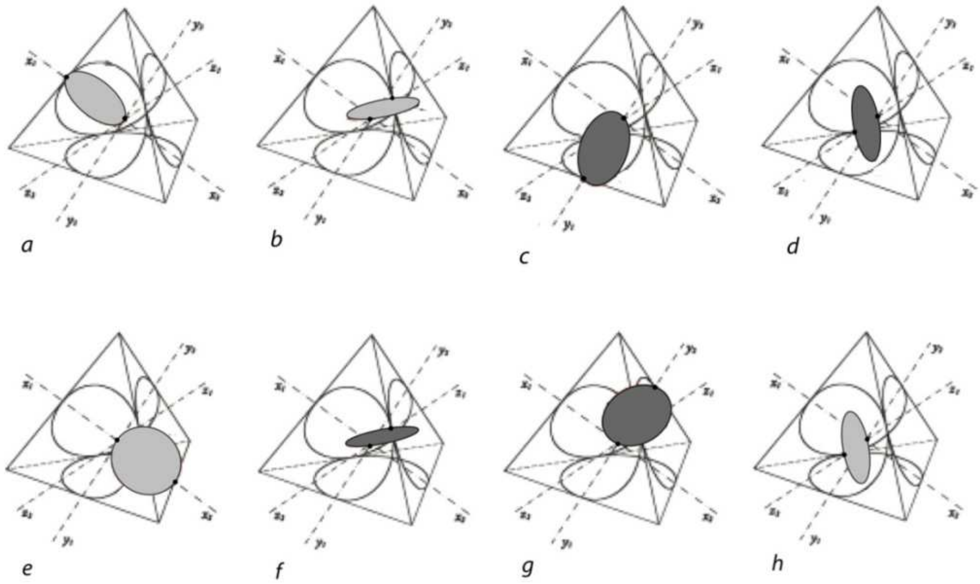


Fig. 10



Figg. 11 *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*

[19] It should be observed that, at every change of position from one semi-axis to the next, the circumference completes a $rq_{1/8}$, i.e. 1/8 of a quadripolar rotation (for a detailed description of this type of rotation see Appendix 1 section 3).

6. ***Monodual System***

Let us consider the idea that the two varieties of Loop, $LS_{2/3}$ and $LV_{2/3}$, are generated, instead of by a single element (respectively, a radius and a circle normal to the curve *LC*, such as in figure 6), from a pair of such elements equal to each other, *q* and *q*', which we will call Monodual System (**MS**) if *q* and *q*' satisfy the following condition: have, in all the positions that they assume with respect to each other, equal characteristics with respect to the *LC*; this implies that *q* and *q*' will keep their mutual distance unchanged along the *LC*.[20]

A monodual system will have the notation **MS**.1 or **MS**.2, depending on whether the elements that make it up are one or two dimensional. Here we will describe a particular example of **SM**.2, whose pair of elements is given by two circles. First, let's take a $LC_{2/3}$ of radius *r*, divide it into a number *n* of equal segments[21] using the six semi-axes as initial reference. Second, we construct two equal circles of diameter *OP* and *OP*' (O center of the curve and *P*, *P*' respectively points of intersection of the curve with *x*1, *x*2) each belonging to the plane normal to the curve (figure 12). For a clear description, the area of the circle in *x*1 is represented in dark gray and in light gray that of the circle in *x*2 (as has already been observed, the planes of the two circles are perpendicular to each other when they are unpaired in *x*1, *x*2 and in *y*1 , *y*2). Our **MS**.2 is now ready for action.

Having assigned a direction of travel to the curve, along this we will make the **MS** execute, intermittently, a complete revolution while keeping the initial characteristics of its two circles unchanged with respect to the curve.

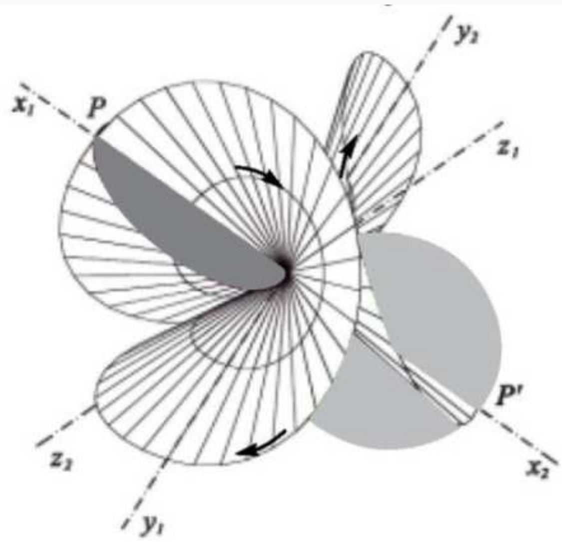


Fig. 12

Observe that, if the **MS** moves forward three segments, the two circles come to be closer" to each other, and their diameters form in *O* an angle $\alpha < 180°$ (figure 13 *a*). Moving the **MS** forward three more segments, said angle is further reduced (figure 13 *b*). After two more passages of this type, there is an overlap of the two circles in *z*1, which is represented by a black circle shown in figure 13 *d*. Each circle of the **MS** has thus completed a $rq_{1/8}$. It can be verified that, whatever the position of

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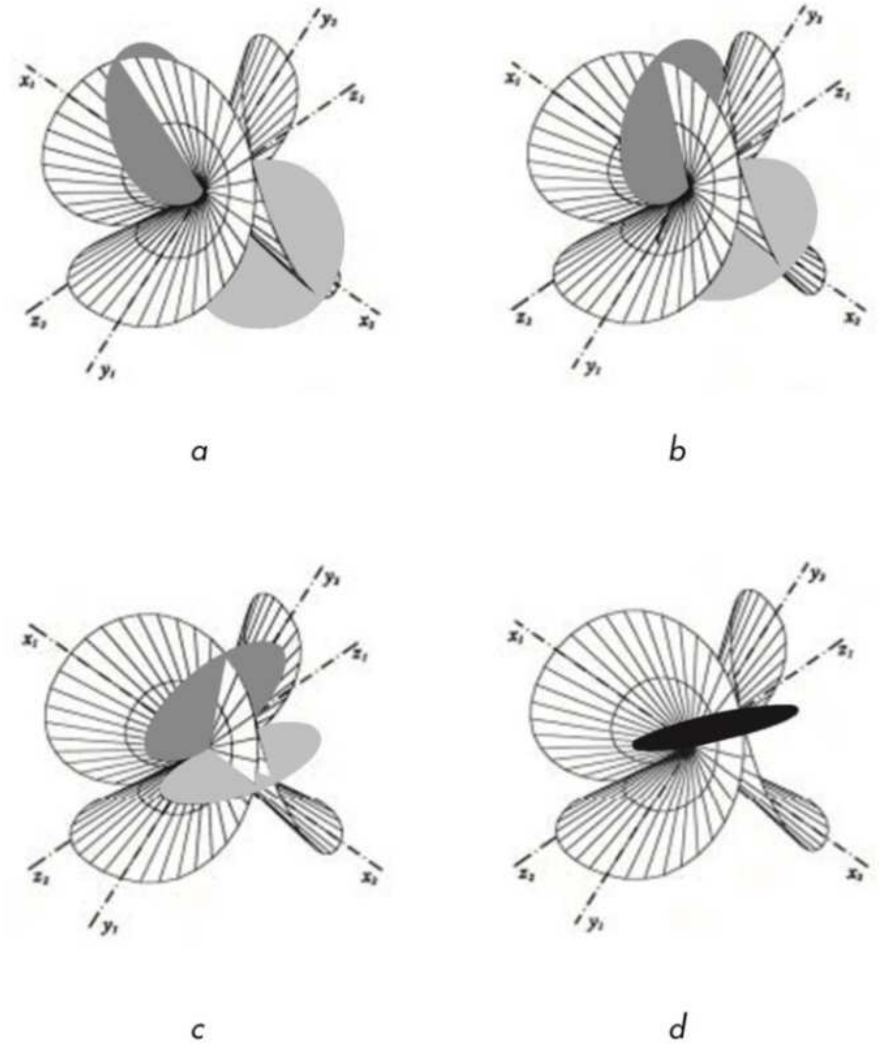
[20] It is the length of the curve $LC_{2/3}$ between the points where the two circles intersect it.

[21] Since the six semi-axes divide the curve into eight equal parts, for what follows it will be convenient to divide this into a number of parts that are multiples of eight. As can be seen in figure 12 and in the 4 subsequent figures, each of these eight parts has been divided into 12 segments, for a total of 96 segments.

the **MS**, its two circles keep their mutual distance unchanged along the curve and, 0'paradoxically', also in *z*1.



Figg. 13 *a*, *b*, *c*, *d*

Continuing to operate in the aforementioned way, the two circles will move away from each other until their diameters coincide respectively with *y*1 and *y*2. Subsequently, they will come together until they overlap (black circle) at *z*2. From here they will move away again until the dark gray circle coincides with *x*2 and the light gray circle with *x*1. Each of the two elements of **MS** will thus have completed an $rq_{1/2}$.

The fundamental characteristic of a **MS**.2 consists in the fact that it does not possess any symmetry and that, in a certain sense, it is in a condition of instability, even if, as a development of a complete rotation (rq_1), it gives rise to a well-defined static geometric figure characterized by eight symmetries (see in Appendix 1, section 2, Euler's formula under Table 1), i.e. the quadripolar spheroidal torus illustrated in the previous figures 7 and 8.

During a complete rotation (rq_1) of the **MS**, kinematically represented in figure 14 with a series of 32 frames, there is a sequence of four actions marked by a beginning and an end (similar, so to speak, to a sequence of four hand claps).

