A simple and unified explanation of the theories of modern physics and of the Universe

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Abstract

This paper summarizes how a new approach to the Universe, which has been recently exposed in two books *[1]*, allows to find a simple, unified and coherent explanation of all the theories of modern physics and of the Universe.

The basic concepts of this approach can be summarized as follows: *(i)* the support of the Universe is a form of *"ether"* which consists of a solid and massive lattice, with the simplest possible elasticity, and in which matter is represented by the set of topological singularities of this lattice (loops of dislocations, disclinations and dispirations), and *(ii)* this lattice exclusively satisfies, in absolute space, the basic classical physical concepts of Newton's law and the two principles of thermodynamics.

With these basic classical concepts alone, we show that it is possible to find all the modern theories of physics, namely that the behaviors of this lattice *(the Universe)* and its topological singularities *(the Matter)* satisfy electromagnetism, special relativity, general relativity, gravitation, quantum physics, cosmology and even the standard model of elementary particles.

The Quest for a Theory of Everything

Modern theories of physics are based on *mathematical relationships postulated to explain observed phenomena*, and not on an inference of these mathematical relationships from an understandable first principle. Electromagnetism is based on *Maxwell's equations*, without simple explanations of what electric and magnetic fields really are, what electric charge is, and how electromagnetic waves can propagate in a vacuum. Special relativity is based on *Lorentz transformations*, without any explanation of the root causes why time expands and lengths contract when an object moves at high speed, or in relation to what the object is moving. General relativity is based on *Einstein's famous equation* that relates the curvature of space-time to the mass and energy of matter in space, without any real explanation of why matter "curves" space-time, and even what space-time is exactly. Quantum physics is based on *Schrödinger's equation*, without any explanation of the deep reason for this relationship, what the wave function really is, and what defines the boundary between a classical and a quantum behavior of an object (quantum decoherence). *Cosmology* is based on *general relativity*, and it tries to describe the observed behaviors of the universe by injecting concepts, such as *dark* *matter* and *dark energy*, which have no underlying physical explanation for the moment, and which are introduced arbitrarily to make the theory fit the experiment. *The Standard Model of Elementary Particles* is constructed from numerous experimental observations, but without any explanation of what an elementary particle really is, why it has mass and electric charge, what its spin really is, what differentiates leptons and quarks, why there are three families of leptons and quarks, what weak and strong forces really are, and what explains the confinement and asymptotic behavior of the strong force.

In addition, these various theories do not have a common origin, and it seems very difficult, if not impossible, to unify them. The search for a theory of everything capable of explaining the nature of space-time, what matter is and how matter interacts, is in fact one of the fundamental problems of modern physics.

Since the 19th century, physicists have sought to develop unified field theories, which should consist of a coherent theoretical framework capable of taking into account the different fundamental forces of nature. Recent attempts to search for a unified theory include the following: the *"Great Unification"* which brings together the electromagnetic force, the weak interaction force and the strong interaction force, the *"Quantum Gravity"* and the *«Looped Quantum Gravitation»* which seek to describe the quantum properties of gravity, the *"Supersymmetry"* which proposes an extension of space-time symmetry linking the two classes of elementary particles, bosons and fermions, the *"String and Superstring Theories"*, which are theoretical structures integrating gravity, in which point particles are replaced by one-dimensional strings whose quantum states describe all types of observed elementary particles, and finally the *"M-Theory"*, which is supposed to unify five different versions of string theories, with the surprising property that extra-dimensions are necessary to ensure its coherence.

However, none of these approaches is currently able to consistently explain at the same time electromagnetism, relativity, gravitation, quantum physics and observed elementary particles. Many physicists believe that the 11-dimensional M-Theory is the Theory of Everything. However, there is no broad consensus on this and there is currently no candidate theory able to calculate known experimental quantities such as for example the mass of the particles. Particle physicists hope that future results from current experiments - the search for new particles in large accelerators and the search for dark matter - will still be needed to define a Theory of Everything.

But this research seems to have really stagnated for about 40 years. Since the 1980s, thousands of theoretical physicists have published thousands of generally accepted scientific papers in peer-reviewed journals, even though these papers have contributed absolutely nothing new to the explanation of the Universe and solve none of the current mysteries of physics. An enormous amount of energy has been put into developing these theories, in a race to publish increasingly esoteric articles, in search of a form of "mathematical beauty" that is ever more distant from the "physical reality" of our world. Moreover, enormous sums have been invested in this research, to the detriment of fundamental research in other areas of physics, in the form of the construction of ever more complex and expensive machines. And, to the great despair of experimental physicists, the results obtained have brought practically nothing new to high energy physics, contrary to the "visionary" and optimistic predictions of the theorists.

