AN INTEGRATED PERSPECTIVE ON KNOWLEDGE AND EXISTENCE

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ABSTRACT

The paper presents an integrated approach on knowledge and existence, as perceived from the perspective of the last achievements in physics. The main assumption founding this new theory is that both knowledge and existence are topological spaces integrated into a unique result, which in fact creates our reality. More precisely, in the present paper it is considered that, from the above-mentioned point of view, there is a better manifesto for the scientific approach, at least in the natural sciences, than the Cartesian *Discours de la méthode*. The paper proposes a new one, that is considered to fit better, giving the present status of our knowledge level and of our civilization: "Discours de la création de la réalité".

KEYWORDS: knowledge, existence, topological structure, *Discours de la methode*, Discours de la création de la réalité

1. Introduction

1.1 Context and main topics

To date back already is a long history of attempts of interpreting knowledge and the process to generate if from science, art, or general cultural frameworks. The last ones will be called in this paper, mythodological aspects. This high amount of approaches leads to a "Theory of Everything" (TOE), which should be able to explain and manage not only knowledge or existence, but also both of them. The perspective adopted in this paper is based only on one type of knowledge, i.e. the particular case of physics as a natural science. *There are some important reasons* of the increased interest in developing integrated perspectives on knowledge and existence based on physics and using topological approaches:

- *Modern physics is increasingly more preocupied in the evaluation of material structures***.** Such models in physics consider that its objects of study are better described as topological spaces. In this paper, the concept of topology comprises a specific set of approaches and developments from mathematics considering that:
    - the studied objects are found in proximity one to the other, as part of a system called a *continuum*, for which several properties are not subjected to changes, which may occur due to transformations in shape and size;
    - the short distance interaction between these elements is defining a certain topological space. Knowledge about them is acquired in steps, as approximations to the best possible description of that step.
- *Recent Nobel Prize in physics* is an example, which confirms the tendency in physics mentioned above. In 2016 the Nobel Prize was awarded to three members of the physics' community (David J. Thouless, F. Duncan, M. Haldane and J. Michael Kosterlitz) for theoretical discoveries on phase topological transitions of matter.
- *The existence of a continuous historical preoccupation for the use of topological approaches* in order to understanding the mathematical equations of physics[2].

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[2] Sneed J., *The Logical Structure of Mathematical Physics*, Synthese Library - D Reidel, 1971

- *The concomitent existence of preoccupations about information systems description* through topological tools, although so far the manner of building the approach is only mentioning the idea of these tools, without actually presenting the way of their use[3].
- *The existence of natural systems***,** similar to which the mankind has built a large amount of artificial cases. These systems bring a multitude of new insights for our integrative research. The natural nuclear reactor in Oklo (Gabon) is an illustration of the actual need of rewriting the physical equations of nuclear reactors. They must not be modelled only as they are already presented in the „classical" manuals, but also by considering this device like a complex selfbuilding and selfregulating machine or creation. Such a „device" was „designed" and it was operating by using both non-alive and living components (non human) and it was a dynamic part of the environment for that period of time in the history of Earth (i.e. 2.5 billion years ago). The best description to be used for such a creation is more complex than actual physics equations of a nuclear reactor, and is related to its description as a topological space. The models for the „reactor physics" and the reactor itself are in our view topological spaces[4] and their proper description[5] requires the use of special logical tools, like for instance the topological logic[6].

Therefore, the trend of an increased interest in using topological specific tools from mathematics either to describe physical systems or knowledge systems on a certain set of physical systems is getting stronger nowadays.

Thereby, the attempt presented in this paper to integrating topological models and topological real objects, i.e. systemic integration of knowledge and existence through mathematical topological approaches and developments, is considered as being natural and possible.

Such an attempt may be also of interest because it may provide alternative, or, possibly, complementary answers to similar questions from philosophy and from other areas of natural science. The answers may indicate the direction to be followed for a TOE structure, if there is one at all.

In physics, the Cartesian approach[7] focused on how to look for answers to scientific inquiries about nature (*Discours de la méthode*) may be considered as a starting point of the modern scientific method of acquiring knowledge. The search for a „scientific truth", as formulated by Descartes, may be presented, without altering the method described by him, under a format as it was shown in a previous paper[8]. This format is being structured in a series of step by step actions classified in three main groups comprising ten categories and another final category for the validation of results (including the feedback for next itteration) model, as described in Figure 1.

The approach of the Discours de la méthode was, by that time and ever since after that moment, for a period of almost four centuries a very successful attempt of breaking the scholastic

[3] Crumpei, G., Gavriluţ, A., Crumpei Tanasă, I., Agop, M., *New Paradigms on Information, Mind and Reality from a Transdisciplinary Perspective*, Junimea Publishing House, Iași, 2016

[4] Serbanescu, D., *On some natural energy systesm and lessons learnt from their analysis,* DOI: 10.13140/RG.2.1.4264.4962 · International Year of Light, Oct 2015, Bucharest, Romania

[5] Serbanescu D., *Some considerations on the lessons learnt from the cavalcade of changes in Physics' models,* DOI: 10.13140/RG.2.1.4734.6968, International Conference on Interdisciplinary Studies, ICIS 2016, June 2016, Constanta, Romania

[6] Baez, John C, Stay, M., *Physics, Topology, Logic and Computation: A Rosetta Stone*, http://math.ucr.edu/home/baez/rosetta.pdf

[7] Descartes, Rene, 1960, *Discourse on Method and Meditations. Laurence J. Lafleur (trans).* New York: The Liberal Arts Press. ISBN 0-672-60278-4

[8] Serbanescu D., *Considerations on some lessons learnt from the Physics models - O privire asupra unor lectii de cunoastere date de cavalcada modelelor in fizica*, DOI: 10.13140/RG.2.1.1249.8409, International year of Light 2015, Oct 2015, Bucharest, Romania

tradition, considered too "speculative" by Descartes. Therefore, the search for knowledge in science was setting a new foundation:

- As being more solid, traceable, retrievable and able to be repeated if correctly applied by anybody using it;
- As being in the favor of the progress of the techniques adopted for building methods of systematic cosmos knowledge.

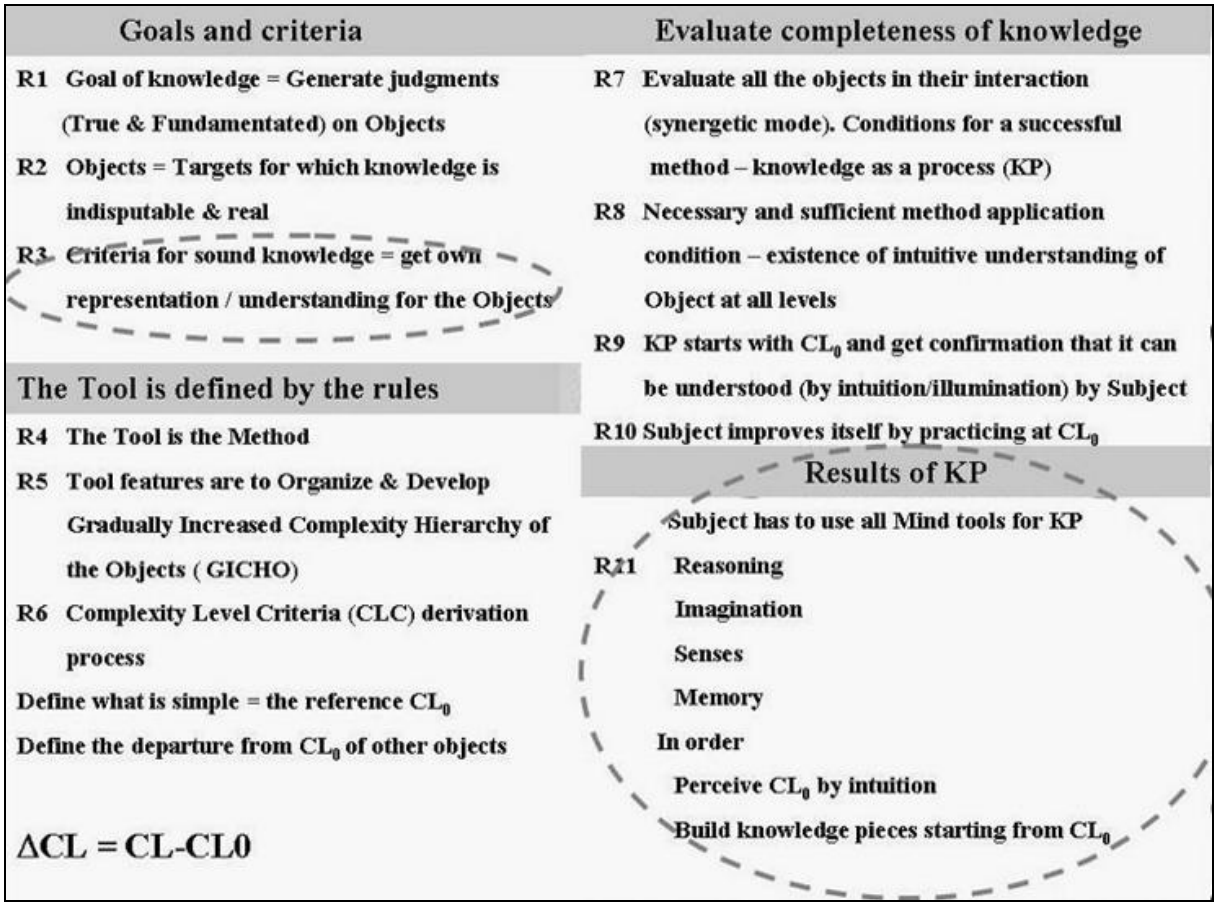


Figure 1. René Descartes, *Discours de la méthode*, 1637[9]

However, the *Discours de la méthode* considered that the scientist, i.e. the subject trying to acquire knowledge, called "the observer", was *independent from what he was observing*. This is something that quantum physics shattered seriously hundred years ago and now it became the dominant aspect of defining the knowledge in the "era of quantum physics". From the perspective of modern physics, the "independence" of the observer in studying topological-like objects becomes a central point of solving the problem on how to manage the scientific search for new explanations and TOE like solutions.

