THE CRYSTALLINE ETHER

Introduction

Storytelling of this book

"What if the Universe was a crystal?" was the question that came to my mind little by little forty years ago when I was preparing a course for physics students in their fourth year of study. At that time, with a degree in physics-engineering and a doctorate in physics, I was pursuing research in *dislocation dynamics* at the Swiss Federal Institute of Technology of Lausanne, and as part of this research activity, I also had to participate in teaching. The course I was responsible for was directly related to my research and was called *physics of dislocations*. Dislocations are defects in arrangement in the crystal structure of solids, such as metals. And it is the movements of these structural defects which explain a good part of the macroscopic properties of deformation of crystalline solids, hence the importance of describing them theoretically and studying them experimentally.

When preparing for my course for the first time, I decided to teach a very theoretical mathematical approach to dislocations developed by M. Zorawski[1]. Unfortunately, this approach is very complicated, because it uses Riemann differential geometry to describe the spatio-temporal evolution of dislocations in local infinitesimal frames, approach involving all the very heavy mathematical artillery of general relativity (metric tensor and symbols of Christoffel). This first version of my course was a bitter failure. This approach not only hid the whole reality of the behavior of dislocations behind an armada of very complicated mathematical objects (tensors), but it also very quickly provoked strong repulsion from students, but also from the professor.

During the second year of teaching this course, I therefore decided to completely change my approach to dislocations, basing it on a more usual description of the deformations of solids, using the classic Lagrange coordinate system and formalizing at best the physical properties of the medium, which is generally not very well done in most courses in the theory of continuous media.

By teaching this theory from year to year, and by perfecting the presentation of my course each time, I saw intriguing analogies appear with other theories of physics. The first analogy that appeared was surprising, as it involved *Maxwell's theory of electromagnetism*. And the analogy became over the years more and more clear and obvious, because it was not limited only to an analogy with one of the two pairs of Maxwell's equations in a vacuum, but it was also generalized to the various phenomenologies encountered in electromagnetism, such as *dielectric polarization* and *magnetization of matter*, as well as *charges and electric currents*.

It is by taking inspiration from the literature that I also showed in my course that it was

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[1] *M. Zorawski, «Théorie mathématique des dislocations», Dunod, Paris, 1967.*

possible to calculate *the rest energy* E_0 of dislocations, which corresponds to the elastic energy of deformation E_{def} 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 movement, which then allowed them to be assigned *a mass* M_0 *of virtual inertia* which satisfies relationships perfectly similar to the famous equation $E_0 = M_0 c^2$ of Einstein's special relativity, but which was obtained here in a completely classic way, that is to say without appealing to a principle of relativity. In addition, the dynamics of high velocity dislocations also satisfied the principles of special relativity and Lorentz transformations.

The analogy with Maxwell's equations was already very astonishing by the simple fact that it was initially postulated that the solid lattice satisfied a very simple dynamic, purely Newtonian, in the laboratory of the experimenter, while the dislocations, responsible for the plastic deformations of the solid, were necessarily subject to a relativistic dynamic within the solid, obligation due to the set of Maxwell equations governing the deformations of the medium. Therefore, I came to the very paradoxical conclusion that the relativistic dynamics of dislocations is in fact nothing more than a consequence of the perfectly classic Newtonian dynamics of the elastic solid lattice in the laboratory of the experimenter.

The numerous analogies which appeared during the preparation of my course between the theory of deformable solid media and the theories of electromagnetism and special relativity were sufficiently surprising and remarkable to not fail to tickle any open and somewhat scientific mind. But it was clear that these analogies were far from perfect. It was therefore very tempting to analyze these analogies in more depth and try to find out how to perfect them. This is what led me to work on this subject, in my spare time and for forty years, and finally to propose several theoretical books developing on the one hand an original approach to the deformation of solids[2] using coordinates of Euler instead of the coordinates of Lagrange, and on the other hand a revolutionary approach of the Universe[3] based on the deepening, the improvement and the understanding of the analogies between the theory of the deformation of crystalline solids and the great theories of modern physics such as Maxwell's equations, special relativity, Newtonian gravitation, general relativity, modern cosmology, quantum physics and the standard model of elementary particles.