Many physicists now have serious doubts about the relevance of these theories of unification. On this subject, I strongly advise readers to consult, among others, the books by Unzicker and Jones *[2]*, Smolin *[3]*, Woit *[4]* and Hossenfelder *[5]*.

What if the Universe was a lattice?

In the approach we will present in this paper *[1,6]*, the problem of the unification of physical theories is treated in a radically different way. Instead of trying to build a unified theory by tinkering with an assemblage of existing theories, making them more and more complex and esoteric, even adding strange symmetries and extra dimensions for their "mathematical beauty», we start exclusively from *the most fundamental classical concepts of physics*, which are *Newton's equation* and *the first two principles of thermodynamics*. And using these fundamental principles, and developing an original geometry based on Euler coordinates to describe the topology of the Universe, we come, by a purely logical and deductive path, to suggest that the Universe could be a finite, elastic and massive solid, a *"cosmological lattice"*, which would move and deform in an infinite absolute vacuum. In this a priori strange concept, it is assumed that the Universe is a lattice of simple cubic crystalline structure, whose basic cells have a mass of inertia that satisfies Newtonian dynamics in absolute space, and whose isotropic elasticity is controlled by the existence of an internal energy of deformation as simple as possible.

By introducing into infinite absolute space *a purely imaginary observer called the Great Observer GO*, and by equipping this observer with a reference system composed of an orthonormal absolute Euclidean reference frame to locate the points of the solid lattice and an absolute clock to measure the temporal evolution of the solid lattice in absolute space, a very detailed description of the spatio-temporal evolution of the lattice can be elaborated on the basis of the Euler coordinate system *[7]*. In this coordinate system of the Great Observer GO, one can then describe in a very detailed way *the distortions (rotation and deformation)* and *the contortions (bending and torsion)* of the lattice. And one can also introduce topological singularities (dislocations, disclinations and dispirations) in this lattice in the form of closed loops *[8]*, as constitutive elements of Ordinary Matter.

If this original concept is developed in detail using an approach similar to the one used in solid state physics, it can be demonstrated by a purely logical and deductive mathematical path that the behaviors of this lattice and its topological singularities satisfy "all" the physics currently known, by spontaneously bringing out very strong and often perfect analogies with all the current major physical theories of the macrocosm and the microcosm, such as *the Maxwell equations [9], special relativity, Newtonian gravitation, general relativity, modern cosmology and quantum physics*.

But this approach does not only find analogies with other theories of physics, it also offers original, new and simple explanations to many physical phenomena that are still quite obscure and poorly understood at present by modern physics, such as the deep meaning and physical interpretation of *cosmological expansion, electromagnetism, special relativity, general relativity, quantum physics and particle spin*. It also offers new and simple explanations of *quantum decoherence* (the boundary between classical and quantum behavior of an object), *dark energy, dark matter, black holes,* and many other phenomena.

The detailed development of this approach also leads to some very innovative ideas and predictions, among which the most important is the appearance, alongside *the electrical charge*, of a new charge characterizing the properties of topological singularities, ***the curvature charge***, which is an inevitable consequence of the treatment of a solid lattice and its topological singularities in Euler coordinates. This concept of curvature charge has very important consequences and provides new explanations for many obscure points in modern physics, such as *weak force, matter-antimatter asymmetry, galaxy formation, segregation between matter and antimatter within galaxies, the formation of gigantic black holes in the heart of galaxies, the apparent disappearance of antimatter in the Universe, the formation of neutron stars, the concept of dark matter, the bosonic or fermionic nature of particles*, etc.

Finally, the study of lattices with special symmetries called *axial symmetries*, symbolically represented by *"colored" 3D cubic lattices*, allows us to identify an astonishing lattice structure whose looped topological singularities coincide perfectly with *the complex zoology of all the elementary particles of the Standard Model*. It also allows us to find simple physical explanations for *the weak and strong forces* of the Standard Model, including *the phenomena of confinement and asymptotic freedom* of the strong force.

It is this concept of *"cosmological lattice"* that we are going to detail in the rest of this paper, and we are going to show how this concept brings a simple and unified explanation of modern theories of physics and the Universe.

The formulation of the deformation of a solid lattice in Euler coordinates

When one wants to study the deformation of solid lattices, it is common practice to describe the evolution of their deformation using a *Lagrange coordinate system* and to use various differential geometries to describe the topological defects they contain.