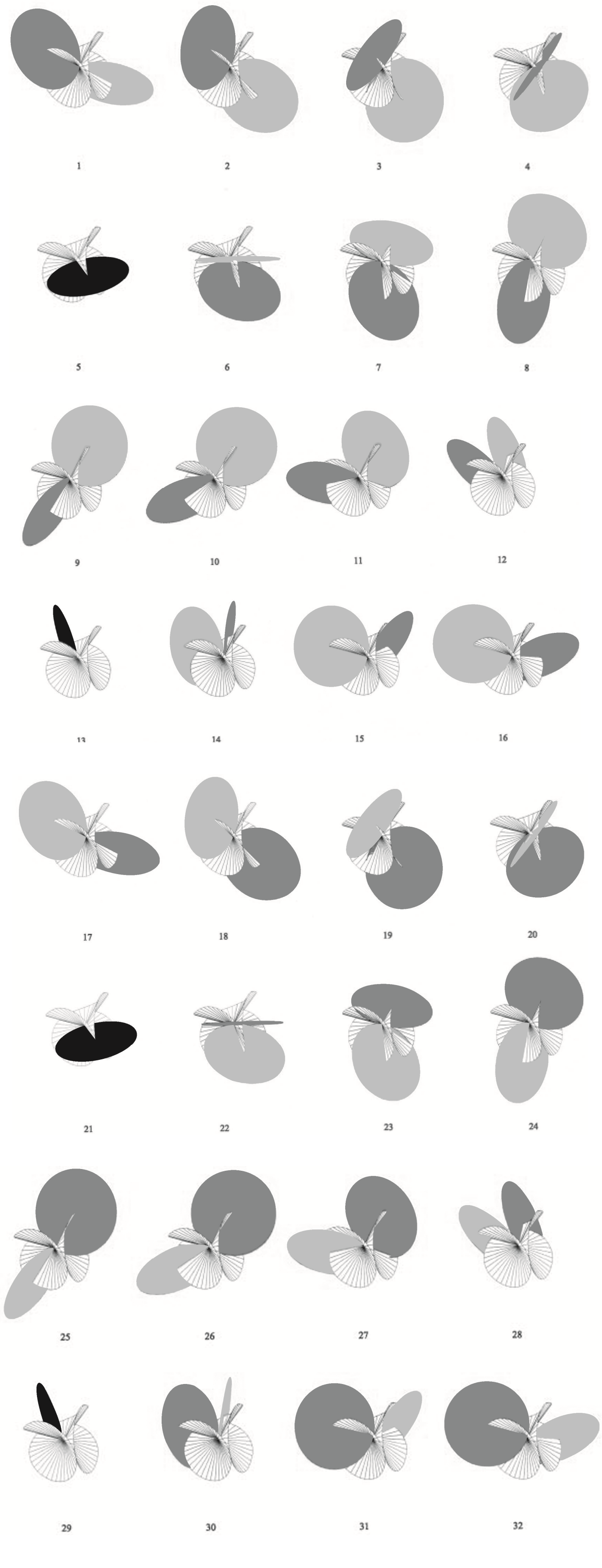
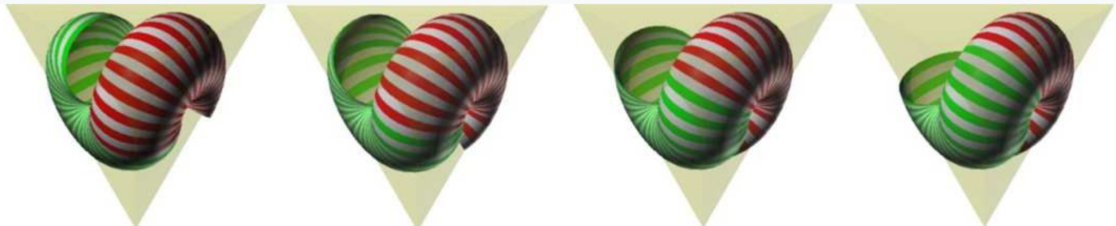


Fig. 14 (sequence of 32 frames of a **MS**.*2*)

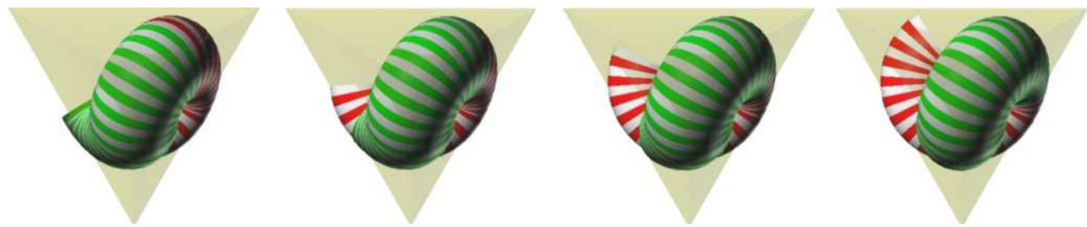
From the above **MS.**2 we can obtain the hemi-loop $HLV_{2/3}$ of the tetrahedron and use it instead of the loop, because it allows us an explicit visualization of the self-interacting phenomenon.

7. *Stream of elementary quanta of proto-phenomenal consciousness*

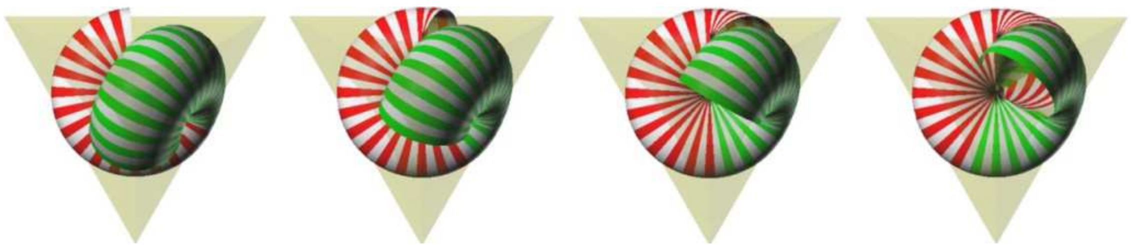
The hemi-loop $HLV_{2/3}$ of the tetrahedron is characterized by two circular extremities that perform the same function as a **MS**, but in this case these extremities, that are connected to each other along the curve in the same way of the pair of circles in figure 14, constitute the boundaries of a sort of tunnel. This tunnel varies continuously and periodically its configuration during each rotation. In order to visualize the behavior of a hemi-loop ($HL\mathrm{V}_{2/3}$), and to emphasize the peculiarity of its way of rotating (it describes an intrinsic angular momentum characteristic of a self-referential process), a computer animation was created by me. A sequence of 32 numbered frames (Fig. 15) was selected from a computer video to make it understandable how the self-referential activity of the hemi-loop takes place (in this case, with the red-white advancing and the green-white following).



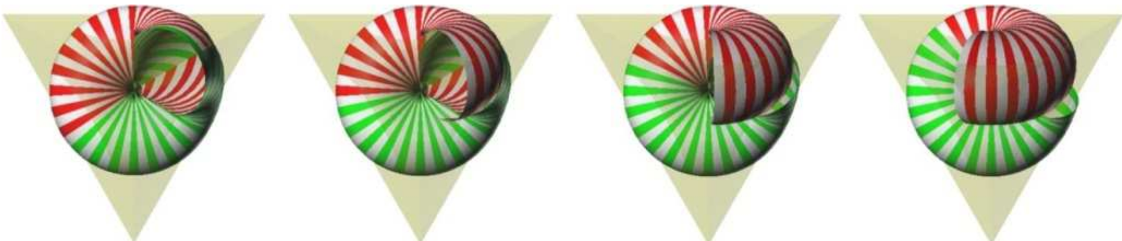
1 2 3 4



5 6 7 8



9 10 11 12



13 14 15 16

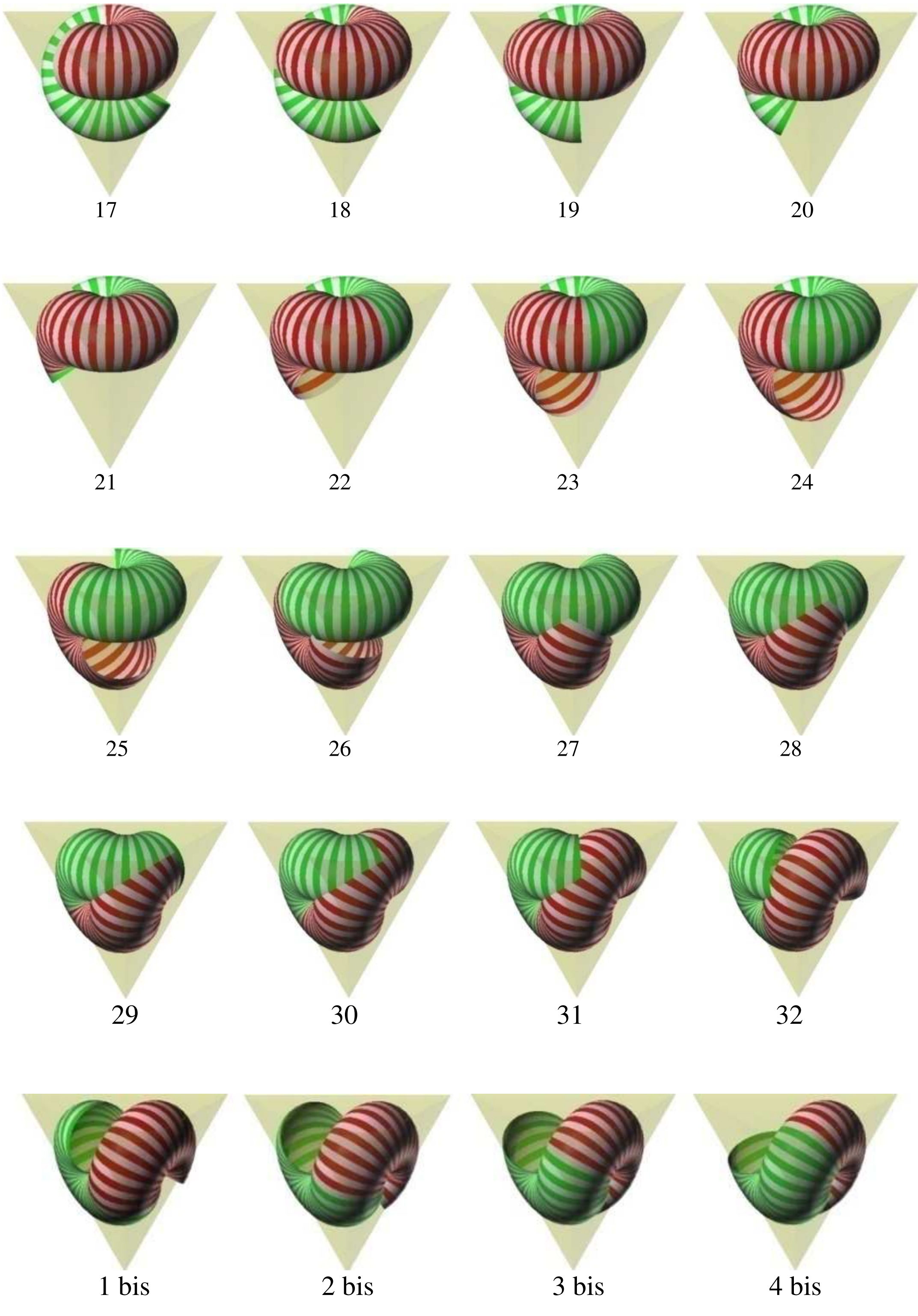


Fig. 15: *HLV*$_{2/3}$, a quadripolar toroidal hemi-loop derived from the intersection of the tetrahedron with the sphere (extrapolated from a computer video of my own design) and describing a flow of proto-experience composed of 32-frame kinematic sequence. Observe that the whole sequence consists of four elementary quanta, each with its own spatial orientation; also observe that the self-penetration is somehow recalling the Klein bottle but without involving, in this case, a derivation from the Moebius strip.