[9] *** https://www.thoughtco.com/multiverse-definition-and-theory-2699273, Edited by Anne Marie Helmenstine, Ph.D.

1.2 Main topics

The topic of possible high role of topological approach in the search for "universal" explanations/solutions of everything (a perpetual search of the mankind, since the times it became self-conscious) is underlined not only by physics, but also by results from mathematics.

However, the attempts made so far to find such unifying approaches were rarely focused on the possibility to have a unique description for both knowledge and existence. Such an approach could be based on the fact that both knowledge and existence are actually similar, homogenous and therefore possible to be described as topological spaces in an integrated manner.

There are, in present, various examples of the reasons to search the topological models for objects defined by physics and to model existence in general using topological tools, as for instance:

i. *The issue of multiverses,*
ii. *The illustration of the Poincaré conjecture and the Hilbert challenge formulated as the 24-th principle*[10]*, which provide models resulting in mathematical topological form of description. This principle is one of the unsolved issues in mathematics (for instance the problems listed in Annex 1).*
iii. *Similarities in nature and science on some topological spaces and*
iv. *Some comparisons with "old" and "new" theories in physics that were convergent in using topologic like description, as illustrated by the present agenda of unsolved issues in physics (Annex 2).*

1.2.1 The multiverses (meta-universes)

Multiverses have many possible representations (one example is in Figure 2) and they are one of the topics suggesting the need to use topological approach for a better description, as solutions to the mathematical equations of physics. Currently there are various opinions on the issue, the most recognized is that there are four (and in some approaches, five) types of multiverses[11].

Type 1 - Bubble Universes – A Big Bang event happened so far away from us, that we can not conceive of the distances involved yet. In accordance with this theory, if we consider our universe to consist of the galaxies created by a Big Bang, that is expanding outward, then we may expect either that eventually our universe might encounter another universe (created in a similar way), or that, due to the fact that the distances involved are so vast, multiverses would never interact.

Type 2 – Multiverse from Repeating Universes – It consideres that, eventually, the arrangements of particles will repeat themselves, due to the fact that the universe is infinite. The implication of this theory is that, if travelling far enough, one may find another Earth and another identical person.

Type 3 - Braneworlds - Parallel Universes – For this type of multiverse, the universe where we are includes also additional dimensions beyond the three spatial dimensions we perceive plus time. It is therefore possible that other three-dimensional "branes" may co-exist in higher-dimension space, acting as parallel universes.

[10] Rüdiger Thiele, *Hilbert's twenty-fourth problem*,American Mathematical Monthly, January 2003

[11] *** https://www.thoughtco.com/multiverse-definition-and-theory-2699273, Edited by Anne Marie Helmenstine, Ph.D.

Type 4 - Daughter Universes – It is based on the quantum mechanics theories describing the universe in terms of probabilities. In accordance with those theories, all possible outcomes of a choice or situation not only can occur, but do occur and at every branch point, a new universe is created.

Type 5 - Mathematical Universes – In this theory (that is present in some descriptions on multiverses) it is assumed that mathematics is a tool used to describe the parameters of the universe. This theory states that it is possible that there could be a different mathematical structure and if this is true, then such a structure could describe a completely different sort of universe.

The common feature of all the *theories on multiverses is that they imply the use of topological approach, as indicated by many of their assumptions, as for instance the presence of fractal type constructions in all of them.*

Figure 2 Type 1 multiverse - Bubble universes [12]

1.2.2 Poincaré conjecture and the unsolved similar mathematical issues

The Poincaré conjecture is about the 3-sphere (see Figure 3) – the hypersphere that bounds the unit ball in four-dimensional pace. *The conjecture states that every simply connected, closed 3-manifold, is homeomorphic to the 3-sphere.* For the purpose of the searches of topological descriptions, this could be considered as a potential method for reducing and connecting any topological space to a hypersphere, i.e. a TOE formulated in mathematical terms. In the stereographic projection of the hypersphere illustrated in Figure 3, the parallels are in red, meridians in blue and hyper-meridians in green. The properties are:

- The curves intersect each other orthogonally, as shown by yellow points.
- All the curves are circles and the curves that intersect in the location (0,0,0,1) have infinite radius and are represented by the straight line.

The next paragraph presents some possible topics that could be studied in the spirit of searches for solutions, which may include topological approaches.

[12] Julian Baum, *Multiverse Definition and Theory*, Getty Images -by Andrew Zimmerman Jones https://www.thoughtco.com/multiverse-definition-and-theory-2699273

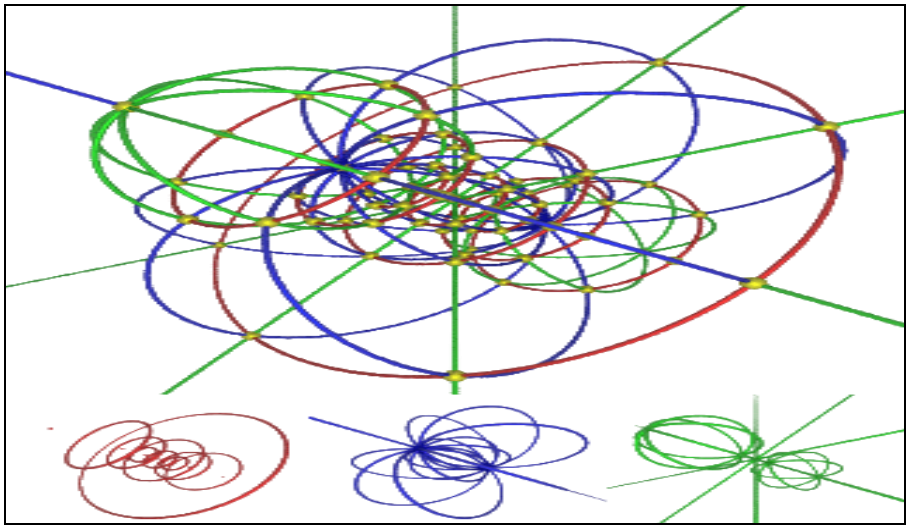


Figure 3 Poincaré hypersphere[13]

1.2.3 Topological spaces in cosmos and human artefacts

There are examples of topics leading to the need for integrated models of the universe, which may be considered from the point of view of searching solutions to mathematical equations of physics.

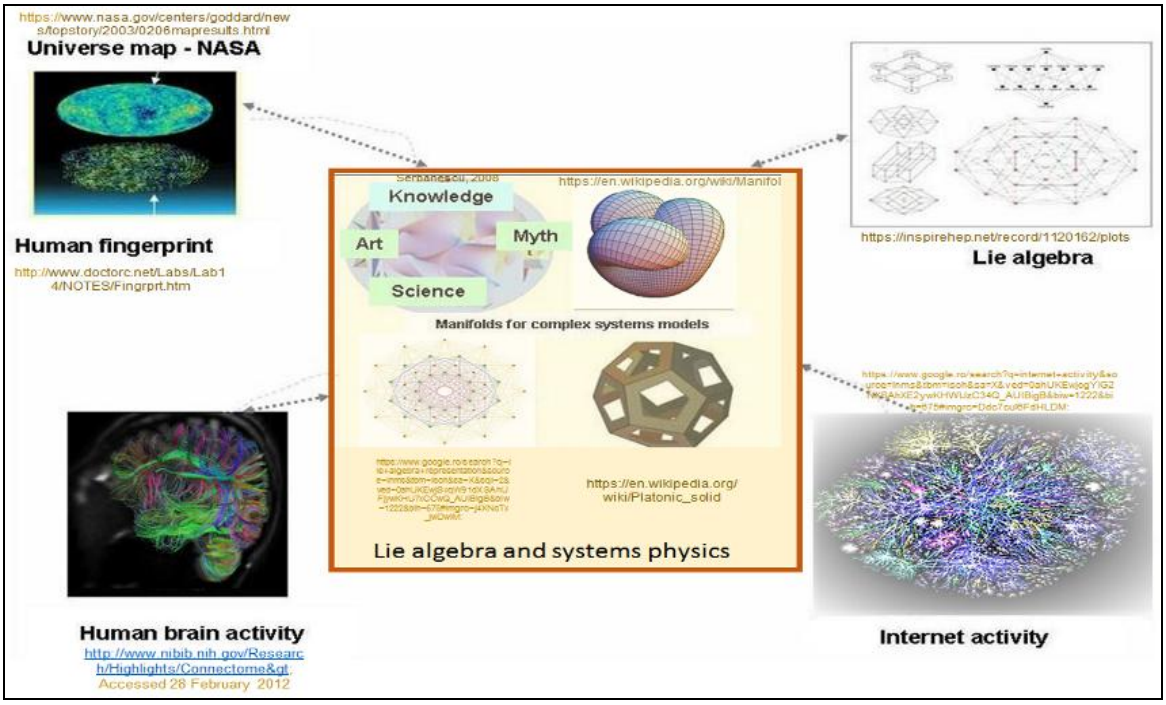


Figure 4 Examples of complex systems and topological similitudes

[13] *** https://en.wikipedia.org/wiki/3-sphere

As illustrated in Figure 4, there are strange, if not explained in a unitary approach, similarities between very diverse types of complex systems (some “old” and some ”new”, historically):

- Universe map
- Human fingerprint
- Lie algebras and Plato poliedra
- Kepler representations of the Cosmos
- Internet activity
- Human brain activity etc.