The use of Lagrange coordinates to describe deformable solids presents a number of inherent difficulties. From a mathematical point of view, the tensors describing the deformations of a continuous solid in Lagrange coordinates are always of a higher order than one in the spatial derivatives of the components of the displacement field, which leads to a very complicated mathematical formalism when a solid presents strong distortions (deformations and rotations). To these difficulties of a mathematical order are added difficulties of a physical order when it is a question of introducing certain known properties of solids. Indeed, the Lagrange coordinate system becomes practically unusable, for example when it is necessary to describe the temporal evolution of the microscopic structure of a solid lattice (phase transitions) and its structural defects (point defects, dislocations, disclinations, joints, etc.), or if it is necessary to introduce certain physical properties of the medium (thermal, electrical, magnetic, chemical, etc.) resulting in the existence in real space of scalar, vector or tensor fields.

The use of differential geometries to introduce topological defects such as dislocations in deformable continuous media was initiated by the work of Nye (1953) *[10]*, who for the first time established the relationship between the dislocation density tensor and the curvature of the lattice. On the other hand, Kondo (1952) *[11]* and Bilby (1954) *[12]* have independently shown that dislocations can be identified with a crystalline version of Cartan's (1922) *[13]* concept of continuum torsion. This approach was formalized in great detail by Kröner (1960) *[14]*. However, the use of differential geometries to describe deformable media very quickly comes up against difficulties quite similar to those of the Lagrange coordinate system. A first difficulty is linked to the fact that the mathematical formalism is very complex, since it is similar to the formalism of general relativity, which consequently makes it very difficult to manipulate and interpret the general field equations thus obtained. A second difficulty appears with differential geometries when it is a question of introducing into the environment topological defects of other types than dislocations. For example, Kröner (1980) *[15]* proposed that the existence of extrinsic point defects, which can be considered as extra-matter, could be identified with the presence of matter in the universe and therefore introduced in the form of Einstein's equations, which would lead to a purely Riemannian differential geometry in the absence of dislocations. He also proposed that intrinsic point defects (vacancies, interstitials) could be approached by a non-metric part of an affine connection. Finally, he also considered that the introduction of other topological defects such as disclinations could call upon even more complex higher order geometries, such as Finsler or Kawaguchi geometries. In fact, the introduction of differential geometries generally gives rise to a very heavy mathematical artillery (metric tensor and Christoffel symbols) in order to describe spatio-temporal evolution in infinitesimal local reference points, as shown for example by Zorawski's mathematical theory of dislocations (1967) *[16]*.

Given the complexity of the calculations thus obtained, whether in the case of the Lagrange coordinate system or in that of differential geometries, it had long seemed desirable to me to try to develop a much simpler approach to deformable solids, but nevertheless just as rigorous, which was finally published in 2013 and 2016 in two first books *[7]* entitled «*Eulerian Theory of newtonian deformable lattices - dislocation and disclination charges in solids*».

These books describe how the deformation of a lattice can be characterized by *distortions and contortions*. For this purpose, *a vector representation of tensors* is used, which has undeniable advantages over the purely tensor representation, if only because of the possibility of using the powerful formalism of vector analysis, which makes it possible to easily obtain the *geometrocompatibility equations*, which ensure the solidity of the lattice, and the *geometrokinetic equations*, which make it possible to describe the kinetics of the deformation. Then, physics is introduced in this topological context, namely *Newtonian dynamics* and *Eulerian thermokinetics*. With all these ingredients, it becomes possible to describe the particular behaviors of solid lattices, such as *elasticity, anelasticity, plasticity and self-diffusion*, and to write *the complete set of evolution equations of a lattice* in the Euler coordinate system.

On the basis of this Eulerian description of solids, it is possible to describe *the various phenomenologies observed on usual solids*. Among others, we can find out how to obtain the functions and equations of state of an isotropic solid, what are the elastic and thermal behaviors that can appear, how waves propagate and why there are thermoelastic relaxations, what are the phenomena of mass transport and why inertial relaxations can appear, what are the usual phenomena of anelasticity and plasticity, and finally how it can appear structural transitions of 2nd and 1st species in a solid lattice.