I would invite you to examine attentively the sequence of images in figure 15 above, since it illustrates the ingredient (namely an hypothetical description of the spin of the electron) that in the introduction I assumed as necessary to connect physical processes with subjective experience. For a much better understanding, I suggest you to enter Google and click on <you tube computer video carlo roselli>, that describes a self-referential process aiming to express the idea of phenomenal experience at its fundamental level. I would point out that the computer video mentioned above describes the self-penetration process much better than figure 15, and that, all in all, it effectively gives us the impression that the electron is actually experiencing something in the course of its spinning activity.

I would now like to make some relevant observations:

(I) - in the real world, the process might not be quite what I just described, but a very similar process based on one of the figures illustrated in Appendix 2, or it might be a similar physical process, as long as it involves *self-interaction*;

(ii) - my hypothesis of the electron spinning around n number of axes with $n \geq 3$ seems the only proposal ever made so far to describe a self-referential physical process somehow connected to the spin of the electron and, thereby, to provide a solution to the difficult problem of consciousness.

(III) - my hypothesis with which I expect to explain what proto-phenomenal consciousness is like, as already mentioned in the abstract, can be subjected to experimental control, even though difficult to devise. For this purpose, one would have to set up an experiment whose results prove that the electron is actually spinning around three or more axes;

(iiii) - Appendix 3 is essential for a clear understanding of the role of spin axes and how electron spin measurements occur through Stern-Gerlach magnets; the Appendix also includes a rational explanation of the so called "incompatible measurements of spin" .[22]

It should be noted that the possible scientific recognition of my hypothesis would have two stunning implications: one would be the solution of the difficult problem of consciousness, while the other implication would be the *fallacy of the concepts underlying quantum theory* and the need to re-found it on the basis of three-dimensional space and the principle of causality.

However, to account for the different degrees of experiential intensity, in addition to the physical self-referential property, a second property will have to be explained, which I will call "self-organizing principle". This principle, given my modest skills in chemistry and biophysics, will be limited to the geometric and mechanical description of coherent assemblies of a given number n of loops that simulate the spins of a coherent set of quantum particles. Such assemblies are called "Harmonic Structures", SAn for short, where n represents the number of elements that compose them (the article in which these Structures are described is not yet available, since it is still being developed).

In the next future, my hypothesis, if proven valid by experiments, would constitute the starting basis for the construction of a broader scientific theory of consciousness

This writing begun to take shape starting from my belief that consciousness represents the foundation of cosmic reality, as without consciousness there would be nothing to question and discuss. Then, taking a philosophical position in favor of the reductionist method adopted by science, and by assiduously studying various areas of knowledge, I have spent much of my time investigating the phenomenon of consciousness wondering where it has its roots and what it is like.

Finally, through a long and rather daring search, I managed to find my answers. Indeed, my constant mental effort and my imagination led me to a vision of the microcosm based on a mechanics capable of expressing self-referential and periodic elementary actions, each with a beginning and an end (as in figures 14 and 15). In this way, nature is seen as a source of iterative and monotonous actions, for each of which a partial representation would have no physical sense, just as, for example, it would not make sense to execute a half-clap of the hands. These actions would take place with self-regulating laws that I assume logically necessary and of maximum economy, in line with Occam's Principle; taken together, they would describe the history of our

[22] See on Google my article "A rational explanation of all Stern-Gerlach- type experimental results", which seems to provide evidence of the electron spinning around more than two axes.

cosmic bubble which, as it evolved (in agreement with the Big-Bang theory), would have undergone phase transitions producing, in sequence, the coagulation of distinct families of fundamental "objects", each thought of, as well as capable of interacting incessantly with itself, and therefore of experiencing something, also of interacting and combining with other objects around it, thus giving rise to the formation of an endless variety of structures.

Given that a single loop represents the elementary unit of consciousness and, at the same time, the fundamental building block of reality, then I find it reasonable the existence of other structures, each formed by a loop of loops, that we can call "super-loop", and then even more complex coiling of loops as it might be DNA within neurons, and so on until form a structure like the human body and, why not? even a super-human body.

8. ***Conclusions***

Summing up, in this essay I provided my answers to the two fundamental questions of where phenomenal consciousness springs from and what it is it like.

An observation is now due on what has just been said: any question concerning the possible understanding of what *a given thing is like*, no matter how difficult it is, does not represent a real mystery;[23] the real mystery concerns the seeming impossibility of answering the question "why is there a given something?", as also remarked by Ludwig Wittgenstein (1889-1951) in his *Tractatus* (6.44). Thus, the answers to the question of why consciousness exists will have conjectural value

Yet, there is a topic that calls into question the *anthropic priciple* and that, under a particular hypothesis, seems to sweep away all the mysteries. In fact, cosmologists who hypothesize the existence of our universe alone are forced to consider it a unique event or, so to speak, a miracle, as it is extremely unlikely on the basis of a random choice of the values of the constants that characterize it (reliable calculations would give it with a probability out of 10^{230}). But if the universe were eternally cyclical, or if instead of there being only one universe, there were an infinite set of universes[24] (with the cardinality of the countable), and if each of them emerged from random initial conditions or laws and were characterized by its own particular duration of time, varying from a small fraction of a second to many billions of years, then there would also be an infinite subset of universes similar or identical to ours. This argument would follow from a law called "totalitarian law" introduced by the physicist Lüdwig Boltzmann at the end of the nineteenth century (but already mentioned a century earlier by the physicist and mathematician Ruggiero Giuseppe Boscovich), according to which, in a globally eternal cosmic reality, any phenomenon compatible with the laws of nature, not only it does happen sooner or later, but it must have already happened and it will have to happen an unlimited number of times,.

To conclude, I express the hope that my theory of consciousness can open a glimmer towards a worldview based on unanimously shared principles and on a physicalistic monism that would still leave room for discussing forms of mysticism under a new light. However, I must add that cosmic reality, although physical in all its aspects, or whatever it might be, is so extraordinary, powerful and dazzling that it resembles a supernatural entity.

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[23] Some questions, even if judged unfathomable, can receive more reasonable answers than others, such as, for example, Aristotle's idea of the eternal universe as more reasonable than the idea of the universe generated by any cause.

[24] The aforementioned scenarios are predicted by some cosmological models and, particularly, by my personal model available on Google with the Title "Into the Depth of Nothingness" (Italian version "Un Modello del Nulla") in which I maintain that cosmic reality exists by logical necessity and that it is given by an infinite set of universes (bubbles) with the cardinality of the countable,

Appendix 1

1. ***Equation of*** $\boldsymbol{LC_{2/3}}$

We now propose to find the equation of $LC_{2/3}$ and to define its curvature and torsion. Given a curve $LC_{2/3}$ inscribed in the unit side tetrahedron (figure 16), a parametric equation will be obtained starting from its flat development (figure 17) and first parameterizing the single arcs $\alpha 2$, $\alpha 3$, $\alpha 4$ and then rotating them by an appropriate angle around each of the sides of the central triangle.

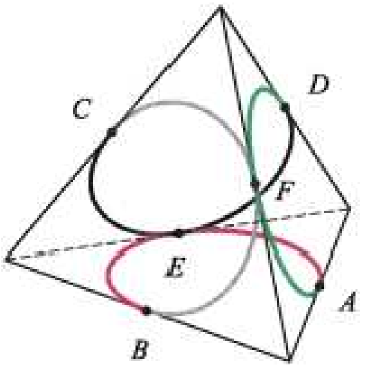

Fig. 16

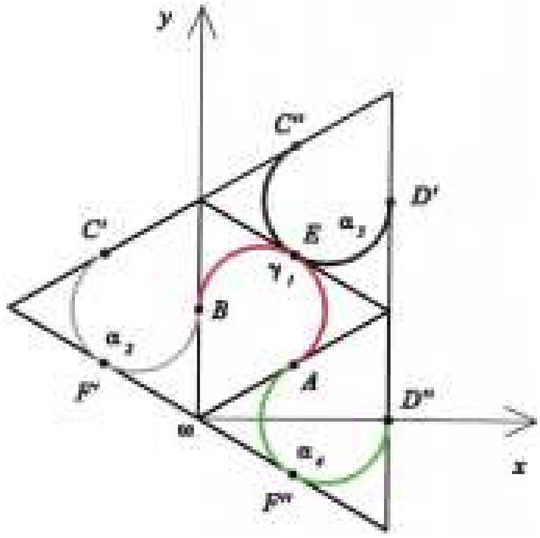

Fig. 17

Equation of $LC_{2/3}$

$$\gamma = \begin{cases} x = \begin{cases} \frac{\sqrt{3}}{6}(1-\cos t) & t\in\left[-\frac{4\pi}{3},0\right] \\ \frac{\sqrt{3}}{18}(1-\cos t) & t\in\left[0,\frac{4\pi}{3}\right] \\ \frac{\sqrt{3}}{36}\cos t+\frac{1}{4}\operatorname{sen} t+\frac{2\sqrt{3}}{9} & t\in\left[\frac{4\pi}{3},4\pi\right] \end{cases} \\ y = \begin{cases} \frac{1}{2}\left(1-\frac{\sqrt{3}}{3}\operatorname{sen} t\right) & t\in\left[-\frac{4\pi}{3},\frac{4\pi}{3}\right] \\ \frac{1}{12}\cos t-\frac{\sqrt{3}}{12}\operatorname{sen} t+\frac{2}{3} & t\in\left[\frac{4\pi}{3},\frac{8\pi}{3}\right] \\ -\left(\frac{1}{12}\cos t-\frac{\sqrt{3}}{12}\operatorname{sen} t\right)+\frac{1}{3} & t\in\left[\frac{8\pi}{3},4\pi\right] \end{cases} \\ z = \begin{cases} 0 & t\in\left[-\frac{4\pi}{3},0\right] \\ \frac{\sqrt{6}}{9}(1-\cos t) & t\in\left[0,4\pi\right] \end{cases} \end{cases}$$

It is verified that the curve is *regular* [25] and that one can always speak of *curvatur*[26] (k); this, in particular, is constant and of value $k = 2\sqrt{3}$ (the reciprocal of the radius $r = \frac{\sqrt{3}}{6}$ incribed on the face of the tetrahedron), while, since $LC_{2/3}$ is composed of four arcs of plane curves, the *torsion*[27] (τ) is $\tau = 0$ everywhere except in the points A, B, C, D of passage from one face to the other of the tetrahedron where it is not defined.

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[25] A curve γ is said to be *regular* if it is C^1 and if $|\gamma'| \neq 0$ $\forall$t.