An important common feature for all those examples, in the sense of the searches for unitary description, is the possibility to describe them by using the mathematical tools of topology.

Topology can be connected, in the understanding of the paper, to issues like:

- The apparent (for the observer) *continuity* of knowledge and existence
- The search for solutions in *iterative manner*, *step by step*, during the search for the optimal description of the structure.

There are already available results from mathematics and from astronomy, which illustrate the use of topology in the study of objects by various natural sciences, as follows (Figure 5):

- Representations of the Cosmos (as described by Kepler).
- Plato poliedra and their corresponding newer developments from Lie algebra in the format of various topological models.
- The Poincare hypersphere mentioned in the paragraph 1.2.2.

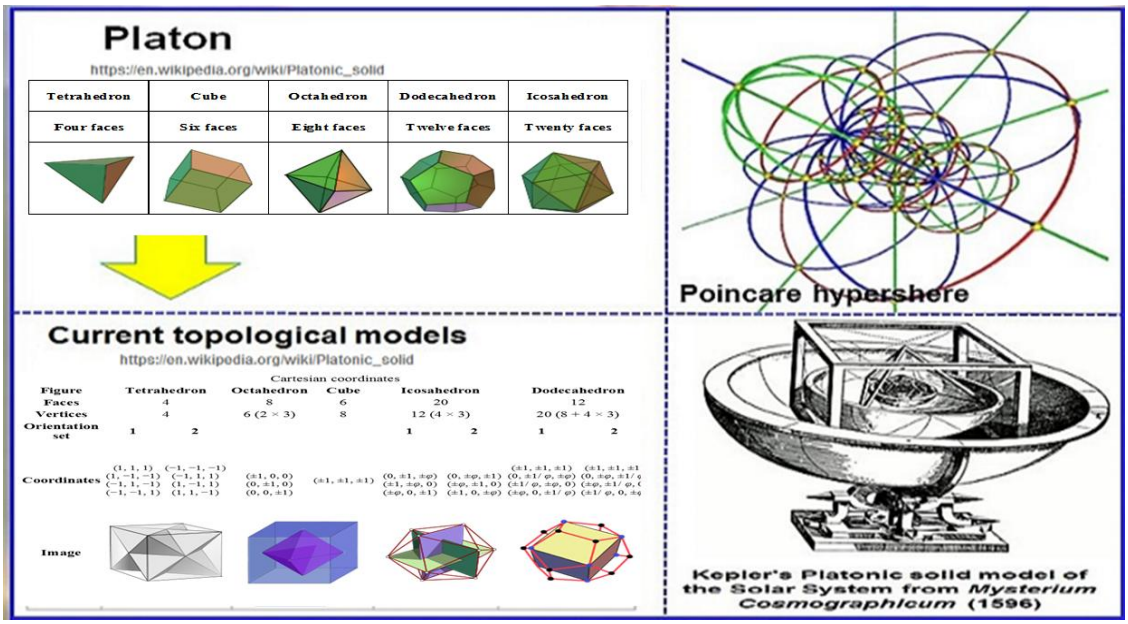
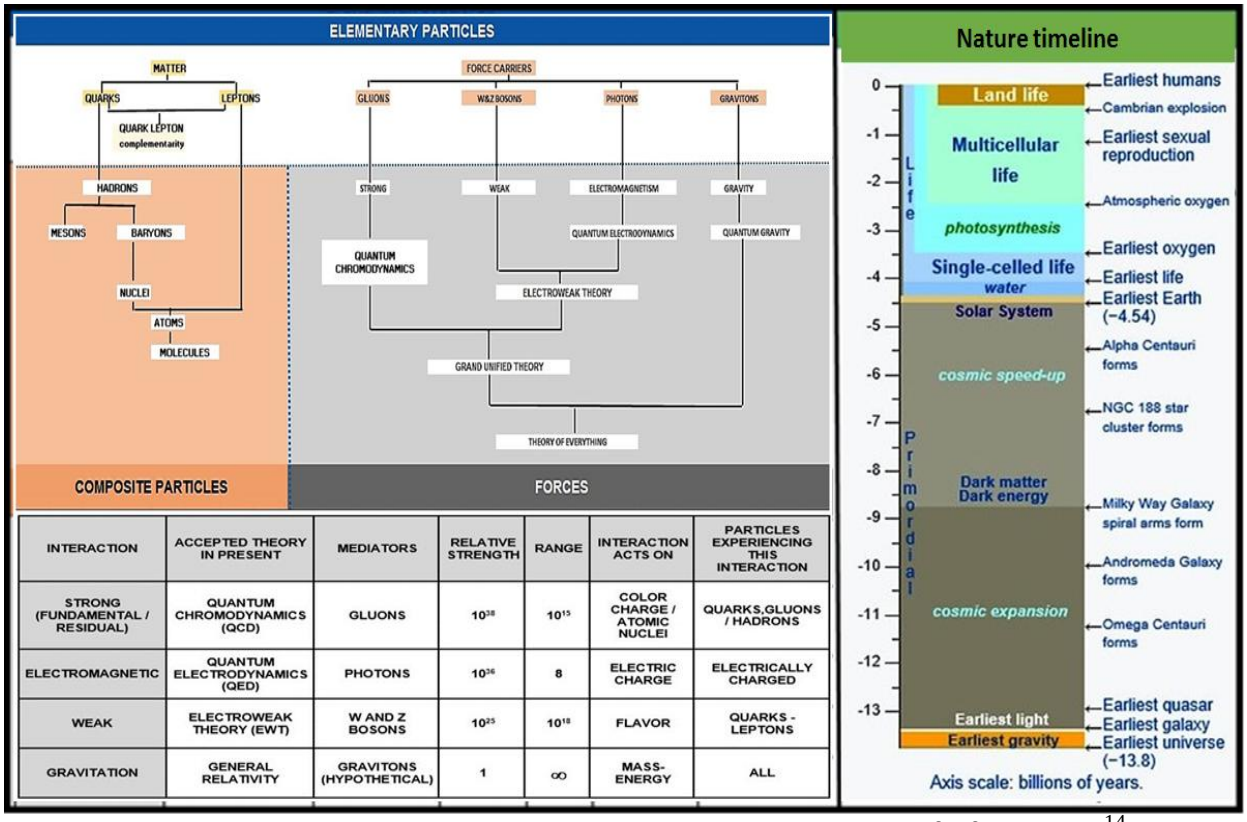


Figure 5 Samples of topological models

Lie algebra is also used in some theories in quantum mechanics. The quantum mechanics theories have as object the force carriers (gluons, gravitons etc) and the matter particles, from quarks to molecules (Figure 6). The established so far quantum mechanics main theories are as follows:

- Quantum CromoDynamics (QCD), describing the strong forces with the gluons as carriers
- ElectroWeak Theory (EWT), describing the weak forces having the bosons as carriers and the electromagnetic forces with photons as carriers
- Quantum Gravity (QG), which describes the forces having the gravitons as carriers.
- The EWT and QCD are included in the Grand Unity Theory (GUT)
- As for the GUT and QG united theory, this is a top unsolved issue in physics and it is considered as Theory of Everything (TOE).

There is also a long evolution (Figure 6) from inorganic matter to life and conscious life (Figure 6). This is considered as a sample case, developed later in paragraph 2.2.2, in order to illustrate the proposed approach in this paper.



INTERACTION	ACCEPTED THEORY IN PRESENT	MEDIATORS	RELATIVE STRENGTH	RANGE	INTERACTION ACTS ON	PARTICLES EXPERIENCING THIS INTERACTION
STRONG (FUNDAMENTAL / RESIDUAL)	QUANTUM CHROMODYNAMICS (QCD)	GLUONS	10^{38}	10^{15}	COLOR CHARGE / ATOMIC NUCLEI	QUARKS,GLUONS / HADRONS
ELECTROMAGNETIC	QUANTUM ELECTRODYNAMICS (QED)	PHOTONS	10^{36}	8	ELECTRIC CHARGE	ELECTRICALLY CHARGED
WEAK	ELECTROWEAK THEORY (EWT)	W AND Z BOSONS	10^{25}	10^{18}	FLAVOR	QUARKS - LEPTONS
GRAVITATION	GENERAL RELATIVITY	GRAVITONS (HYPOTHETICAL)	1	∞	MASS-ENERGY	ALL

Figure 6 Standard model in quantum physics and illustration of life timeline[14]

2. Approaches about the search for integrated description of knowledge and existence

2.1 Investigating the range of possible approaches

2.1.1 *Investigating the known available range of approaches*

The paper refers to an example that might be a way to look for solutions in the search of a TOE type of answers from the perspective of natural sciences. The "toolbox" to solve the problem consists of a set of possible approaches, of which there are two "extreme" possible.