The concepts of dislocation and disclination charges in lattices

The description of defects (topological singularities) that can appear within a solid, such as dislocations and disclinations, is a field of physics, initiated mainly by the idea of the macroscopic defects of Volterra (1907) *[17]*, which has undergone a dazzling development during its century of very rich history, as illustrated very well by Hirth (1985) *[18]*. It was in 1934 that the theory of lattice dislocations really began, following the papers by Orowan *[19]*, Polanyi *[20]* and Taylor *[21]*, who independently described the edge dislocation. Then it was in 1939 that Burgers *[22]* described screw and mixed dislocations. And it is finally in 1956 that the first experimental observations of dislocations are reported, simultaneously by Hirsch, Horne and Whelan *[23]* and by Bollmann *[24]*, thanks to the electron microscope. As for disclinations, it was in 1904 that Lehmann *[25]* observed them for the first time in molecular crystals, and it was in 1922 that Friedel *[26]* gave a first physical description of them. Then, from the middle of the twentieth century, the physics of defects in solids took a considerable extent.

In the Eulerian theory introduced here *[7]*, dislocations and disclinations are approached by intuitively introducing the concept of *dislocation charges*, using the famous "pipes" of Volterra (1907) *[26]* and an analogy with electric charges. In Euler coordinates, the notion of charge density then appears in *a geometrocompatibility equation* of the solid, while the notion of charge flux is introduced in *a geometrokinetic equation* of the solid. *The rigorous formulation of the concept of charges in solids makes the essential originality of this approach of topological singularities*. The thorough development of this concept reveals first-order tensor charges, *dislocation charges*, associated with *plastic distortions (plastic deformation and rotation)* of the solid, and second-order tensor charges, *disclination charges*, associated with *plastic contortions (plastic bending and torsion)* of the solid. It appears that these topological singularities are quantified in a solid lattice and that they can be topologically localized only in *strings (thin tubes)*, which can be modeled as *one-dimensional lines of dislocation or disclination*, or in *membranes (thin plates)*, which can be modeled as *two-dimensional joints of bending, torsion or accommodation*.

The concept of dislocation and disclination charges allows us to rigorously retrieve the main results obtained by the classical dislocation theory. However, it allows us to define a tensor $\vec{\Lambda}_i$ of *linear dislocation charge*, from which we derive a scalar Λ of *linear rotation charge*, which is associated with the screw part of the dislocation, and a vector $\vec{\Lambda}$ of *linear bending charge*, which is associated with the edge part of the dislocation. For a given dislocation, the two charges Λ and $\vec{\Lambda}$ are then perfectly defined without having to use a convention to define them, contrary to the classical definition of a dislocation by its *Burgers vector.* On the other hand, the description of dislocations *in the Euler coordinate system* by the concept of dislocation charges allows to treat in an exact way the evolution of charges and deformations *during very strong volume contractions or expansions of a solid medium.*

By analytically introducing the concepts of *density and flux of dislocation and disclination charges in lattices*, it is possible to describe in detail the macroscopic and microscopic topological singularities of the lattice that can be associated with dislocation and disclination charges, and to describe the movement of dislocation charges within the lattice by introducing *the fluxes of dislocation charges* and *the Orowan relationships*. *The Peach and Koehler force* acting on dislocations is also deduced and *a new complete set of lattice evolution equations* in the Euler coordinate system can be established, this time taking into account the existence of topological singularities within the lattice.

The concept of charges within the Eulerian solid lattice allows the development of *a very detailed dislocation theory in common solids*. It is also possible to calculate *the fields and ener-*

gies of screw and edge dislocations in an isotropic solid lattice, as well as *the interactions that can occur between dislocations*. One can also develop *a model of dislocation string*, which is the fundamental model to explain most of the macroscopic behaviors of the anelasticity and plasticity of crystalline solids.

The premises of a possibility to describe the Universe by a "cosmological lattice"

On the basis of the Eulerian description of solid lattices, we show that it is possible to calculate *the rest energy* E_0 *of dislocations*, which corresponds to *the elastic energy stored in the lattice by their presence*, and *their kinetic energy* E_{cin}, which corresponds to *the kinetic energy of the particles of the lattice mobilized by their motion*, which then allows to attribute to them *a virtual mass of inertia* M_0 which surprisingly satisfies relations similar to Einstein's famous equation $E_0 = M_0 c^2$ of special relativity, but which is obtained here in a quite classical way, i.e. without calling upon a principle of relativity. Moreover, at high speed, it is shown that dislocation dynamics also satisfies *the principles of special relativity* and *the Lorentz transformations*.