[26] Placing the curve in the form $\gamma = \gamma(s)$ with curvilinear abscissa s, it is called *curvature* $k = |\ddot{\gamma}(s)|$; it is an index of deviation of the trend of the curvefrom that of a straight line.

[27] If t, n are unit versors respectively tangent and normal to the curve and $\boldsymbol{b} = \boldsymbol{t} \wedge \boldsymbol{n}$ we say *torsion* $\tau = |\dot{\boldsymbol{b}}(s)|$; it is an index of deviation of the trend of a curve from the flat one.

2. ***Axes and planes of symmetry of $LC_{2/3}$***

We want to look for any axes and planes of symmetry of $LC_{2/3}$. For this purpose, among the isometries of the group of the tetrahedron, S_T, let us consider those which also leave the aforementioned curve unchanged; they are of two types: *axial symmetry* and *orthogonal symmetry*. Here we will examine them with reference to figure 18, where 1, 2, 3 and 4 indicate the positions that the vertexes of the tetrahedron will maintain in space.

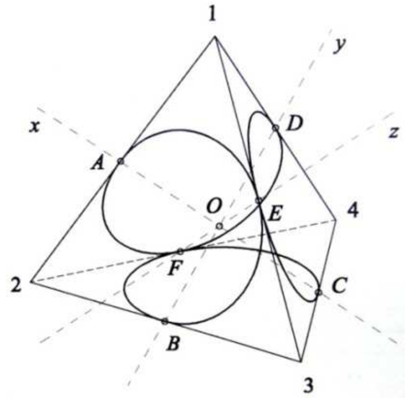


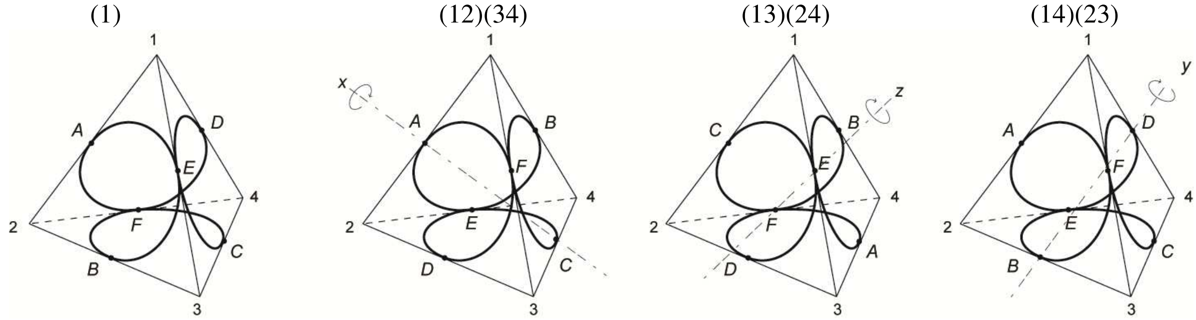
Fig. 18

Axial symmetry (or rotational symmetry) has as its axis the straight line which connects the midpoints of two opposite sides of the tetrahedron, for example the straight line x which connects points *A* and *C*. The symmetry is obtained following a rotation of 180 ° around said axis, which, in the example considered, exchanges the vertices in positions 1 and 2 and the vertices in positions 3 and 4. Indicate with y and z the other two straight lines which join the midpoints of two opposite sides of the tetrahedron , we will obtain two other similar symmetries. The x, y, z axes of the tetrahedron are therefore the axes of symmetry of $LC_{2/3}$.

These straight lines, perpendicular to each other, identify three pairs of points symmetrical with respect to the center of the curve and behave with respect to this in two different ways: z intersects it in the two multiple points *E* and *F* (in fact, both the arc *AB* that *CD*, and through F pass both the arc *DA* and *BC*), while both x and y intersect it in two points, respectively *A*,*C* and *D*,*B*, counted only once.

In summary, the symmetries of the tetrahedron that leave the $LC_{2/3}$ curve unchanged are: the identity rotation and the rotations around the x, y, z axes (figures 19 *a*, *b*, *c*, *d*):

(1) (12)(34) (13)(24) (14)(23)



Figg. 19 *a*, *b*, *c*, *d*.

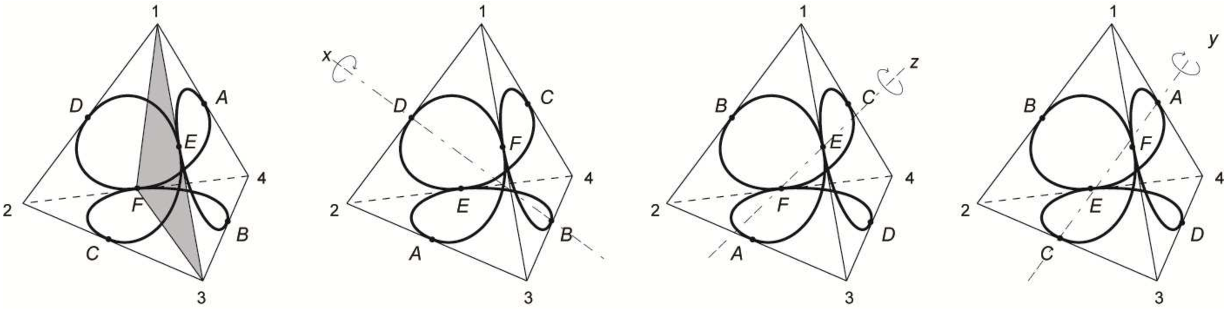
The set of these transformations represents the following group:

$$\mathbf{V} = \{(1), (12)(34), (13)(24), (14)(23)\}$$

which is of the type 4-Klein group.

We then see that there are two orthogonal symmetries (or reflection symmetries), one with respect to the plane passing through the two vertices of the tetrahedron in positions 1 and 3 and the midpoint of the opposite side, the other with respect to the plane passing through the two vertices at positions 2 and 4 and the midpoint of the opposite side; said planes are therefore the planes of symmetry of $LC_{2/3}$. By composing one of the two reflections, for example (24), with the previous rotations, the following further symmetries are obtained (figures 20 *a*, *b*, *c*, *d*):

(24) | (24)∘(12)(34) = (1432) | (24)∘(13)(24) = (13) | (24)∘(14)(23) = (1234)



Figg. 20 *a*, *b*, *c*, *d*

.

The set of all transfprmations of the tetrahedron that leave the curve $LC_{2/3}$ unchanged forms the following group of order 8:

$$\mathbf{M} = \{(1), (12)(34), (13)(24), (14)(23), (24), (1432), (13), (1234)\}$$

which is isomorphic to the dihedral group **D**4 (congruence group of a square) and, therefore, non-abelian.

We report below the table of composition of the group **M**.

Table 1

∘	**(1)**	**(12)(34)**	**(13)(24)**	**(14)(23)**	**(24)**	**(1432)**	**(13)**	**(1234)**
(1)	(1)	(12)(34)	(13)(24)	(14)(23)	(24)	(1432)	(13)	(1234)
(12)(34)	(12)(34)	(1)	(14)(23)	(13)(24)	(1432)	(24)	(1234)	(13)
(13)(24)	(13)(24)	(14)(23)	(1)	(12)(34)	(13)	(1234)	(24)	(1432)
(14)(23)	(14)(23)	(13)(24)	(12)(34)	(1)	(1234)	(13)	(1432)	(24)
(24)	(24)	(1234)	(13)	(1432)	(1)	(14)(23)	(13)(24)	(12)(34)
(1432)	(1432)	(13)	(1234)	(24)	(12)(34)	(13)(24)	(14)(23)	(1)
(13)	(13)	(1432)	(24)	(1234)	(13)(24)	(12)(34)	(1)	(14)(23)
(1234)	(1234)	(24)	(1432)	(13)	(14)(23)	(1)	(12)(34)	(13)(24)

It can be seen that the table is not symmetric with respect to the diagonal and, therefore, the group **M** is not commutative (that is, in general, a∘b ≠ b∘a). In fact, for example, (14)(23)∘(24) ≠ (24)∘(14)(23). Furthermore, observe that **M** has **V** as its commutative subgroup.

We conclude this section by verifying whether $LC_{2/3}$ satisfies Euler's formula m = 2(S+F+V−2), where "m" denotes the total number of symmetries. Assuming that the concepts of sides and faces are generalized respectively in terms of edges denoted by "E", vertices by "V" and planes of spatial orientation by "P", and that therefore $m = 2(E+V+P-2)$, the curve $LC_{2/3}$ (as well as the conical surface $LS_{2/3}$) has $m = 2(1+1+4-2) = 8$.[28]

3. ***A new type of isometry: the pluripolar rotation (in this case it is quadripolar)*** [29]

We now want to propose a particular isometry which allows the curve $LC_{2/3}$ (and thus also all the analogous figures, described and depicted in the sequel of this chapter and towards the end of the next one) to transform into its symmetrical one without resorting to a plane of reflection. This satisfies the entirely personal need to interpret 3-D geometry in a physical sense and therefore to consider only the transformations obtainable by "moving" the object within the 3-D space. Let's see how this is possible.

Let us take an $LC_{2/3}$ inscribed for simplicity in a tetrahedron (figure 21) and draw four half-lines, a, b, c, d, with origin in the center of the curve and passing through the center of the faces of the tetrahedron (they coincide with the extension of the four heights of the tetrahedron). These half-lines, which we call the polar axes of the curve, form two by two an angle $\alpha = 2\text{arc}\cos(1/3)$. If $LC_{2/3}$ is made to "scroll" around its four polar axes, all its points move by arcs of equal measure, but without keeping the reciprocal distances equal in three-dimensional space. However, the initial distances between the points are reset each time they have traveled a quarter of the curve. Four different symmetries are thus obtained which we call "quadripolar rotations", in this case of 240°, 480°, 720°, 960°, and which we will denote respectively by $rq_{1/4}$, $rq_{1/2}$, $rq_{3/4}$, rq_1 (rq_1 is equivalent to the identity rotation).

As an example, let's take a $LC_{2/3}$ (figure 22 *a*), where 1, 2, 3, 4, 5 and 6 indicate the positions that its critical points will keep in space, and let's see how the transform is obtained (figure 12 *b*) applying a $rq_{1/4}$ according to the sliding direction indicated by the arrows: point *A* goes from position 1 to position 2, point *B* from position 2 to 3, *C* from 3 to 4, *D* from 4 to 1, while the points *E* and *F* exchange each other in positions 5 and 6. The result is equal to the reflection symmetry (1432) previously described (figure 20 *b*).