[14] Serbanescu, D., *Elemente de istoric al teoriilor despre univers – privite mai ales prin prisma teoriilor fizicii*, DOI: 10.13140/RG.2.2.31825.33128, Feb 2017, Bucharest, Romania, CRIFST-DLMFS Simposium Modele fundamentale ale Materiei si Universului.

The two type of approaches presented in the paper are given by *David Hilbert in his notes on the challenge called the 24th* and by *Emil du Bois- Reymond*.

In short, the two approaches are defined by the statements, which were made by their authors, as follows:

- *Ignoramus et Ignorabimus* "We do not know and will not know", describing the limits of scientific knowledge, as stated by *Emil du Bois-Reymond* in his *Über die Grenzen des Naturerkennens* [On the limits of our understanding of nature] in 1872 [15]
- *Wir müssen wissen — wir werden wissen*. [Our motive must be to learn. We shall this way greatly achieve], as *David Hilbert* wrote in his notes on the challenge 24[16]

Some more details on the two approaches are presented below:

i. *du Bois-Reymond formulated a list of "riddles" in his 1880 speech* at the Academy of Sciences Berlin. He declared that, neither science nor philosophy could ever explain all those riddles:
   1. the ultimate nature of matter and force,
   2. the origin of motion,
   3. the origin of life,
   4. the "apparently teleological arrangements of nature," not an "absolutely transcendent riddle"
   5. the origin of simple sensations, "a quite transcendent" question
   6. the origin of intelligent thought and language, which might be known if the origin of sensations could be known
   7. the question of freewill.

Concerning the "riddles" 1, 2 and 5, Bois - Reymond proclaimed "ignoramus et ignorabimus" - "we do not know and will not know. "[17]

ii. *David Hilbert and his 24th challenge* that was formulated by him in draft notes. It was never presented in his speech (on the challenges faced in mathematics/the 23 problems) at the International Congress of Mathematicians in Paris on 8 August 1900. The issue from this challenge is related to criteria of simplicity of certain proofs, or to the proof of the greatest simplicity. Hilbert indicated in this unpublished notes some features of a successful route to make a proof and suggested some approaches to reach this goal, as follows:
   - Under a given set of conditions there can be but one simplest proof.
   - In general, if there are two proofs for a theorem, one must use both of them, until one can be derived from another or until it becomes evident what conditions and aids have been used in the two proofs.
   - Consequently, it seems that Hilbert noted that if there are two routes for a proof, then it is not right to take any of these two or to look for a third, but it is necessary to investigate the area lying between the two routes.

[15] William E. Leverette Jr., E. L. Youmans' *Crusade for Scientific Autonomy and Respectability*, American Quarterly, Vol. 17, No. 1. (Spring, 1965), pg. 21

[16] Rüdiger Thiele, *Hilbert's twenty-fourth problem*, American Mathematical Monthly, January 2003

[17] Finkelstein, Gabriel Ward (2013). Emil du Bois-Reymond: *Neuroscience, Self, and Society in Nineteenth-Century Germany*. Cambridge, Massachusetts: The MIT Press. p. 272. ISBN 9780262019507

- He also proposed to reach the simplicity of a proof by using syzygies, for which he gave a different interpretation than the one now used in mathematics. The new approach on syzygies is presented in the next paragraphs. Hilbert considered that the use or the knowledge of a syzygy simplifies in an essential way a proof that a certain identity is true, due to the fact that:
  - any process of addition is an application of the commutative law of addition,
  - the use of syzygies always corresponds to geometric theorems or logical conclusions.

The last reason mentioned by Hilbert for using syzygies is, on our view, an early indication of the suggested use of topological approaches in demonstration of various theorems, and hence a topological support for mathematical background of various physics' equations. Hilbert underlined the idea of the usefulness to use syzygies by connecting his challenge (the so called "24th challenge") with the manner in which in certain theorems of elementary geometry (the Pythagoras theorem for instance) it can be easily established which of the proofs is the simplest[18].

The paper presents in the next paragraphs an approach inspired by the David Hilbert's ideas on the syzygy type of solutions. Previous results of the proposed approach [19] are reiterated and extended.

2.1.2 Investigating some approaches available in physics

Before proceeding to the presentation of the topological approaches, it is also important to mention that they are in line, from many perspectives, with a "traditional" method available in physics: dimension analysis.

This alternative, that is considered by some physicists a possible solution apparently "theory independent" (in the sense that they do not involve recognition or rejection of any of the present theories in hysics), is fit to the search for unified approaches of the elements of existence studied in physics.

The approach is based on the dimension analysis for equations and the dimension aspects related to the constants (as partially illustrated in Figure 7). The evaluation of how the constants appear (if they are real at all) and how they are related to each other is a central point of this approach.

The answer to such questions is actually connected to the possibility to derive a minimal basic set of constants to describe all the phenomena and reality in physics', as well as to describe the manner they are connected between them, and is a central challenge in modern days for this science.

It might be considered therefore, that these are equivalent formulations with the search for syzygies in any theoretical system in physics. A more detailed presentation on the use of syzygies in the knowledge process (KP) is included in previous papers[20].

[18] David Hilbert, *"Mathematical Problems"*. , Bulletin of the American Mathematical Society, vol. 8, no. 10 (1902), pp. 437–479. Earlier publications (in German) appeared in Göttinger Nachrichten, 1900, pp. 253-297, and Archiv der Mathematik und Physik, 3dser., vol. 1 (1901), pp. 44-63, 213-237.

[19] Serbanescu D., Considerations on some lessons learnt from the Physics models - O privire asupra unor lectii de cunoastere date de cavalcada modelelor in fízica, DOI: 10.13140/RG.2.1.1249.8409, International year of Light 2015, Oct 2015, Bucharest, Romania

[20] Serbanescu, D., *O perspectivă din interiorul fizicii și energeticii nucleare asupra istoriei acestora, dar mai ales asupra dilemelor lor actuale -Cu accent asupra specificului din Romania* , DOI: 10.13140/RG.2.2.15099.52005, Symposium: Romanian Academy - 150 years, CRIFST-DLMFS, Bucharest, Romania, Sept 2016

The KP that is using syzygies has inputs from hysics' dimensional analysis, by using the concept of syzygies in algebra and the concept of category in mathematical understanding.

However, the examples developed so far and presented by the author previously [21] were related only to knowledge and did not consider an integrated approach for knowledge and existence, as it will be presented in the next paragraph of the paper.

For a given equation of the type "F = const * X * Y ", the dimensions of each side have to be identical and able to derivate the dimension of the constants, if any (Figure 7).

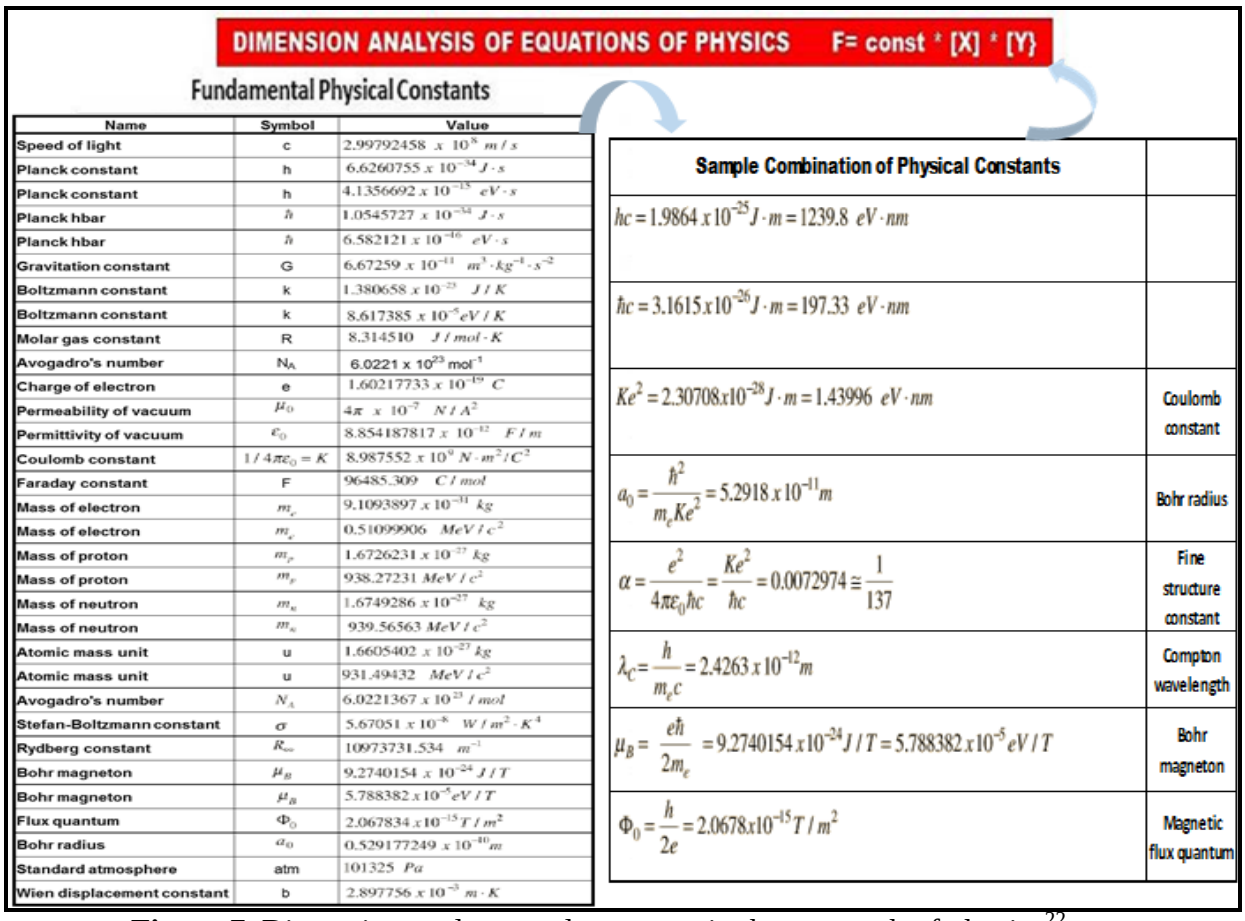


Figure 7. Dimension analyses and constants in the approach of physics[22]