It can also be shown that, in the case of isotropic solid media having a homogeneous and constant volume expansion, thus deforming only by shear, *a perfect and complete analogy with Maxwell's equations of electromagnetism* appears, thanks to the possible replacement of the shear tensor by the rotation vector. The existence of an analogy between electromagnetism and the theory of incompressible continuous media was already perceived a long time ago and developed by many authors, as Whittaker (1951) *[27]* has shown. However, the analogy becomes much more complete by using the Euler coordinate approach *[7]*, because it is not limited to an analogy with one of the two pairs of Maxwell equations in vacuum, but is generalized to the two pairs of Maxwell equations as well as to the various phenomenologies of *dielectric polarization* and *magnetization of matter*, and to the notions of *electric charges and currents*. This analogy makes it possible to consider the cosmological lattice as *a physical support for electromagnetic fields*, and to give *physical interpretations to the various quantities of electromagnetism*. For example, the local rotation field of the lattice corresponds to the electric induction field of electromagnetism and the velocity field of the lattice to the magnetic field.

The analogy with Maxwell's equations is very astonishing by the simple fact that it is initially postulated that the solid lattice satisfies *a very simple dynamic, purely Newtonian*, in the absolute reference frame of the external observer's laboratory, which is equipped with orthonormal rules and a clock giving a universal time, whereas the topological singularities within the solid lattice, namely dislocations and disclinations with their respective charges, responsible for the distortions and plastic contortions of the solid, are subject to *relativistic dynamics* within the solid, precisely due to *the set of Maxwellian equations* governing the shear forces in the medium. From this point of view, the relativistic dynamics of topological singularities is nothing else than *a consequence of the perfectly classical Newtonian dynamics of the elastic solid lattice* in the frame of reference of the external observer.

Finally, it also appears in Euler coordinates that at long distance from *a localized cluster* of topological singularities, formed for example by one or more dislocation loops or one or more disclination loops, the tensorial aspect of the distortion fields generated at short distance by this cluster may be neglected at long distance, so that lattice perturbations can be perfectly described *at a large distance* by the only *two vectorial fields of torsional rotation and bending curva-*

ture associated with the only two scalar charges of the cluster, its *scalar rotation charge* Q_λ and its *scalar curvature charge* Q_θ. The rotation charge then becomes the perfect analogue of *the electric charge* in Maxwell's equations, whereas the curvature charge has some analogy with *a gravitational mass* in gravitation theory.

The existence of analogies between *the mechanics of continuous media and the physics of defects* and *the theories of electromagnetism, special relativity and gravitation* had already been the subject of numerous publications, the most famous of which are certainly those of Kröner *[4,5]*. Excellent reviews in this field of physics have also been published, notably by Whittaker (1951) *[20]* and by Unzicker (2000) *[28]*. But none of these publications had gone as far in highlighting these analogies as the approach presented in my first books *[7]*.

The numerous analogies that appeared in the first books *[7]* between the Eulerian theory of deformable media and the theories of electromagnetism, gravitation, special relativity, general relativity and even the Standard Model of elementary particles, reinforced by the absence of charges similar to magnetic monopoles, by a possible solution to the famous paradox of the electrical energy of an electron, and by the existence of a weak asymmetry between lacunar and interstitial charges of curvature, were sufficiently surprising and remarkable not to fail to titillate any open and somewhat curious scientific mind. But it is clear that these analogies were by no means perfect. It was therefore very tempting to analyze these analogies in greater depth and to try to find out how to perfect them, and this is what has led to the last books *[1]*, which are devoted to the deepening, improvement and understanding of these analogies, and whose main steps are illustrated in the following.

The "cosmological lattice" and its Newton's equation

By introducing quite particular elastic properties of *volume expansion*, *shear* and especially <u>*rotation*</u>, expressed *in free energy per unit volume of lattice*, we obtain an imaginary lattice with *a very particular Newton's equation*, in which *a new term of force* appears, which is directly related to the energy of distortion due to the singularities contained in the lattice (Matter), and which is called to play a fundamental role in the analogies with Gravitation and with Quantum Physics.

Wave propagation in this cosmological lattice has some interesting peculiarities: the propagation of linearly polarized transverse waves is always associated with longitudinal wavelets, and pure transverse waves can only be propagated *by circularly polarized waves* (which has a direct link with photons). On the other hand, the propagation of longitudinal waves can disappear (as in general relativity), but in favor of the appearance of *localized longitudinal vibration modes* (which has a direct link with quantum physics) in the case where the volume expansion of the medium is below a certain critical value.

Calculating *the curvature of wave rays* in the vicinity of a singularity in the volume expansion of the lattice allows us to find conditions that the expansion field of a singularity must satisfy in order for a trap that captures transverse waves to appear, in other words, a *"black hole"*.