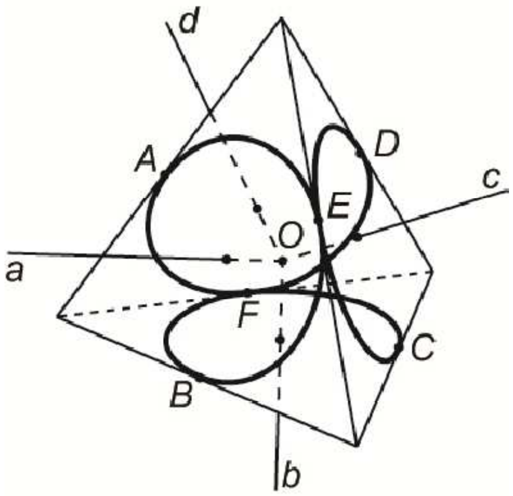


Fig. 21

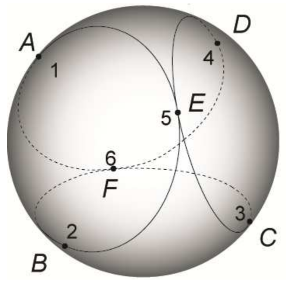


Fig. 22 *a*

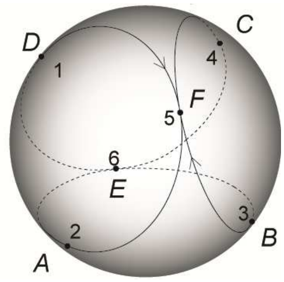


Fig. 22 *b*

It can thus be demonstrated that the group **M** of the symmetries of $LC_{2/3}$ is entirely expressible through rotations, of the axial and quadripolar type.

4. ***The M group through quadripolar rotations***

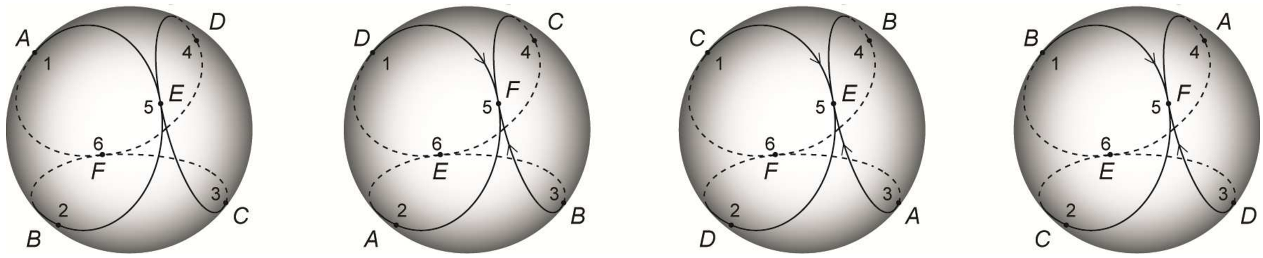
We will apply the quadripolar rotations to the curve of figure 22 *a*, indicating its sliding direction by means of arrows. Since here reference is made to six positions, and no longer to four (those that the vertices of the tetrahedron keep in space, as seen in the previous section 4), the form with which the transformations of $LC_{2/3}$ will now be indicated will be the following: figures 23 *a*, *b*, *c*, *d* (note that the 23 *a*, *b* are equal to the 22 *a*, *b*) and figures 24 *a*, *b*, *c*, *d*:

---

[28].Figures analogous to $LC_{2/3}$ can be constructed, for example one with m = 12. This figure, which we call $LC_{3/4}$ ($LS_{3/4}$ and $LV_{3/4}$), is obtained from the intersection of a hexahedron with side *a* and a sphere with center in the barycenter of the hexahedron and radius $r = ½\, a$. (see Appendix 2).

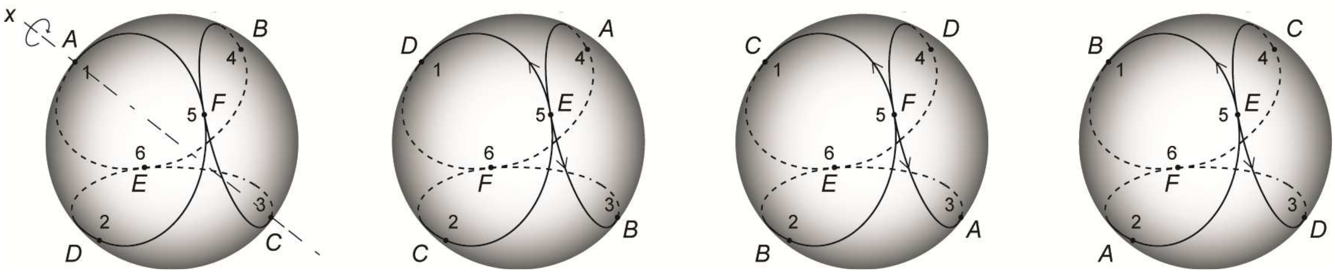
[29] To follow the description of quadripolar rotations in an easier and more enjoyable way, it is suggested to use a model of $LS_{2/3}$ (surface of $Loop_{2/3}$) which can be constructed with cardboard and scissors by following the instructions in Appendix 2.

(1) | *$rq_{1/4}$* (1234)(56) | *$rq_{1/2}$* (13)(24) | *$rq_{3/4}$* (1432)(56)



Figg. 23 *a*, *b*, *c*, *d*.

(24)(56) | *$rq_{1/4}$* 24)(56) ∘ (1432)(56) = (14)(23) | *$rq_{1/2}$* (24)(56) ∘ (13)(24) = (13)(56) | *$rq_{3/4}$* (24)(56) ∘ (1234)(56) = (12)(34)



Figg. 24 *a*, *b*, *c*, *d*.

Figures 23 *a*, *b*, *c*, *d* represent, in order, the identity rotation and the three rotations *rq1/4*, *rq1/2*, *rq3/4*, while figures 24 *a*, *b*, *c*, *d* represent the axial rotation followed by the aforementioned three rotations. The following group **L** of order 8 is thus obtained, including all the transformations which leave the curve $LC_{2/3}$ unchanged:

$$\mathbf{L} = \{(1), (56)(1234), (13)(24), (56)(1432), (24)(56), (14)(23), (13)(56), (12)(34)\}.$$

We observe that the axial rotation (figure 24 *a*), here applied around the x axis passing through the pair of points in positions 1 and 3, leaves these fixed and exchanges the points in positions 2 and 4 and the points in positions 5 and 6; consequently, in the following three transformations, the arrows indicating the direction chosen for scrolling the curve will be inverted. Furthermore, we note that the rotation *rq1/2* is equivalent to an axial rotation, while the rotations *rq1/4* and *rq3/4* are both equivalent to a reflection symmetry. Finally, the elements of **L** can be compared with those of **M**, described previously, to verify that each element of one set corresponds to an equivalent element of the other set. For example, one will find that (1234)(56) of **L** is equivalent to (1432) of **M**. So, in summary, **L** = **M**.

5. *Properties of the x, y, z symmetry axes of $LC_{2/3}$*

Referring to figure 18, it can be demonstrated that the *x*, *y*, *z* axes are mutually perpendicular. We observe that with respect to the curve they behave in two different ways: the *z* axis intersects $LC_{2/3}$ in the two points *E* and *F*, each counted twice (in fact, both the arc *AB* and *CD* pass through the point *E*, and through the point *F* pass both arc *DA* and *BC*), while the x and y axes intersect $LC_{2/3}$ each in two points (respectively *A*,*C* and *D*,*B*) counted only once.

The three axes *x*, *y*, *z* identify a variety of sub-curves of $LC_{2/3}$, whose properties and symmetries we will study below.

6. *Subcurves of $LC_{2/3}$*

Referring again to Figure 18, $LC_{2/3}$ can be seen as formed by the two closed curves *AECFA* and *BEDFB* which intersect along the *z* axis, and which we will call *Loop Curve*$_{1/3}$, briefly $LC_{1/3}$ (Figures 25 *a*, *b*).

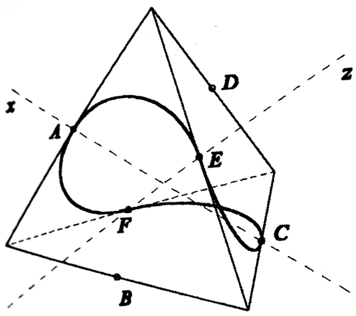


Fig. 25 *a*

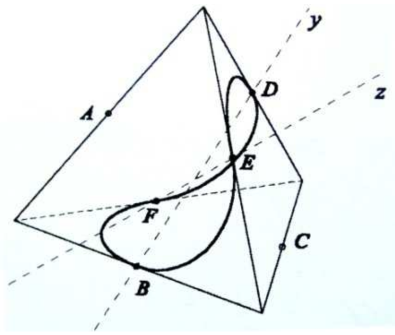
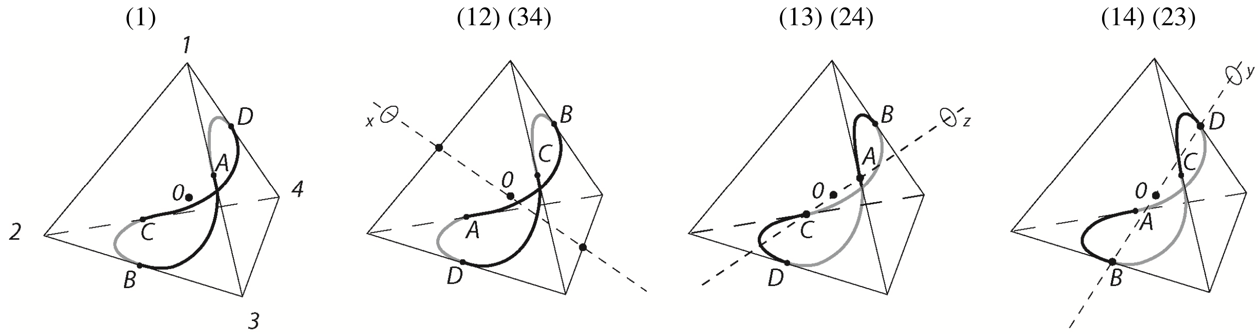


Fig. 25 *b*

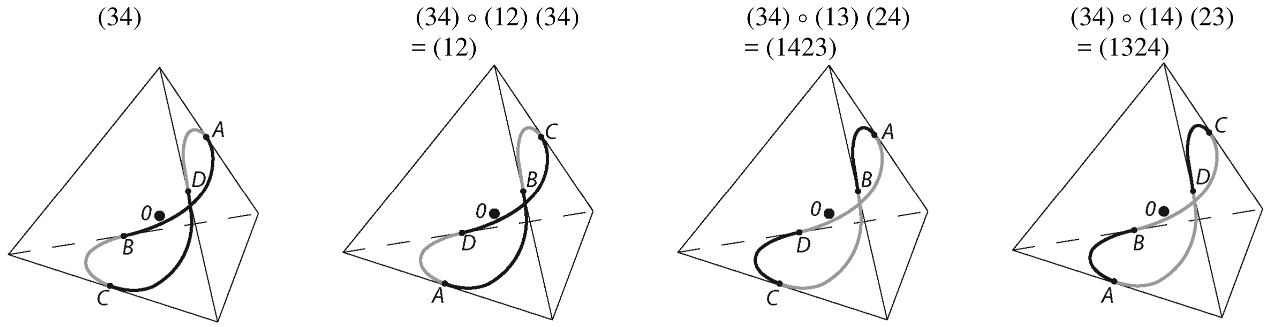
The two curves thus identified are symmetrical and superimposable. $LC_{2/3}$ has two axes that pass through its center, each intersecting it in two symmetrical points with respect to the latter. As can be seen, this curve has, like $LC_{2/3}$, four critical points (in the figures they are respectively *A*,*E*,*C*,*F* and *B*,*E*,*D*,*F*) but no point counted twice.