2.2 Towards an Integrated approach for description of knowledge and existence. Methodology and results

2.2.1 Knowledge Topology (K^T) and Knowledge Process (KP)

The use of topological approaches to describe the KP was presented before[23] including an example of its application. The approach was based on the hypothesis that knowledge topological space (K^T) is built considering the following assumptions:

[21] Serbanescu, D., *Selected topics in Risk Analyses for some Energy Systems*, LAP Lambert Academic Publishing, May 2015, https://www.lap-publishing.com/catalog/details//store/gb/book/978-3-659-71468-9/selected-topics-in-risk-analyses-for-some-energy-systems, ISBN-13: 978-3-659-71468-9, ISBN-10: 3659714682, EAN: 9783659714689

[22] *** http://hyperPhysics.phy-astr.gsu.edu/hbase/Tables/funcon.html

- KP is a triadic process, having facets for: science, art and cultural-mythological-social aspects.
- The resultant Knowledge is based on the degree of reaching certain levels considered adequate, based on various criteria, as for instance:

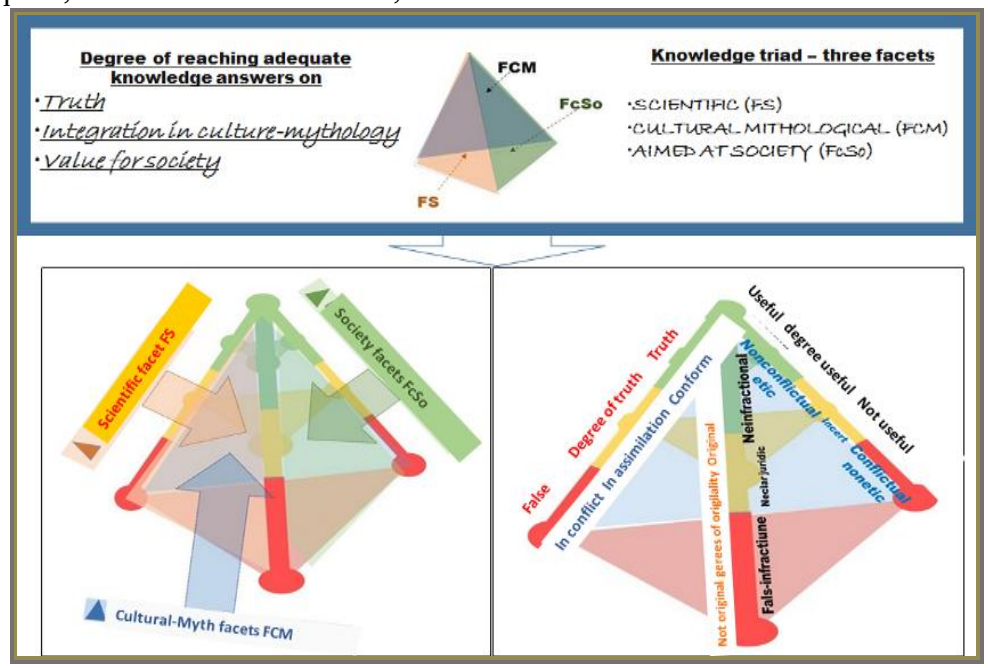


Figure 8. Criteria for the evaluation of the Knowledge Triad

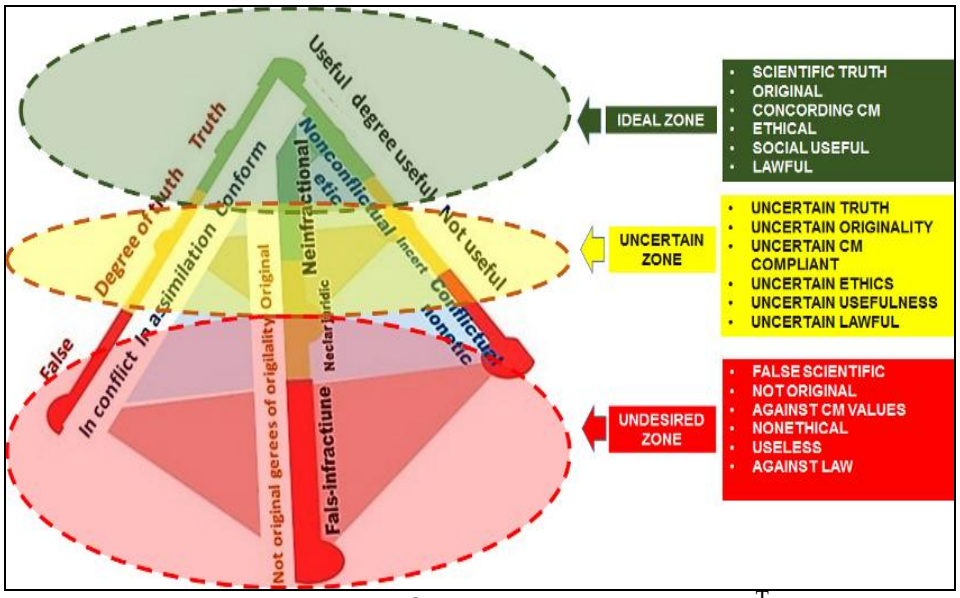


Figure 9. Zones of Knowledge Topology (K^T)

[23] Serbanescu D., *Unele aspecte ale modelării in fizică*, DOI: 10.13140/RG.2.2.25114.44483, CRIFST-DLMFS Simposium Modele fundamentale ale materiei și Universului, Bucharest, Romania, Feb 2017

- The level of truth,
- The level of conformity and integration in the cultural environment and
- The value for society.

The degree of compliance with the above-mentioned criteria may be graded and therefore, the areas where the possible type of (K^T) is situated may be divided (as represented in Figure 8) in *Undesired Zones* by all criteria, *Uncertain Zones* by most of criteria and *Ideal Zones*.

The KP is iterative and the transformation is taking place gradually, in the spirit of a common sense non-mathematical understanding of topology, as represented in Figure 9.

The created K^T consists of a graded change of its characteristics. The criteria used to describe each zone are related to (Figure 9):

- Scientific truth
- Originality
- Cultural values
- Ethics
- Usefulness
- Legality

There are three major zones, described by those criteria:

- **In the Undesired Zone** the **worst values are reached.**
- **For the Uncertain Zone** the criteria have **unproved and untrusted evaluations**
- In **the Ideal Zone,** the **best graded evaluations** are reached.

In a previous paper,[24] the author concluded that the triadic approach in studying the KP and its results has the implication that the type of acquired knowledge becomes characteristic for the type of society (from the knowledge acquisition point of view) where it was developed.

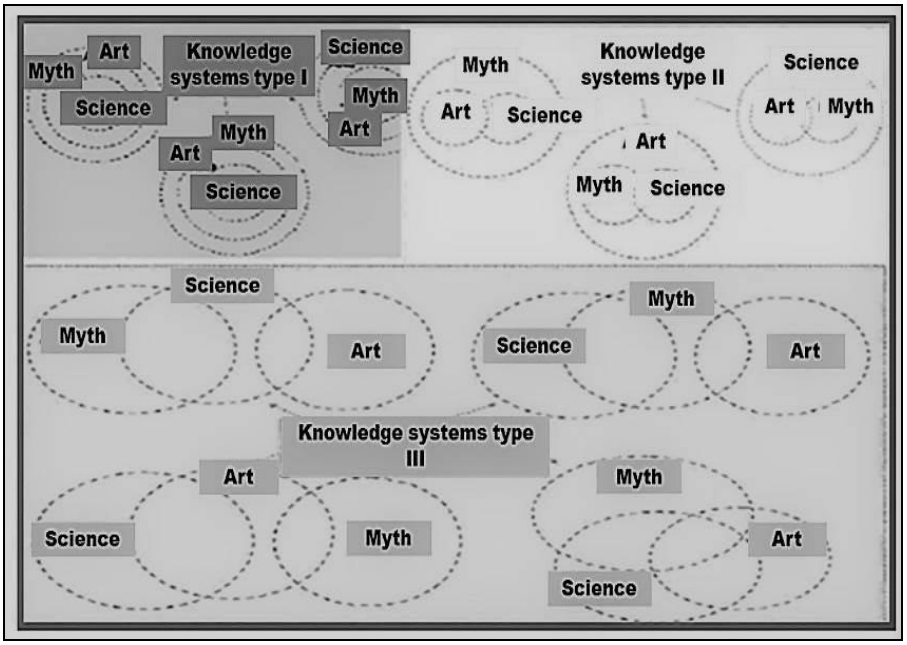


Figure 10 Types of civilization classified by the appproach to acquire knowledge and manage KP

[24] Serbanescu D., *On Some Knowledge Issues in Sciences and Society*, *ECKM13*, Kaunas, 2013

In Figure 10 there is a representation of the three types of civilization classified by the manner the KP is developed:

- *KP_Type I when a dominant facet of the above mentioned triad is dominant (art, science of mythology-cultural)*
- *KP_Type II when two of the facets are dominant and governing the KP*
- *KP_Type III when the multidisciplinarity, transdisciplinarity and interdisciplinarity are the dominant approaches of acquiring knowledge and managing the KP*.