Such a cosmological lattice, finite in absolute space, can exhibit *dynamic volume expansion and/or contraction* provided that it contains a certain amount of kinetic energy of expansion, a phenomenon quite similar to *the cosmological expansion of the Universe*. Depending on the signs and values of the elastic moduli, several types of cosmological behaviors of the lattice are possible, some of which present *the phenomena of big-bang, rapid inflation and acceleration of* *the expansion speed*, and which can be followed in some cases by *a re-contraction of the lattice leading to big-crunch and big-bounce phenomena*. It is *the elastic and kinetic energies of expansion contained in the lattice* which are responsible for these phenomena, and in particular for *the increase in the speed of expansion*, a phenomenon which is observed in the current Universe by astrophysicists and which is attributed by them to a hypothetical *"dark energy"*.

Maxwell's equations and special relativity

Newton's equation of the cosmological lattice can be separated into *a rotational part and a divergent part*. The rotational part shows a set of equations for the macroscopic local rotation field which is perfectly identical to *the Maxwell's equations of electromagnetism*.

Newton's equation can also be separated in a different way into *two partial Newton's equations* which allow on the one hand to calculate the elastic distortion fields associated with the topological singularities, and on the other hand to calculate the volume expansion perturbations associated with the elastic distortion energies of the topological singularities. Using Newton's first partial equation, one can then tackle the calculations of the elastic distortion fields and energies of topological singularities within a cosmological lattice. It is thus shown that it is possible to attribute in a quite classical way *an inertial mass* to the topological singularities, which *always* satisfies *the Einstein's famous formula* $E_0 = M_0 c^2$.

The topological singularities also satisfy *a typically relativistic dynamic* when their velocity becomes close to the velocity of transverse waves.

The cosmological lattice behaves in fact like *an aether*, in which the topological singularities satisfy exactly the same properties as those of the Special Relativity concerning the contraction of rules, the dilation of time, the Michelson-Morley experiment and the Doppler-Fizeau effect. The existence of the cosmological lattice then makes it possible to explain very simply certain somewhat obscure aspects of Special Relativity, notably by definitively giving *a simple and convincing explanation of the famous twins paradox*.

Gravitation, General Relativity, Weak Interaction and Cosmology

Disturbances in the scalar expansion field associated with a localized topological singularity are in fact an expression of *the existence of a static external "gravitational field" at a long distance from this singularity*, as long as the latter has *an energy density or a rotation charge density below a certain critical value*.

Thanks to *Newton's second partial equation*, one can calculate *the external fields of expansion perturbations*, i.e. *the external gravitational fields* associated with localized macroscopic topological singularities, either of *a given elastic energy of distortion*, of *a given curvature charge*, or of *a given rotation charge*.

We can also introduce *macroscopic lacunar or interstitial singularities*, which may appear within the lattice in the form of a hole in the lattice or an interstitial embedding of a lattice piece, which will later prove to be ideal candidates to explain respectively *the black holes* and *the neutron stars* of the Universe.

By applying the calculations of the external gravitational field of topological singularities to the microscopic singularities in the form of *screw disclination loops*, *edge dislocation loops* or *mixed dislocation loops*, we deduce all the properties of these loops. The notion of *"mass of curvature"* of edge dislocation loops then appears, which corresponds to the equivalent mass associated with *the gravitational effects of the curvature charge of these loops*, and which can be positive (in the case of loops of a vacancy nature) or negative (in the case of loops of an interstitial nature). This concept, which does not appear at all in modern theories of physics, such as general relativity, quantum physics or the Standard Model, implies *a very slight deviation from the equivalence principle of general relativity*: the inertial mass and the gravitational mass of a particle are very slightly different. If the inertial mass of a particle and its antiparticle are exactly the same, the gravitational mass of an antiparticle is very slightly higher than that of its antiparticle because of their opposite sign curvature charge. Even in the particular case of the neutrino, the effect of the curvature charge outweighs the inertial mass, and the gravitational mass of the neutrino becomes negative *(antigravity)*, whereas the gravitational mass of the anti-neutrino is positive and the inertial mass of the neutrino and the anti-neutrino are identical, very small and always positive.

In our approach, it is precisely this mass of curvature that will be responsible for the appearance of *a weak asymmetry* between particles (hypothetically containing edge dislocation loops of an interstitial nature) and anti-particles (hypothetically containing edge dislocation loops of a vacancy nature), and which will play a major role in the cosmological evolution of the topological singularities.

By considering the gravitational interactions existing between topological singularities composed essentially of screw disclination loops, we can deduce the behaviors of the local rules and clocks of local observers according to the local expansion field that reigns within the cosmological lattice. We then show that for any local observer, and whatever the value of the local volume expansion of the lattice, Maxwell's equations always remain perfectly invariant, so that, for this local observer, *the transverse wave velocity is an immutable constant*, whereas this velocity depends very strongly on the local volume expansion if it is measured by the observer outside the lattice.