7. ***Symmetries of $LC_{1/3}$***

The symmetries that $LC_{1/3}$ send in themselves are the identity, the three axial rotations and the four corresponding reflections (figures. 26 *a*, *b*, *c*, *d* and 27 *a*, *b*, *c*, *d*). They are therefore the same ones already studied for $LC_{2/3}$. However, if you compare these figures with 19 *a*, *b*, *c*, *d* and 20 *a*, *b*, *c*, *d*, you can see that the first four elements are the same, while the elements relating to the four reflections are different. The reason for this lies in the initial choice of the identity element and, in the specific case of the $LC_{1/3}$ studied here, the reflection symmetries are related to two of the six orthogonal symmetry planes of the tetrahedron in which it is inscribed, which however are not (and cannot be) the same as the reflection symmetries of the $LC_{2/3}$ of Figure 8 in which it was identified. In fact, the two reflection planes of $LC_{2/3}$ are, in this case, one passing through side 12 and the midpoint of side 34, and the other passing through 34 and the midpoint of 12.



Figg. 26 *a*, *b*, *c*, *d*



Figg. 27 *a*, *b*, *c*, *d*

On the basis of what has been observed above, the elements of the reflection symmetries of a LC1/3 having, for example, the identity element as in figure 15 *a*, will be (23), (14), (1324), (1243). Clearly, in order for $LC_{1/3}$ to re-propose the elements (24), (13), (1432), (1234) observed in figures 14 *a*, *b*, *c*, *d*, it will be enough to choose the identity element in an appropriate way.

The group structure of $LC_{1/3}$ is, like that of $LC_{2/3}$, isomorphic to the dihedral group **D**4.

Appendix 2

1. ***Some of the thirteen toroidal Hemiloop and Loop Volumes (shortly HLV and LV) derived from the respective Platonic Loop[30] curves are illustrated below*:**

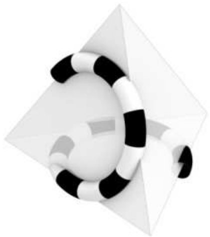


Fig.28 *a*
$ELV_{2/3}$ of the tetrahedron

Fig. 28 *b*
$LV_{2/3}$ of the tetrahedron

Fig. 28 *b*-bis
$LV_{2/3}$ Self- interaction

Fig. 29 *a*
$ELV_{1/3}$ of the tetrahedron

Fig. 29 *b*
$LV_{1/3}$ of the tetrahedron

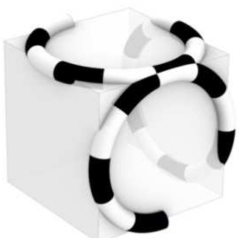


Fig. 30 *a*
$ELV_{3/4}$ of the hexahedron

Fig. 30 *b*
$LV_{3/4}$ of the hexahedron

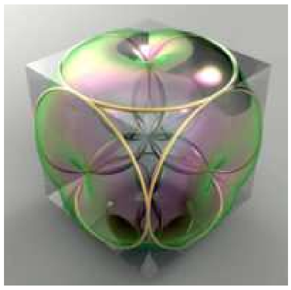


Fig. 30 *b*-bis
$LV_{3/4}$ Self-interaction

2. ***Hemiloops and corresponding platonic loops that have a development of 720°***

Fig. 31 *a*
$ELV_{1/2}$ of the hexahedron

Fig. 31 *b*
$LV_{1/2}$ of the hexahedron

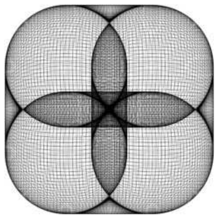


Fig. 31 *b*-bis
$LV_{1/2}$ Self-interaction

[30] For more information, see on Google my article "Spherical Loops" Research Gate. Note that the Hemiloop and Loop illustrated here could be extended up to their center (as in the passage from figure 29 *b* to 29 *b*-bis). The Hemiloops and Loops of the dodecahedron and icosahedron will not be shown because difficult to read.

Fig. 32 *a*
$ELV_{1/3}$ of the octahedron

Fig. 32 *b*
$LV_{1/3}$ of the octahedron

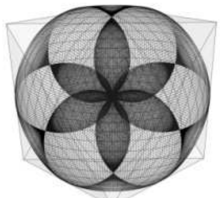


Fig. 32 *cb*-bis
$LV_{1/3}$ Self-interaction

Fig. 33 *a*
$ELV_{1/5}$ dof the dodecahedron

Fig. 33 *b*
$LV_{1/5}$ of the dodcahedron

Fig. 33 *b*-bis
$LV_{1/5}$ Self-interaction

Appendix 3

1. ***Spin of the electron***

Let's see how the electron, conceived as a spherical loop rotating around more than two axes, behaves when it passes through a Stern-Gerlach magnet (S-G) to measure its spin.

According to the philosophical view of EPR-Bohm (EPRB), quanta correlations are pre-determined at the source, i.e. each of the two particles in the spin singlet state "knows", since its origin, how to react with the measurement device towards which it is directed. But it should be stressed that the EPRB argument does not include a model capable of explaining *how* quantum correlations are predetermined at the source and therefore, it is not strong enough to contrast Bohr's philosophical position. We should definitely need something different!

In the thought experiment I'm going soon to propose, I will describe quantum systems and their dynamics with specific topological properties.

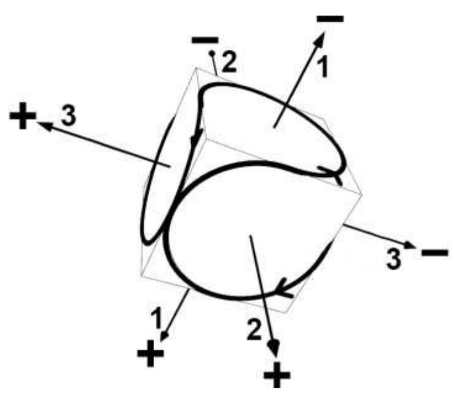
The experiment is based on three physical concepts:

(a) –Electrons, are spherical loops:[31] particularly, their intrinsic angular momentum is correspondent to a spinning about a number n of axes with $n \geq 3$, among which only one plays an effective role in the measuring process; more precisely, it is the axis which forms the minor angle with the direction of the S-G magnetic field and which will here be called "**DSA**" (Dominant Spin Axis).

(b) – Two loops in the spin one-half singlet state, after being emitted from the source, move away in opposite directions maintaining the initial orientation[32] until they interact with the magnetic field of the S-G apparatuses towards which they are directed.

(c) – The **DSA** of a loop which is crossing a S-G apparatus is subject to a precession[33] around the direction of its field.

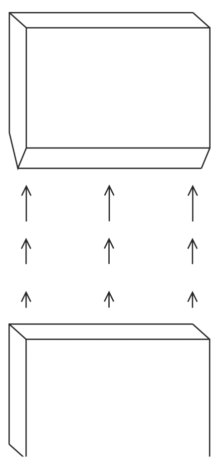
In the following we will assume that the intensity of the S-G magnetic field increases from its north pole (the lower component labelled "−") to its south pole (the upper cuneiform component labelled "+"), as shown in figure 35.



a

Fig. 34

+



−

Stern-Gerlach magnet

Fig. 35

In figure 34, the spherical loop of the hexahedron, **a**, simulates an electron that moves along the direction of x; a will cross the inhomogeneous magnetic field of the Stern-Gerlach magnet and ,it will come out deflected up(wards), because il will be attracted by the upper positive component more strongly than it will be by the lower negative component.

2. "***Incompatible measurements of spin***", first version**.**

Let us imagine a source capable of emitting pairs of particles in the spin-1/2 singlet state, **a** and **b**, respectively directed towards a detector vertically oriented and a detector horizontally oriented.

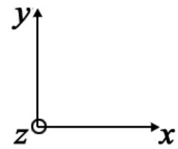
---

[31] Each of these loops is thought as a stationary wave enclosed inside a spherical pluripolar horizon, i.e. energy forced to circulate restlessly along a close path and, therefore, behaving like an electrical field that generates a magnetic field..

[32] This condition referred to a pair of loops in the singlet state can be defined "principle of conservation of spatial orientation".

[33] It is called "Larmor precession" from the name of physicist Joseph Larmor. In the new context of the loops, the precession means that, while a loop is crossing the inhomogeneous magnetic field of a S-G apparatus, its spin axes which do not interact with the field will rotate around the **DSA** (for an adequate description of this process See footnote 18).

The experimental setup is now sketched in figures 36*a* and 36*b*, where you can see a pair of particles simulated by a pair of loops $LC_{3/4}$ of the hexahedron, two detectors labelled “M1” and “M2” and two observers, A situated on the left sector and B on the right sector.



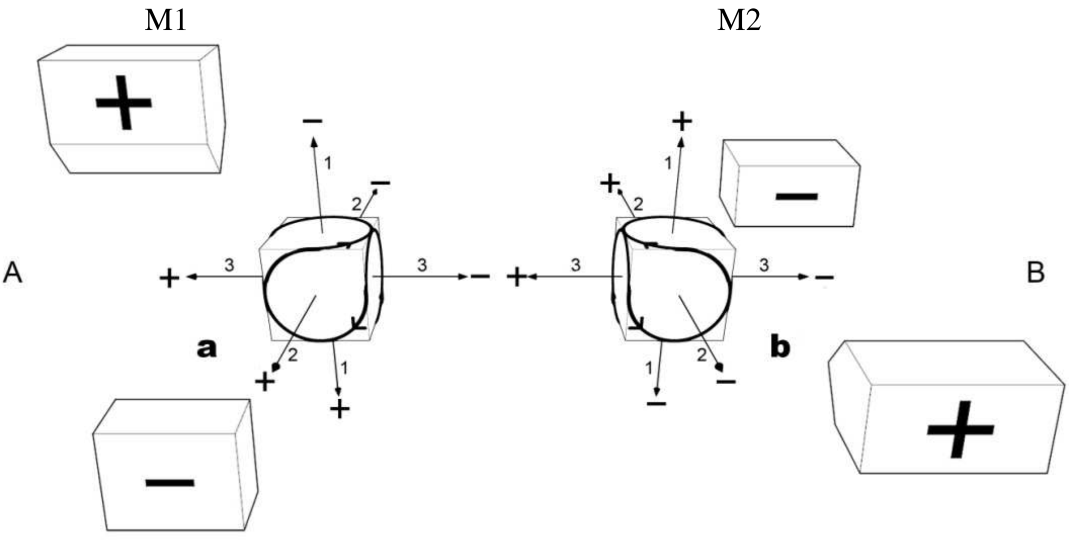


Fig. 36*a*
scenario n°1
(**a**'s **DSA**=1), A will measure spin $s=y+$ (**b**'s **DSA**=2), B will measure spin $s=z+$
(More simply, observer A will measure **a**’s spin *up*, while observer B will measure **b**’s spin left).