The Knowledge topology (K^{T}) is therefore dependent on the type of civilization that is creating it. Other theories on civilization, targetting mainly the material level that is reached by a certain civilization rather than the KP used for it, consider type of civilizations based on the level of energy that can be harnessed by it[25], i.e.:

- *KSH_Type I – for energy received from the sun on the planet hosting a given civilization*
- *KSH_Type II – for all energy at the level of sun system*
- *KSH_Type III – for energy at level of a galaxy*

From the perspective of this classification our civilization is far away from type I and may reach it in around 200 years, provided that it will not self destroy due to the effect of chaotic behavior[26].

2.2.2 Integrated Topological Approach on Knowledge and Existence (ITAKE)

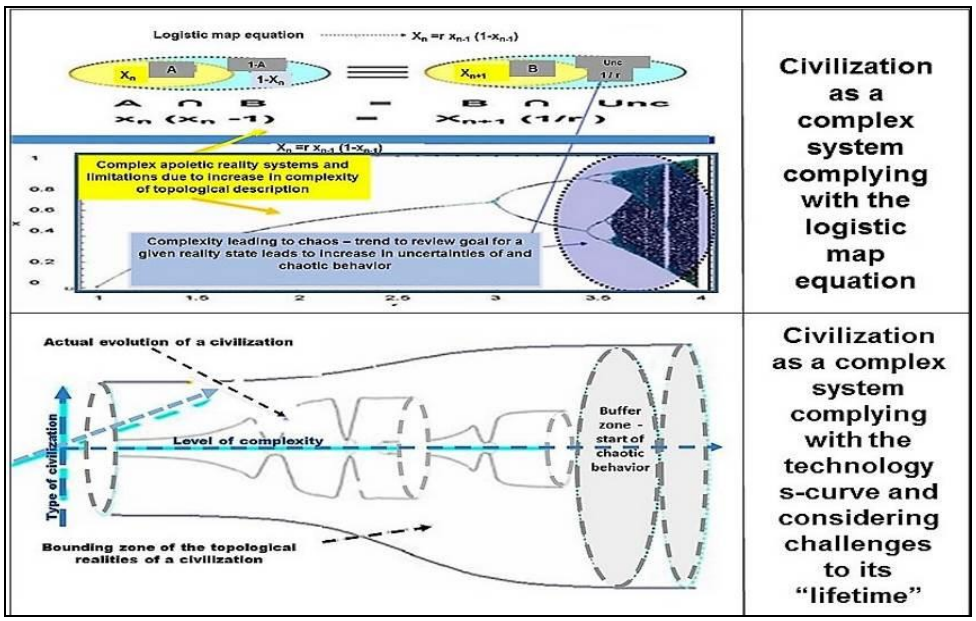


Figure11. Civilization as a complex system and its „lifecycle"

As it was shown in the previous paragraphs, there are reasons to search for an Integrated Topological Approach on Knowledge and Existence *(ITAKE)*, both for knowledge and existence, considered in the assumptions mentioned in the first paragraph. *ITAKE* has as a starting point the

[25] Kardashev, N., *Cosmology and civilizations*, AstroPhysics and Space Science 252, 1997, doi:10.1023/A:1000837427320

[26] Serbanescu, D., *Omenirea incotro? - Quo vadis Domine?* , DOI: 10.13140/ RG.2.2.13895.29603 ·10/2016, Conference: Annual session of the Division of Logic models of Romanian Academy oct 2016

David Hilbert type of approach and elaborates on the syzygy type of solutions, as drafted by him. Previous results of the proposed approach [27] are now reiterated and extended. *ITAKE* is part of the level of civilization reached. Civilization may be considered as a super sinergetic set of technologies (Figure 11). The civilization as a technology is described by the „*technology s-curve" for its survival capability*.

On the other side, the *level of complexity* (Figure 11) evolves during the civilization lifetime and reaches a *critical point* (*cusp point*), after which a *chaotic behavior* is possible. A civilization is characterized during its lifetime by various *survival related criteria*. In paragraph 2.2.1 for our case it was considered, that given the level of the energy we use currently, our civilization is below KSH_Type I (the lowest category).

The *„civilization enveloping technology s-curve"* describes the evolution of its survival criteria in a three dimensional space that takes into account *its level of complexity*, too (Figure 11).

There is an ideal bounding level of a possible evolution of those criteria. However the real evolution has ups and downs, as illustrated also in Figure 11. The difference between the real and the ideal curves shows the existing margin for improvements.

A chaotic behavior is much faster possible to happen (before reaching even a level of KSH_TypeI) due to the increased level of complexity and delay in adopting a wide spread approach to change the KP to a fully implemented KP_Type III one (an integrated K^T generated by a multidisciplinary, transdisciplinary aand interdisciplinary KP).

In our opinion only a ***KP_Type III civilization is able, from KP perspective, to create an integrated K^T and lead to fast set of changes / improvements of a civilization.***

Even if the positioning on the criteria for KSH_Type I are not reached[28], our civilization could have a new reset of its state and enter a period of explosive devlopments if a KP_Type I is adopted. As a result a coordinated change of knowledge and existence, as an integrated knowledge and existence topology ($K\ E^T$), will create a new reality, that will position our civilization higher on any scale.

Such change will also assure a time delay in getting closer to the „Buffer Zone" (the zone before entering into a chaotic evolution) allowing our civilization to prepare for further evolutions.

An intensive use of KP_Type III, even for a lower than KSH_type I civilization, may lead, in our opinion, to the delay in reaching a chaotic selfdistructive zone. On the other side, it is important to mention that all those evaluations are guided by the use of topological approaches.

Summarizing, an integrated topological approach for the evaluation of the knowledge and existence is possible due to the following main reasons:

- The elements defining existence (objects of study of physics) and knowledge (results of the understanding and behavior prediction of the physical objects) have features making them adequate to topological approach, i.e.
  - continuity,
  - iterative step by step emergence of their states and/or of the gained knowledge on them and
  - a specific type of logic, that is the best suited for the approach, called topological logic.

[27] Serbanescu D., Sticlaru G., Spiridon L.V., *O privire asupra cavalcadei modelelor in fizică: evoluții previzibile, ritmicitate sau haos?,* Academia Română, Divizia de Logică, Metodologie și Filosofia Științei (DLMFS), Comitetul Român de Istoria si Filozofia Științei și Tehnicii (CRIFST) , Sesiunea de primăvară, 23 aprilie, 2015

[28]Serbanescu, D., *Scientific Knowledge and Mythology*, DOI: 10.13140/RG.2.1.2447.7201 · SRA conference Boston, USA, Dec 2008

- The topologies defined for knowledge and existence cannot be separated and they have to be considered in an integrated manner, if the goal is to search for a TOE, including the quantic level.

The Integrated Approach on Knowledge and Existence Topology *(ITAKE)* as a process, defines a structure, *called Integrated Topological Reality (ITR $^{(i)}$)* at any iteration "i". *The elements of ITR$^{(i)}$* define states that change / emergence to various levels based on very clear rules. There are *three basic principles for ITR $^{(i)}$* (as presented in detail in[29]).

The three principles of *ITAKE* are as follows**:**

- **First Principle** – The topological structure ITR $^{(i)}$ is described by the notion of category.
- **Second Principle** – The reality building process takes place in iterations made for the categories, defined in accordance with the first principle.
- **Third Principle** – The process leads asymptotically to a final stable state. However, the structure of the final state cannot be known in advance.