The gravitational interactions thus obtained present very strong analogies with *Newton's Gravitation* and with *Einstein's General Relativity.* For example, there is a perfect similarity with *Schwarzschild's metric* at great distance from a massive object and with *the curvature of wave rays* by this massive object.

But our Eulerian approach of the cosmological lattice also brings new elements to the theory of Gravitation, in particular very short-range modifications of Schwarzschild's metric and a better understanding of the critical radii associated with black holes: the radii of the sphere of perturbations and of the point of no return are both similar and equal to *the Schwarzschild radius* $R_{Schwrzschild} = 2\boldsymbol{G}M / c^2$, and the limit radius for which the expansion of the observer's time would tend towards infinity becomes zero, so that our approach is not limited by infinite quantities for the description of a black hole beyond the Schwarzschild sphere.

It is possible to draw a complete picture of *all the gravitational interactions existing between the various topological singularities* of a lattice. If we then consider topological singularities formed from the coupling of a screw disclination loop with an edge dislocation loop, which are called *dispiration loops*, *an interaction force similar to a capture potential* appears, with *a very low range*, which allows interactions between loops that are *perfectly analogous to the weak inter-*

actions between elementary particles of the Standard Model.

On the basis of the cosmological expansion-contraction behaviors of the lattice and the gravitational interactions between topological singularities via the local volume expansion of the lattice, we can then imagine *a very plausible scenario of cosmological evolution of the topological singularities* leading to the current structure of our Universe. This scenario is entirely based on the fact that, in the case of the simplest edge dislocation loops, *analogously similar to neutrinos*, the mass of curvature dominates the mass of inertia, so that neutrinos should be *the only gravitationally repulsive particles*, while anti-neutrinos would be gravitationally attractive. This assertion then allows us to give a simple explanation to several facts that are still very poorly understood in the evolution of matter in the Universe. *The formation of galaxies* could correspond to *a phenomenon of precipitation* of matter and antimatter within a sea of repulsive neutrinos. *The disappearance of antimatter* could correspond to *a phenomenon of segregation* of particles and antiparticles within galaxies, due to their slight difference in gravitational properties, a segregation during which antiparticles would gather in the center of galaxies to finally form *gigantic black holes in the heart of galaxies*. Even the famous *"dark matter"* that astrophysicists had to invent to explain the abnormal gravitational behavior of the periphery of galaxies would then be very well explained in our approach. Indeed, the *"dark matter"* would in fact be *the sea of repulsive neutrinos* in which the galaxies would have precipitated and bathed, which, because of the compressive force it exerts on the periphery of the galaxies, would explain the abnormal gravitational behavior of the latter.

Finally, we can also easily deal with *the Hubble constant*, *the redshift of galaxies* and *the evolution of the background cosmic radiation* in the framework of our cosmological lattice theory.

Quantum physics, particle spin and photons

In the case where the energy density or the rotation charge density of a topological singularity becomes greater than a certain critical value, the expansion field associated with this localized topological singularity can no longer exist as a static gravitational expansion field, but has to appear *as a dynamic expansion perturbation*, which will cause *quantum behaviors of this singularity to appear*. The critical value of the energy density or the rotation charge density then becomes an extremely important quantity since it actually corresponds to a quantitative value that defines the famous *quantum decoherence limit*, i.e. the limit of passage between a classical and a quantum behavior of a topological singularity.

Using Newton's second partial equation, in the dynamic case, it is shown that there are also *dynamic longitudinal gravitational fluctuations* associated with moving topological singularities within the lattice. By introducing *operators similar to those of quantum physics*, it is then shown that Newton's second partial equation allows us to deduce the gravitational fluctuations associated with a topological singularity moving almost freely at relativistic velocities within the lattice.

In the case of non-relativistic topological singularities linked by a potential, it is shown that the second partial Newton equation applied to the longitudinal gravitational fluctuations associated with these singularities leads very exactly to *the Schrödinger equation of quantum physics*, which makes it possible to give *for the first time* a simple and realistic physical interpretation of the Schrödinger equation and the quantum wave function: *the quantum wave function deduced* *from the Schrödinger equation represents the amplitude and phase of the longitudinal gravitational vibrations associated with a topological singularity moving in the cosmological lattice*.

All the consequences of Schrödinger's equation then appear with a simple physical explanation, such as *the standing wave equation* of a topological singularity placed in a static potential, *Heisenberg's uncertainty principle* and *the probabilistic interpretation of the square of the wave function*.