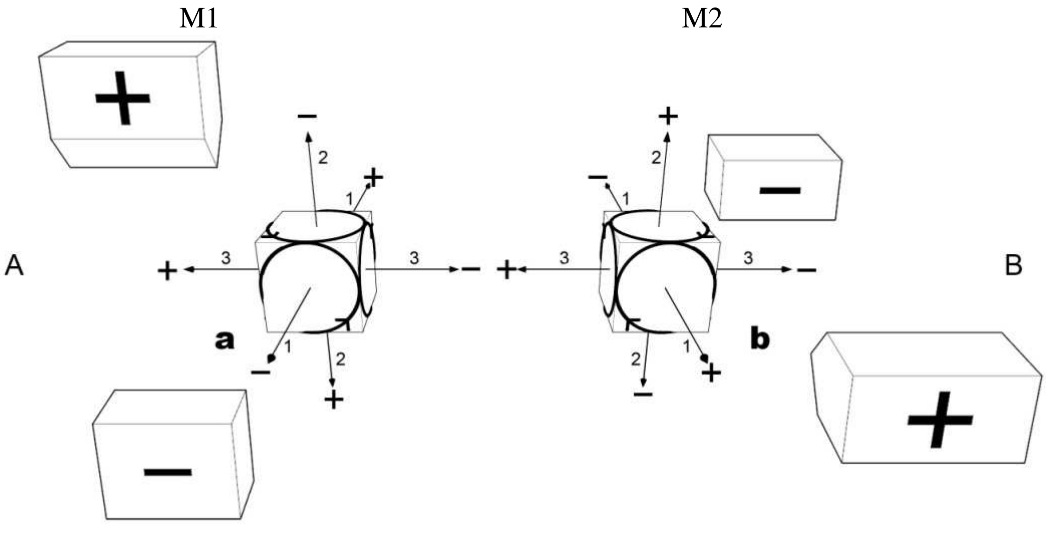


Fig. 36*b*
scenario n°2
(**a**'s **DSA**=2), A will measure spin $s=y+$ (**b**'s **DSA**=1), A will measure spin $s=z-$
(here, the pair of loops **a** and **b**, with respect to the scenario n°1, are rotated by 90° clockwise about the positive direction of the *x*-axis: thus, the configuration has changed and, while observer A will again measure **a**’s spin *up*, observer B will now measure **b**’s spin *right;* note that the pair of loops of figure 36*a* would assume other different configurations if again rotated clockwise about the positive direction of the *x*-axis, a first time by 180° and a second time by 270°).

In the example sketched in the above figure, imagine that observer A measures **a**'s spin, s, along the y-axis, and finds $s_y = s+$. According to the principals of quantum theory, **b**'s spin will be in the state $|\, s-\rangle$. In the other sector, if observer B decides to measure **b**'s spin along the same axis, he will find $s_y = s-$ with probability P=1. But what happens if B decides to measure **b**'s spin along the z-axis? He will have probability ½ to find $s_z = s+$ and. probability ½ to find $s_z = s-$. Supposing that he finds $s_z = s+$ (spin *left*), he would deduce that **a**'s spin is now in the state $|\, s-\rangle$, i.e. $|\, s$, right$\rangle$. But such a supposition is meaningless if referred to the above figures, since the particle is going to be, or has already been, measured by a S-G vertically oriented. As well-known, in all the experiments performed so far, the spin of electrons (more precisely, silver atoms vaporized in an oven) emerging from a S-G apparatus, e.g. vertically positioned, has been always observed in one of two possible deflections, *up* or *down*, and never in any other intermediate deflection. These results have not yet found a logical explanation and, as I presume, the reason should be due to the fact that the electron is to simply thought of as a tiny magnetic bar. But now, having conceived an innovative model of the electron, it will be possible to provide a logical explanation to those results. In fact, the idea that atomic systems, such as electrons, may rotate around more than two axes, instead of one only, sounds much more reasonable, even though very difficult to imagine.

3. "***Incompatible measurements of spin***", second version.

We recall the attention to section 2 in which we have imagined a source capable of emitting pairs of particles in the spin-1/2 singlet state, **a** and **b**, respectively directed towards a detector vertically oriented and a detector horizontally oriented.

The experimental setup is now sketched in figures 37*a*, *b*, *c*, where you can see a pair of particles simulated by a pair of loops $LC_{3/4}$ of the **octahedron,** two detectors labelled "M1" and "M2" and two observers, A situated on the left sector and B on the right sector.

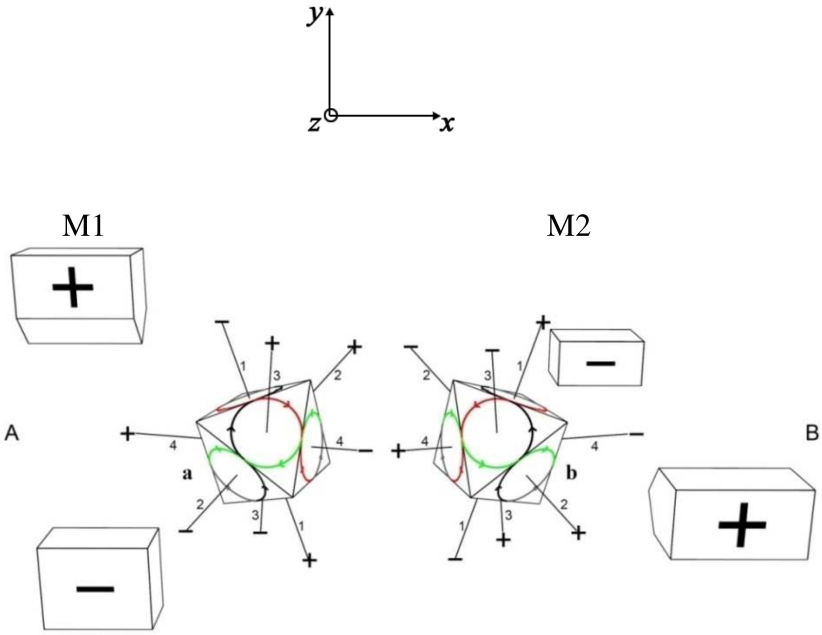


Fig. 37*a*
scenario n°1

(**a**'s **DSA** = 1), A will measure spin $s = y+$ (**b**'s **DSA**=2), B will measure spin $s = z^-$

M1 M2

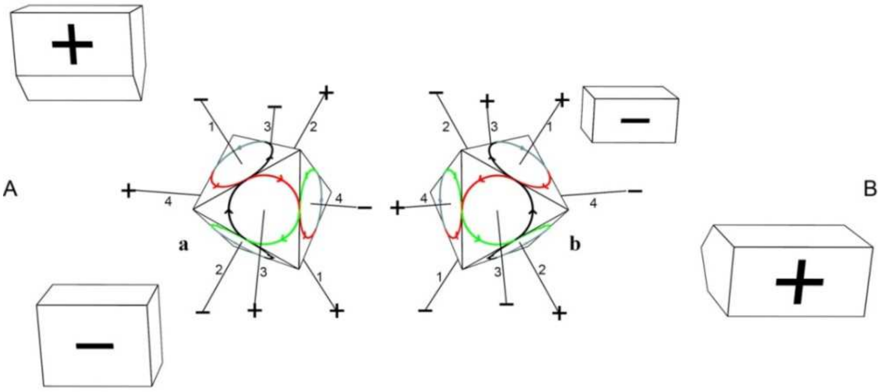


Fig. 37*b*
scenario n°2
(**a** and **b**, with respect to scen. n°1, are rotated by 25° clockwise around the positive direction of the *x*-axis)
(**a**'s **DSA** = 1), A will measure spin *s* = *y*+ (**b**'s **DSA** = 3), A will measure spin *s* = *z*+

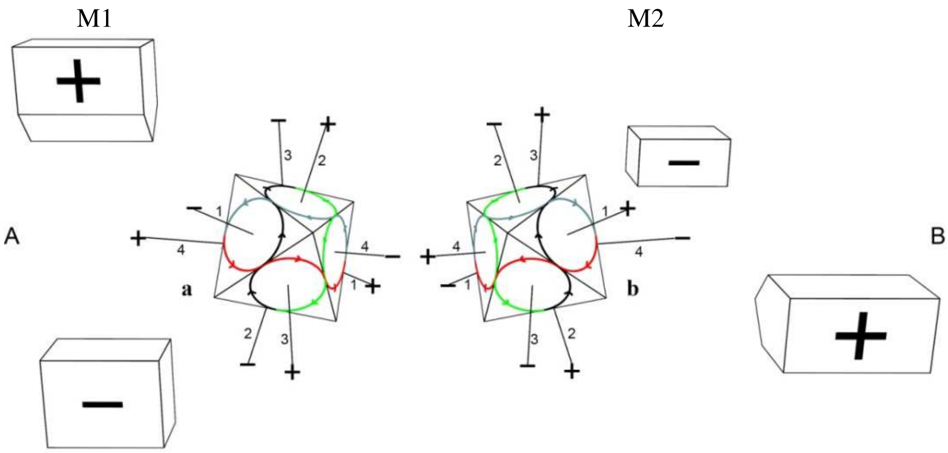


Fig. 37*c*
scenario n°3
(**a** and **b**, with respect to scen. n°1, are rotated by 60° clockwise around the positive direction of the *x*-axis)
(**a**'s **DSA** = 2), A will measure spin *s* = *y*− (**b**'s **DSA** = 3), A will measure spin *s* = *z*+

In conclusion, we have to say that each observer has probability ½ to measure either the spin *s*+ or *s*− for the simple reason that he doesn't know which of the possible scenerios is given when he is effectively going to measure the spin.