It is quite remarkable to be able to deduce all the great theories of modern physics from a logical development based exclusively on the simple concepts that are, from a physical point of view, the three main principles of classical physics, namely Newtonian dynamics (Newton's equation), the first principle of thermodynamics (conservation of the total energy of a system) and the second principle of thermodynamics (the existence of a physical quantity, entropy, measuring the disorder of a system), and from a mathematical point of view, the detailed

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[2] *G. Gremaud, "Théorie eulérienne des milieux déformables – charges de dislocation et désinclinaison dans les solides", Presses polytechniques et universitaires romandes (PPUR), Lausanne (Switzerland) 2013, 751 pages, ISBN 978-2-88074-964-4*
G. Gremaud, "Eulerian theory of newtonian deformable lattices – dislocation and disclination charges in solids", Amazon, Charleston (USA) 2016, 312 pages, ISBN 978-2-8399-1943-2

[3] *G. Gremaud, "Univers et Matière conjecturés comme un Réseau Tridimensionnel avec des Singularités Topologiques", Amazon, Charleston (USA) 2016, 664 pages, ISBN 978-2-8399-1940-1*
G. Gremaud, "Universe and Matter conjectured as a 3-dimensional Lattice with Topological Singularities", Amazon, Charleston (USA) 2016, 650 pages, ISBN 978-2-8399-1934-0

description of the spatio-temporal evolution of a lattice thanks to an original geometry based on Euler coordinates.

But if the basic principles of my approach are very simple and quite classic, the developments leading to find the great theories of modern physics from these principles are long, quite difficult and very theoretical, with many mathematics formulas. They are therefore not an easy approach, even for physicists, and especially if these are not versed in the field of solid state physics and their deformations. This is why I undertook to write this new book in which I have the ambition to make known, if possible with the minimum of mathematics, the ins and outs of my approach, in order to familiarize physicists and all people passionate about knowing the Universe at the simplicity and elegance of my original approach to it on some simple and very classic basic concepts.

I must note here that the existence of analogies between the mechanics of continuous media and the physics of defects and the theories of electromagnetism, special relativity and gravitation is by far not my own idea. Indeed, it had already been the subject of numerous publications before I was concerned about it. Excellent reviews on this subject have been published, notably by Whittaker[4] in 1951 and by Unzicker[5] in 2000.

For example, Nye[6] initiated in 1953 the use of differential geometries to introduce topological defects such as dislocations in deformable continuous media, and for the first time made the connection between the dislocation density tensor and the curvature of the lattice. On the other hand, Kondo[7] in 1952 and Bilby[8] in 1954 have independently shown that dislocations can be identified with a crystalline version of 1922 Cartan's concept[9] of twisting a continuum.

And this approach was formalized in great detail by Kröner[10] in 1960, who also proposed in 1980 that the existence of extrinsic point defects, which can be considered as extra-material, could be identified with the presence of matter in the universe[11] and be introduced consequently in the form of Einstein 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 on even more complex higher-order geometries, such as Finsler or Kawaguchi geometries.

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[4] *S. E. Whittaker, «A History of the Theory of Aether and Electricity», Dover reprint, vol. 1, p. 142, 1951.*

[5] *A. Unzicker, «What can Physics learn from Continuum Mechanics?», arXiv:gr-qc/0011064, 2000*

[6] *J.F. Nye, Acta Metall.,vol. 1, p.153, 1953*

[7] *K. Kondo, RAAG Memoirs of the unifying study of the basic problems in physics and engeneering science by means of geometry, volume 1. Gakujutsu Bunken Fukyu- Kay, Tokyo, 1952*

[8] *B. A. Bilby , R. Bullough and E. Smith, «Continous distributions of dislocations: a new application of the methods of non-riemannian geometry», Proc. Roy. Soc. London, Ser. A 231, p. 263–273, 1955*

[9] *E. Cartan, C.R. Akad. Sci., 174, p. 593, 1922 & C.R. Akad. Sci., 174, p.734, 1922*

[10] *E. Kröner, «Allgemeine Kontinuumstheorie der Versetzungen und Eigenspannungen», Arch. Rat. Mech. Anal., 4, p. 273-313, 1960*

[11] *E. Kröner, «Continuum theory of defects», in «physics of defects», ed. by R. Balian et al., Les Houches, Session 35, p. 215–315. North Holland, Amsterdam, 1980.*

Kröner's analogies between the mechanics of continuous media and the great modern theories of physics are undoubtedly the most famous. However, none of this previous research had gone as far in highlighting analogies as the approach presented in this book.