In the case where the gravitational fluctuations of expansion of two topological singularities are coupled, explanations of the concepts of *bosons and fermions*, as well as *Pauli's exclusion principle* also appear quite simply.

At the very heart of a topological singularity loop, it is shown that there can be no static solutions to Newton's second partial equation for longitudinal gravitational fluctuations. It therefore becomes *necessary to find a dynamic solution* to this equation, and the simplest dynamic solution that can be envisaged is that *the loop actually rotates on itself*. By solving this rotational motion with Newton's second partial equation, which in this dynamic case is nothing other than the Schrödinger's equation, we obtain the quantized solution of the internal gravitational fluctuations of the loop, which is in fact *the spin of the loop*, which can take several different values (1/2, 1, 3/2, etc.) and which is perfectly similar to the spin of the particles of the Standard Model. If the loop is composed of a screw disclination loop, *a magnetic moment of the loop* also appears, proportional to the famous *Bohr magneton*. The famous argument of the pioneers of quantum physics according to which the spin can in no case be a real rotation of the particle on itself because of an equatorial speed of rotation higher than the speed of light is swept away in our approach by the fact that the static expansion in the vicinity of the core of the loop is very high, which leads to speeds of light in the vicinity of the core of the loop much higher than the equatorial speed of rotation of the loop.

We can also show how to construct a bundle of pure circularly polarized transverse waves and why *a quantification of the energy of these fluctuations appears*. These wave packets form *quasi-particles* which have properties perfectly similar to the quantum properties of photons: *circular polarization, zero mass, non-zero momentum, non-locality, wave-corpuscle duality, entanglement and decoherence phenomena*.

Standard model of elementary particles and strong force

One can also search for ingredients that should be added to the cosmological lattice to find an analogy with the various particles of the Standard Model. We show that by introducing into a cubic lattice *families of planes (imaginary "colored" in red, green and blue) which satisfy some simple rules concerning their arrangement and rotation*, we find topological loops *perfectly analogous to all particles, leptons and quarks, of the first family of elementary particles of the Standard Model*, as well as topological loops *analogous to the intermediate bosons of the Standard Model.*

It also spontaneously appears *a strong force*, in the sense of a force that exhibits *asymptotic behavior*, between quark-like loops, which are then *topologically forced by the formation of an energetic disorientation joint* to group together *in triplets to form baryon-like loop assemblies*, or *in doublets to form meson-like loop-anti-loop assemblies*. In addition, there are also simple *"two-color" topological loops* that perfectly match *the gluons* associated with the strong force in the Standard Model.

To explain then the existence of *three families of quarks and leptons* in the Standard Model, we show that the introduction of a more complex topological structure of edge loops, based on *the assembly of a pair of wedge disclination loops*, allows to explain satisfactorily the existence of three families of particles of very different energies.

Quantum fluctuations of the vacuum, cosmological theory of multiverses and gravitons

It is still possible to deduce some *very hypothetical consequences* of the perfect cosmological lattice associated with *pure gravitational fluctuations (fluctuations of the lattice expansion scalar).*

One can imagine the existence of pure longitudinal fluctuations within the cosmological lattice that can be treated either as random gravitational fluctuations that could have an analogy with *the quantum fluctuations of the vacuum*, or as stable gravitational fluctuations, which could lead at the macroscopic scale to *a cosmological theory of Multiverses*, and at the microscopic scale to the existence of a form of *stable quasi-particles that could be called gravitons*, by analogy with photons, but which in fact have nothing in common with the gravitons usually postulated in the framework of General Relativity.

About the epistemology of our lattice approach of the Universe

Our lattice approach to the Universe is based on the *two basic concepts* mentioned in the summary, which are disarmingly simple. And by judiciously applying these two perfectly classical initial concepts (massive and elastic solid lattice, Newton's law, principles of thermodynamics), it is really *very surprising* to note that the behaviors of this lattice (the Universe) and its topological singularities (the Matter) satisfy all modern theories of physics, even though we postulated that the lattice in absolute space rigorously follows the perfectly classical laws of Newton and thermodynamics.

But in this approach of the Universe, nothing comes yet to give a definitive explanation to the existence of the Universe, to the root cause of the big bang, and to the actual composition of the solid, massive and elastic cosmological lattice. These points remain, at least for the moment, within the scope of individual philosophy or beliefs. But, *from an epistemological point of view*, this approach shows that it is perfectly possible to find *a very simple framework to understand, explain and unify the different theories of modern physics*, a framework in which there would no longer be many mysterious phenomena other than the "raison d'être" of the Universe.

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