It should now be clear that, if you consider more reasonable a model of the electron based on the explicit properties illustrated in the above figures, your conclusion is that probabilities are epistemic. In fact, those figures are telling you that **a** and **b** "know" how to react with their respective detectors, no matter how A and B decide about their orientation.

4. *Amore detailed explanation of Stern-Gerlach experimental results*

A collimated beam of silver atoms[34] vaporized in an oven is directed towards a detector containing a Stern-Gerlach apparatus, which is here oriented along the *y*-axis and has its inhomogeneous magnetic field intensity increasing from the negative component up to ihe positive component. The detector has one entrance on the left and two exits on the right which are labelled "+" and "−"(figure 38). The beam will be split into two beams of equal intensity. The spin *s* of the electrons belonging to the upper beam will be denoted with "*sy* = *s*+", and the spin of the electrons belonging to the lower beam with "*sy* = *s*−".

[34] In a physical system such as a silver atom, the magnetic moment is associated to the magnetic angular momentum (spin) of the outmost electron. 0

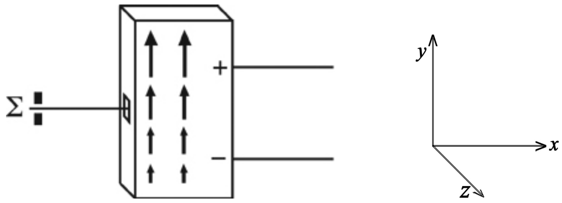


Figure 38

A beam of electrons is here simulated by a sequence of n **loops of the octahedron** randomly oriented (figure 39).

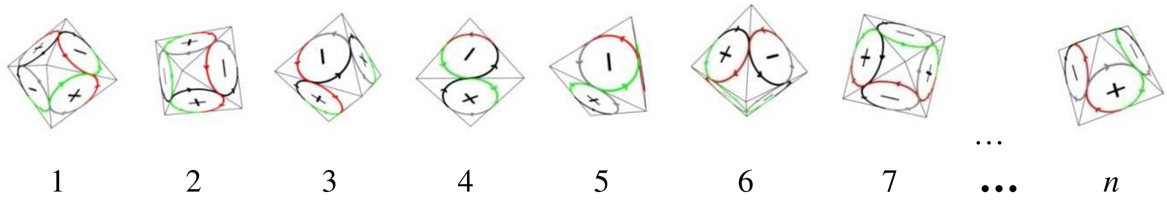


Fig. 39
(beam of loops 4-$LC_{1/3}$ of the octahedron, each with four spin axes)

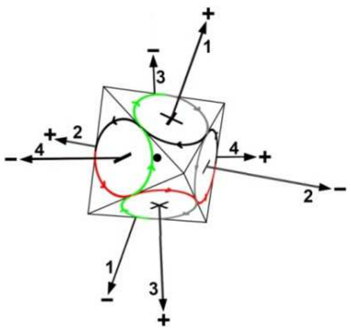


Fig. 40

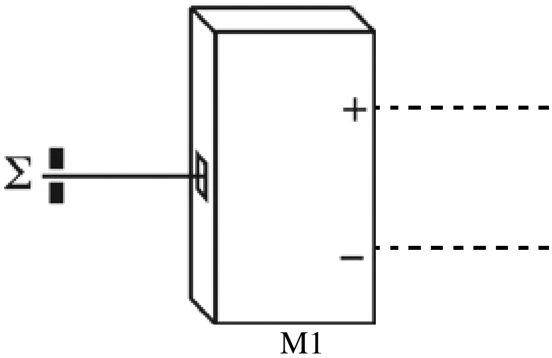


Fig. 41

In the above figures 38 and 39 is illustrated a source Σ which emits, though a collimator, a spherical loop of the octahedron towards the entrance of M1. The loop should be positioned on the right of the source but, in order to be visualized in all details, it is here shown on the left.

1st phase - The loop, once entered M1 with the **DSA 1**, will precess about the direction of the S-G magnetic field B(y) (figure 42) and, with its **axes 2, 3 and 4**, it will rotate about it.

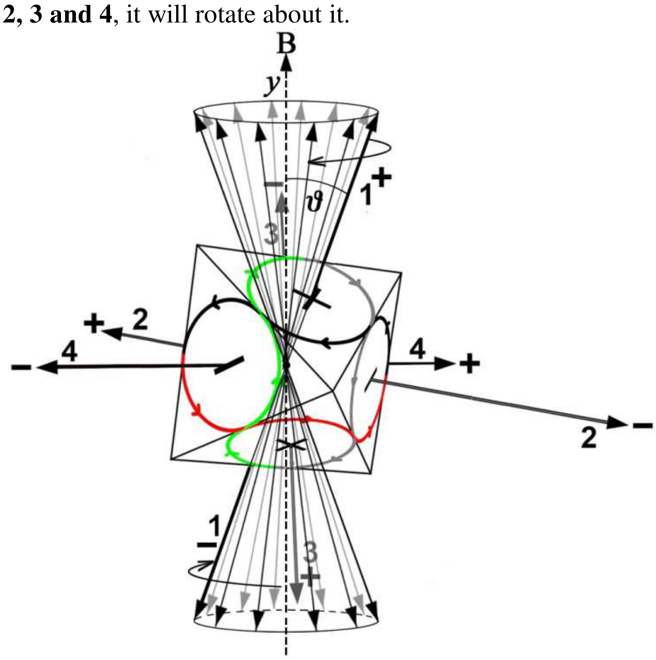


Fig. 42
(precession of **DSA 1** about B)

2nd phase – The loop enters M2 (figure 43) and its **DSA** will be one of the axes 2, 3 or 4, each with probability ½ of having the negative pole facing either the positive or the negative component of the S-G magnet (horizontally positioned). Therefore, the loop has probability 1/6 to assume one of six possible orientations.

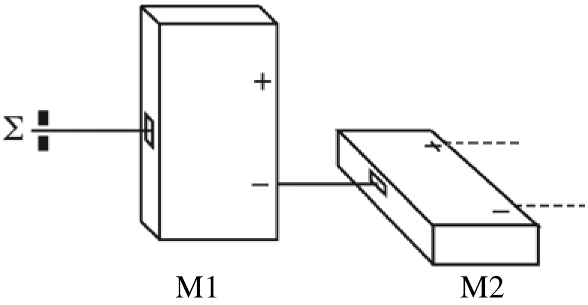


Fig. 43

Let us suppose that inside M2 the loop's **DSA** is the axis **4**, as illustrated in figure 44. This, which is oriented along the the direction of z, jointly with the **axes 1, 2 and 3**, will precess about B,.

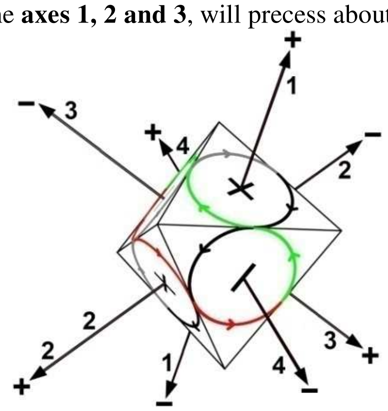


Fig. 44

The spin component of the loop, if measured, would be $s_z = s-$, so that it will emerge from the negative channel of M2 and proceed moving towards M3 (figure45).

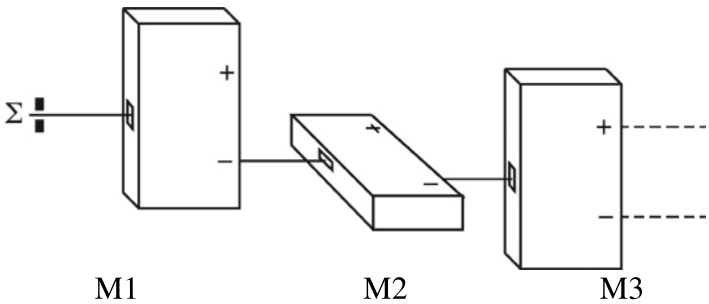


Fig. 45

3rd phase – We suppose that the loop, as soon as it is inside M3, has the **DSA 2** precessing about B(y) (figure 46).

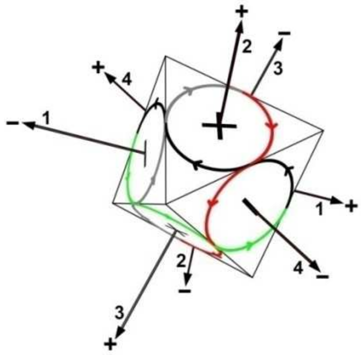


Fig. 46

If a measurement is now effectuated, the loop's spin will be found $s_y = s-$, for it will clearly emerge from the negative channel of M3 (figure 47).

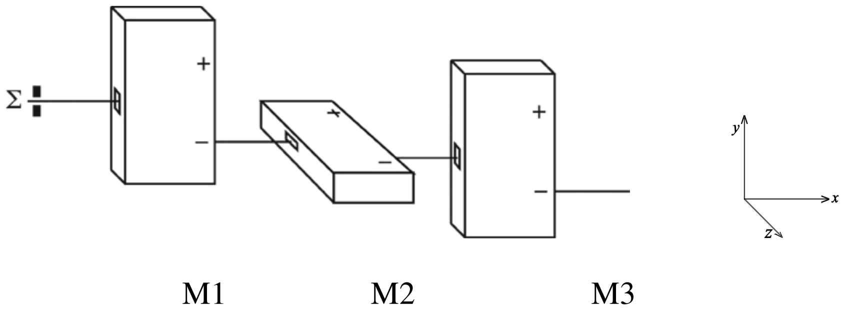


Fig. 47

Since in each phase, the loop has equal probability ½ to emerge either from the positive or the negative channel of the detector M3, we can come to the conclusion that a beam of n loops (with n very large), if directed towards three detectors in sequence, as illustrated in figure 48, will emerge from M3 being split into two beams of equal intensity, each constituted by $n/8$ loops. In this example, ¾ of the original loops will be dispersed out of the positive channels of M1 and M2, more precisely, ½ out of the positive channel of M1 and ¼ out of the positive channel of M2.

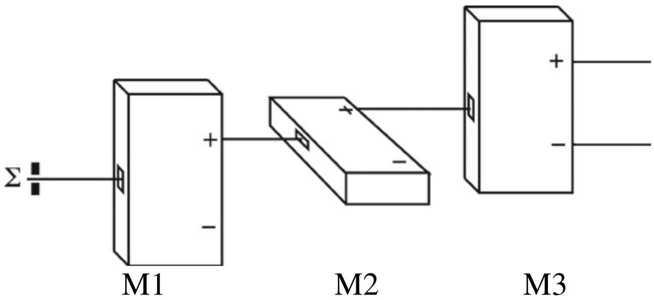


Fig. 48

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