In search of a Theory of Everything

One of the fundamental problems of modern physics is the search for a Theory of Everything capable of explaining the nature of space-time, what matter is and how matter interacts. Since the 19th century, physicists have sought to develop theories of unified fields, which should consist of a coherent theoretical framework capable of taking into account the various fundamental forces of nature. Some attempts to find a unified theory include:
- *The "Great Unification"* which brings together the electromagnetic interaction forces, the weak forces and the strong forces,
- *Quantum Gravity, Quantum Loop Gravitation, and String Theories*, which seek to describe the quantum properties of gravity,
- *Supersymmetry,* which proposes an extension of space-time symmetry connecting the two classes of elementary particles, bosons and fermions,
- *The Theories of Strings and Superstrings,* which are theoretical structures integrating gravity, in which the point particles are replaced by one-dimensional strings whose quantum states describe all the types of elementary particles observed,
- *M Theory*, which unifies five different versions of string theories, with the surprising property that extra-dimensions are required to ensure its consistency.

However, none of these approaches is yet capable of explaining in a consistent manner and at the same time the electromagnetism, relativity, gravitation, quantum physics and the elementary particles observed. Many physicists believe that the 11-dimensional M Theory is the Theory of Everything. However, there is not a broad consensus on this point and there is currently no candidate theory capable of calculating experimental quantities known as the fine structure constant or the mass of the electron. Particle physicists hope that the future results of current experiments - the search for new particles in large accelerators and the search for dark matter - will still be necessary to define a Theory of Everything.

But these researches seem to have really stagnated for about 40 years, and many physicists now have serious doubts about the suitability of these theories. On this subject, I strongly advise readers to consult among others the books of Smolin[12], Woit[13] and Hossenfelder[14]. Since the 1980s, thousands of theoretical physicists have published thousands of scientific articles that are generally accepted in peer-reviewed journals, event if these papers have contributed absolutely nothing new to the explanation of the Universe and solve none of the current

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[12] *Lee Smolin, «The trouble with Physics», Penguin Books 2008, London, ISBN 978-0-141-01835-5*
Lee Smolin, «La révolution inachevée d'Einstein, au-delà du quantique», Dunod 2019, ISBN 978-2-10-079553-6
Lee Smolin, «Rien ne va plus en physique., L'échec de la théorie des cordes», Dunod 2007, ISBN 978-2-7578-1278-5

[13] *Peter Woit, «Not Even Wrong, the failure of String Theory and the continuing challenge to unify the laws of physics», Vintage Books 2007, ISBN 9780099488644*

[14] *Sabine Hossenfelder, «Lost in Maths», Les Belles Lettres 2019, ISBN978-2-251-44931-9*

mysteries of physics. An enormous amount of energy has been mobilized to develop these theories, which are becoming very remote from the physical reality of our world. It is a race to publish more and more esoteric articles and to search for a form of "mathematical beauty" at the expense of "physical reality". Moreover, huge amounts of money have been invested in this research, to the detriment of fundamental research in other areas of physics, in the form of building increasingly complex machines. And, to the despair of experimental physicists, the results obtained have brought almost nothing new to high-energy physics, contrary to the "visionary" and optimistic predictions of the theorists.