First Principle of ITAKE – The topological structure ITR $^{(i)}$ is described by the notion of *category*. The notion of category is considered to reflect a *hierarchical structure of "Matrioshka" type* (various levels noted as "l"). This structure may be described as a more generalized type of cybernetic system, in which its elements are "black boxes" for every level of emergence and described by a more general notion of "category" from mathematics. The following are specific features of the approach using the notion of category:

- ***For a given layer "l" the elements of ITR $^{(i)}$ are the objects $R_{(k)}^{(i)}$.*** Those elements (k) of reality of type (i) are each of them defined as a *triad*, which is composed of:
  - The *elements* of study by the methods of physics (for instance "mass" and "energy") $Obj_{(1)}{}^{(i)}$, $Obj_{(2)}{}^{(i)}$……
  - A *connector* between the elements are defined by rules of any type called *functors*, which are *morphisms* at the level of element definition f(j1),f(j2)…and f(j1) * f(fj2)….. called functor. The functors are morphisms / maps.
  - A given *paradigm* based on which the functors are defined **(**for instance *"mass and energy may be transformed into each other"). This paradigm is assumed to be defined by a set of minimal descriptors, called syzygy of level (i).*

  For example the *syzygy for the layer "Galilean mechanics" (GAM)* can be described as in (1):

$$Syzygy_G = [F_{G1}, F_{G2}, F_{G3}] \quad (1)$$

Where

$Syzygy_G$	= Syzygy for Galilean Approach in Mechanics (GAM)
F_{G1}	= Syzygy component of GAM defined as "mass" (inertial)
F_{G2}	= Syzygy component of GAM defined as "acceleration"
F_{G3}	= Syzygy component of GAM defined as a principle of a mechanical movement.

[29] Serbanescu D., Spiridon L., *On information issues in nature and society.Despre informatie in Natura si Societate,,* Academia Romana Sesiunea de primavara 2014 a Diviziei de Logică, Metodologie şi Filosofia Ştiinţei, CRIFST Tema - Cursa dintre teorie şi experienţă Bucuresti, 24 aprilie 2014, Bucharest, Romania

- $R_{(k)}^{(i)}$ defines a certain layer 'i" of the "Matrioshka" type of description of topological structure. The emergence from one layer to another is performed by *emergence functors, which are syzygies of level (i+1), which are composed of paradigms of the syzygy of the lower layers.*
  For instance one example of possible *syzygies* used *for transfer / emergence from layer "Aristotelian mechanics" (AM) to layer "Galilean mechanics" (GAM)* can be described as in (2):

$$\text{Syzygy}_{A\text{-}G}^{E} = [F_{A\text{-}G1}^{E}, F_{A\text{-}G2}^{E}] \quad (2)$$

Where
$\text{Syzygy}_{A\text{-}G}^{E}$ = Syzygy defining the emergence from AM to GAM
$F_{A\text{-}G1}^{E}$ = Syzuygy component of emergence from AM to GAM "force independent of speed",
$F_{A\text{-}G2}^{E}$ = Syzygy component of emergence from AM to GAM "fall independent of mass"

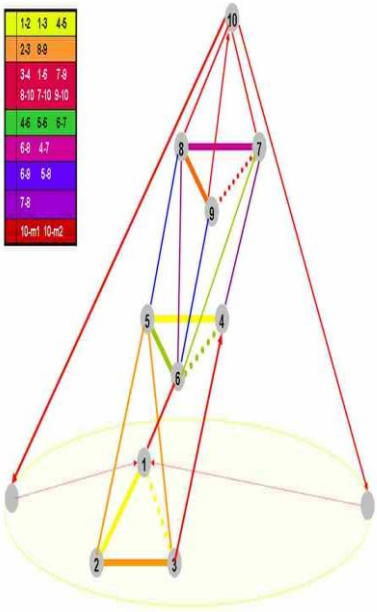
LEVEL CODE	DESSCRIPTION LEVEL	GRAPH DESCRIPTION	STATE DESCRIPTION	LIMITS / INTERNAL DRIVING FORCE OF TRANSITION TO ANOTHER STATE	STATE CODE
I	DEFINE STATES AND PRINCIPLES OF EMERGENCE		DEFINE THE STATE AND THE NEED TO GENERATE IT	A UNIQUE SOURCE FOR A GIVEN STATE	1
			CLARRIFY DIFFERENCES BETWEEN OPTIONS / EMERGENCE DIRECTIONS OF A GIVEN STATE - APPARENTLY BEING CONTRADICTORY	DUALITY AS A BASIS FOR A GIVEN STATE	2
			GENERATE MECHANISMS TO FIND AND / OR REACH OPTIONS ABLE TO ASSURE EMERGENCE TO OTHER STATES	THE THIRD WAY AS A SOLUTION FOR EMERGENCE FROM A STATE DESCRIBED AS A FUNDAMANTAL DUALITY	3
II	DEVELOP RULES OF EMERGENCE FOR A STATE		ASSURE STATE STABILITY	STABILITY OF A STATE AS A DIRECT CONSEQUENCE OF THE PARADOX RESISTANCE CAPABILITY OF THE STATE	4
			COAGULATION OF BELIEFS/PRINCIPLES IMPEADING THE EMERGENCE FROM ONE STATE TO ANOTHER	EVERY STATE IS DEFINED AND MAINTAINED STABLE AS LONG AS SOME BELIEFS / PRINCIPLES DEFINING THE STATE ARE DOMINANT/GOVERNING ANY CHANGE	5
			A GIVEN STATE TENDS TO OPTIMIZE ITSELF AS A STRUCTURE WORKING TO REACH A CERTAIN DEFINED GOAL	ATETS GET OPTIMAL AND WORK TO REACH A PREDEFINED GOAL	6
III	CONSOLIDATE THE DEFINED STATE		THERE IS A TREND OF THE STATES TO COMBINE BETWEEN THEM IN ORDER TO REACH THEIR PREDEFINED GOALS	COMBINATION OF STATES IS GOVERNED BY THEIR INTRINSIC TREND TO OPTIMIZE THE RATIO BETWEEN THE USEFULNESS OF THE COMBINATIONS AND OF THE INDIVIUAL STATES, I.E. ASSURE TELEOLOGIC SYNERGY OF THE STATES.	7
			STATES NEED TO BE (SELF)MANAGED / SELFREGULATED SO THAT TO BE ABLE TO REAACH THEIR GOAL IN AN OPTIMAL MANNER	STATE OPTIMIZATION BY THEIR HIERARCHICAL SYSTEMIC ORGANZATION	8
			STATES TEND TO EXPLORE FULFILLING ALSO OTHER GOALS THAN THE ONES PREDEFINED FOR THEM	EXPLORATION OF THE STATES STRUCTURE AND OPERATION LEADS TO THE NEED FOR A TOTAL (SELF)CHANGE / (SELF)RESTART.	9
IV	FEEDBACK		THERE IS A GOVERNING STATE DEFINING THE NEED FOR RESTART THE EMERGENCE PROCESS	FEEDBACK REACTION AS INFORMATION ENTROPY INJECTION IN THE EMERGENCE PROCESS OF STATES	10 -0 - LEVEL I

Figure 12 $ITR^{(i)}$ states description and their change / emergence driving mechanism

The Second Principle of ITAKE – The reality building process**,** i.e. the ITAKE, takes place in iterations made for the categories**,** defined in accordance with the first principle. The following aspects of this process described previously in [30] are considered important:

- An iteration process at a certain level, which is governed by a syzygy, takes place as described by the first principle. However, the iteration has limitations and is governed by the need to solve the created paradoxes at each phase of the process.
- Specific paradigms are characteristics of each phase and their change leads to the elimination of the paradox at that phase and possibility for emergence to a new phase.
- Emergence from one set of reality structures $ITR^{(i)}$ to another is governed by a specific set of rules described in Figure 12.

In Figure 12 there are three groups of states described for a given $ITR^{(i)}$:

Group I – Definition of the states and their principles of emergence

1. *The transition from this state is driven* by the need to define the state and the need to generate it *from a unique source for a given state*
2. For this state clarrification of the differences between options / emergence directions of this state are needed. *The differences are driven by the fact that it is a contradictory duality as a basis for a given state.*
3. The third category of states describes the options for emergence to other states being driven by the *search for the third way, as a solution for emergence from a state described as a fundamantal duality.*

Group II – Development of the rules of emergence for a state

4. This state is describing the stability of the reality structure. The state *is driven by the fact that stability of a state is a direct consequence of its capability to resist to paradoxes*.
5. The fifth state is defined by the coagulation of beliefs/principles assuring *the emergence from one state to another and is driven by the capability to have strong intuitive beliefs / principles*.
6. In this state the structure tends to optimize itself as a structure working to reach a certain *defined goal, which is governed by the fact that states get optimal and work to reach a predefined level.*

Group III – Consolidation of the defined state

7. The seventh state has a structure resulted from the trend of the other states to combine between them in order to reach their predefined goals. The state is driven by the fact, that combination of states is governed by their *intrinsic trend to optimize the ratio between the usefulness of the combinations, i.e. to assure teleologic synergy of the states*.

[30] Serbanescu D., Despre o perspectivă integrată a cunoașterii și existenței-On an integrated perspective on Knowledge and Existence, Simpozionul aniversar-In honorem Mircea Malița – 90: Provocările științei și civilizația actuală, Bucharest, Romania, Feb 2017

8. This state reflects the situation of the structure when it becomes absolutely neccessary to develop it as a (self)managed / selfregulated one. The structure in this state has to be able to reach its goal in an optimal *manner and this is governed by the fact that the state optimization is assured by their hierarchical systemic organzation.*
9. In the ninth state the structures tend to explore fulfilling also other goals than the ones defined initially for them. *This trend is governed by the fact that exploration of the states structure and operation leads to the need for a total (self)change / (self)restart*.

Figure 12 illustrates also a fourth group related to the *feedback process, coded as „10-0-level 1".* This is a generic governing mechanism to restart the emergence process.

Feedback reaction is understood in this process as an information entropy injection in the emergence process of states.