In this book, the problem of unifying physical theories is dealt with in a radically different way. Instead of trying to build a unified theory by tinkering with an assembly of existing theories, making them more complex, even adding strange symmetries and additional dimensions for their "mathematical beauty", I start exclusively from the most classic fundamentals concepts of physics that are Newton's equation and the first two principles of thermodynamics. Using these fundamental principles, and by developing an original geometry based on the Euler coordinates, I come, by a purely logical and deductive path, to suggest that the Universe could be a crystal, a three-dimensional lattice, elastic and massive, and that the constituent elements of Ordinary Matter could be structural defects (hereinafter called topological singularities) of this crystal lattice, namely various loops of dislocation and disclinations which we will describe in detail. For an isotropic face-centered cubic lattice satisfying Newton's law, and with specific assumptions on its elastic properties, I find that the behaviors of this lattice and its topological singularities gather "all" the physics known today, by making appear spontaneously *very strong and often perfect analogies with all the great current physical theories* of the Macrocosm and the Microcosm, such as *Maxwell's Equations, 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 proposes quite original, new and simple explanations to many physical phenomena that are still quite obscure and poorly understood at the present time by physics, such as the meaning and deep physical interpretation of *cosmological expansion, electromagnetism, special relativity, general relativity, quantum physics, and particle spin*. It also offers explanations of what *quantum decoherence, dark energy, dark matter, black holes*, and many other phenomena really are.

The detailed development of this approach also leads to some very innovative ideas, among which the most important is *the appearance of the curvature charge*, which is an unavoidable consequence of the treatment of a solid lattice and its topological singularities in Euler coordinates. This concept does not appear at all in all modern theories of physics, whether in general relativity, quantum physics or in the Standard Model, whereas in our approach this concept provides explanations for many obscure points of these theories, such as *weak force, matter-antimatter asymmetry, the formation of galaxies, the 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, by studying face-centered cubic lattices with special symmetries called axial, symbolically represented by *"colored" 3D lattices*, one can identify a lattice structure whose

loops of topological singularities perfectly coincide with the complex zoology of all elementary particles of the Standard Model, and one also finds simple physical explanations of the weak and strong forces of the Standard Model, with all their specific properties.

This approach, published in my second book *"Universe and Matter Conjectured as a Three-Dimensional Network with Topological Singularities"*[3], does not pretend to present a Theory of All which would already be fully developed and usable, but it should and could by against proving to be extremely fruitful in giving simple explanations to modern physical theories whose deep meaning it is difficult, if not impossible, to understand, but also and above all to define close links and unifying bridges between the various major theories of modern physics.

The aim of this book is therefore to make this approach known to an informed and interested public, by approaching it in the simplest possible way, on the basis of numerous figures, by explaining it *"with the hands"* and by trying to avoid as much as possible the development of the underlying mathematical equations. On the other hand, I think that it is important to highlight the most fundamental equations of theory in figures, but without it being necessary to understand them. Regarding the organization of the content of the book, I tried to follow as closely as possible the plan of the initial theoretical book, so that those interested could refer directly to the complete mathematical treatments it contains.

In this book, I begin by autonomously summarizing the theory[2] published initially in 2013, which methodically laid the foundations for an original approach to solid lattices by Euler coordinates, and which also introduced in detail the concept of charge of dislocation and disclination within a crystal lattice, a concept which makes it possible to quantify structural defects, topological singularities, which can appear on the microscopic scale of such a lattice.

On the basis of this original approach of solid lattices and their topological singularities, I deduce a set of fundamental and phenomenological equations which makes it possible to treat in a very rigorous way the macroscopic spatio-temporal evolution of a solid Newtonian lattice deforming in the absolute space of the laboratory of an observer outside this lattice.

I then introduce an imaginary lattice, with rather special elastic and structural properties, the concept of which was imagined and published in 2016 in my second book[1], and which I termed a *"cosmological lattice".* Initially, this lattice was imagined with a simple cubic structure, which forced me to do some perilous acrobatics to describe the three families of elementary particles of the standard model. But in this new version of 2021, I introduce *a face-centered cubic lattice, which I poetically call the crystalline ether*, which was suggested to me by my friend Willy Benoit, and which allows to describe much more judiciously the three families of elementary particles of the standard model. With *a few well-chosen conjectures*, the Newton equation of this lattice and the topological singularities that it may contain present a set of very surprising properties, which will progressively show strong and surprising analogies with all the major current physical theories, as summarized in the table of contents .