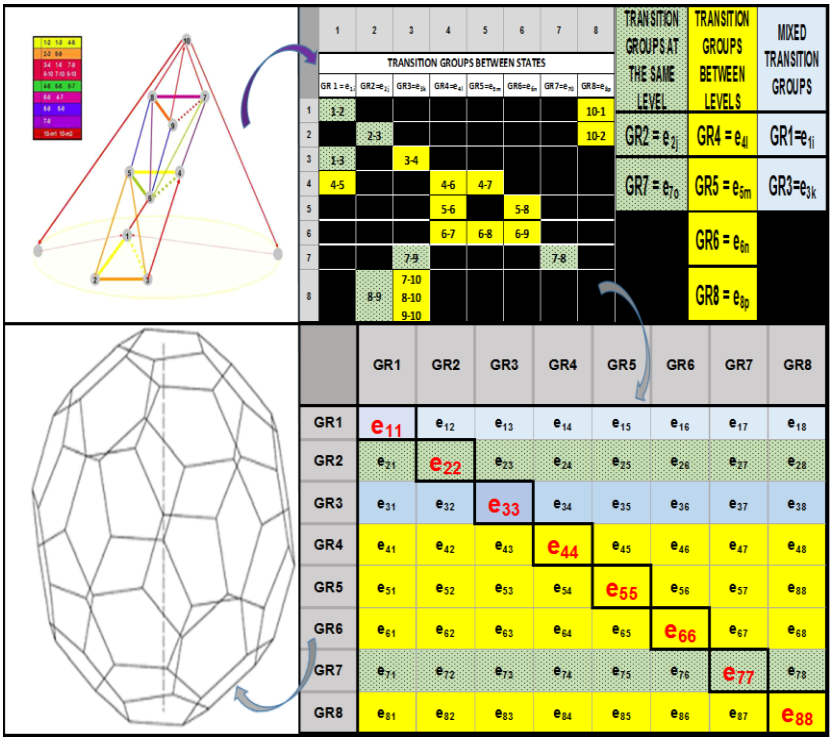


Figure 13 Transition Matrix (TM) for the state change process and the resultant algebric structure of many iterations for ITR

An *ITAKE* process defined for a structure ITR $^{(i)}$ will follow the *Emergence Rules* described by the *Transition Matrix* in Figure 13. The results of various emergence processes will be a structure represented as in the lower part of Figure 13 and described by an algebraic structure called octonions.

The notions of *"*progress" or "evolution" are actually not easy to define and to proove their existence is not so obvious at all. *Therefore, the timeline for reality building process may consider only a process of emergence leading to changes in the states of the topological structure that defines the reality.*

The application of the previous mentioned set of rules describing the first and second principles of the *ITAKE* leads to topological structures, which are dependent on some important factors, as mentioned in the previous paragraphs:

- the type of civilization KP,
- the specifics of the ITR structure, as for instance
  - what type of triadic „object-model-reality element" is considered,
  - the type of paradigms governing each phase and
  - the solutions to change the syzygies based on „import" from other complementary triadic sources of reality, except science: art and cultural-mythological areas.

An example of the resultant ITR „i" with its representative TM is illustrated in Figure 14. Figure 14 illustrates an ITR structure for a type II KP (from Figure 10), i.e. the case of emergence from AM to GAM (described in formula (2), too).

Summarizing, on the ITAKE process from the perspective of its first two stated principles, we can conclude that this is an iterative dynamic process performed for a multitude of intervals. The process involves individual researchers and whole communities, is being performed in a given period of our civilization and in a step by step manner and it is considering that there is a "continuum space" created by resultant realities. This continuum is a homorphism of the studied objects, as defined for physics approaches.

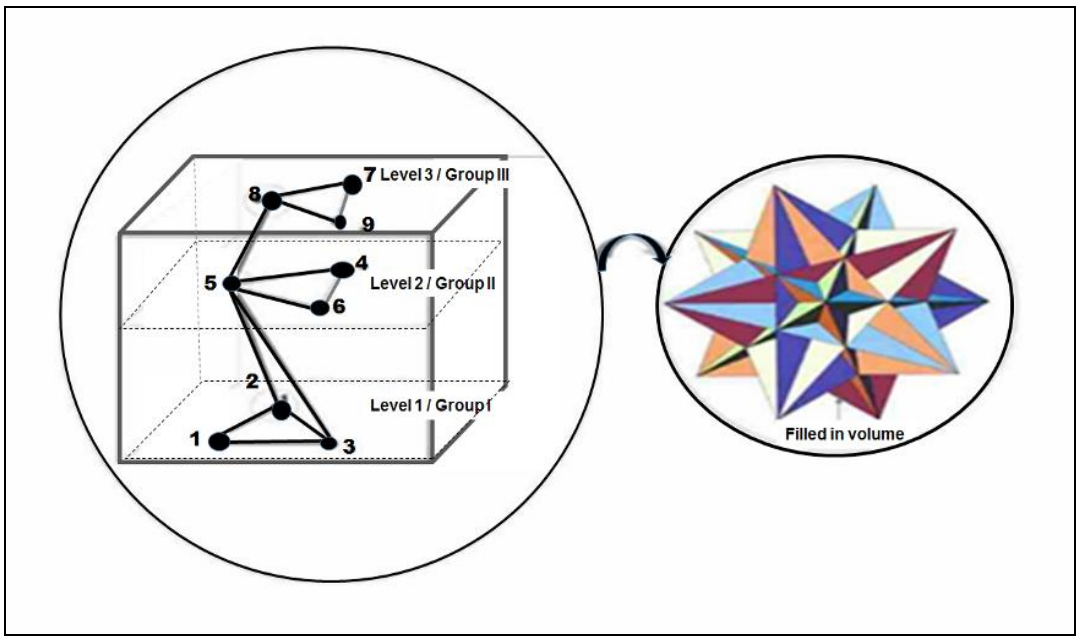


Figure 14 Representation of a TM for an ITR in a type I culture (the example of emergence from AM to GAM described in formula (2))

A syzygy set is continuously optimized from diverse approaches – mathematics, physics, philosophy etc.

Based on those optimized sets it is possible to reach (as *per theorem of Hilbert for syzygies in mathematics - a final minimal set of syzygies for a given model).*

However, *reaching this state does not prevent the existence of even more paradoxes, requiring new sets of syzygies, from another perspective (art, cultural-mythological, if those of physics are not able anymore to solve paradoxes).*

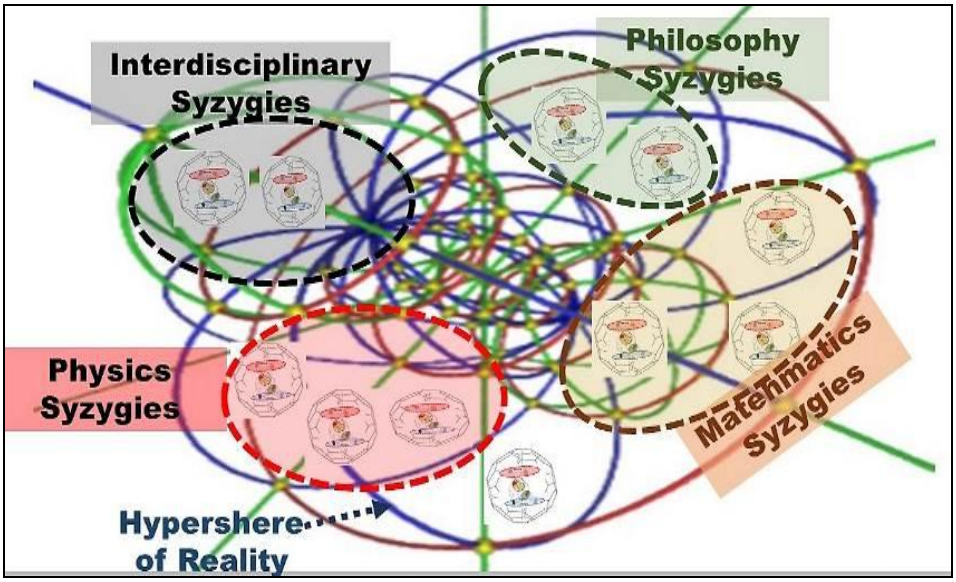


Figure 15 Solving paradoxes in resultant ITR structures by using diverse sets of syzygies

Then the process is repeated with the new syzygies in the new paradigms and so on (as illustrated in Figure 15). The description of the ITR structure is under the Plato poliedra type and is governed by specific sets of syzygies (for physics, mathematics, philosophy,iInterdisciplinary etc). *Search for solutions from one set of syzygy is ended if the paradoxes need the total change to another set* (from physics to philosophy for instance) and restart of the process for this new set. *The solutions for ITR are all part of a hypersphere.*

For more clarifications on the syzygy process, some short comments are presented on results from an example of an ITAKE process applied to obtain a reality ITR structure developed in[31]. The example is related to a structure that includes the elements of a **Chain of Cosmic Energy (CCE)** levels / components, i.e.:

- Subquantic SQ
- Quantic Q
- Electromagnetic EM
- Molecular MO
- Molecular and life MOL
- Conscious planetary life CPL
- Stellar and universe not alive SUNA
- Stellar and universe life SUA
- Conscious stellar and universe CSU

[31] Serbanscu D., Omenirea la răscruce privindu-se în oglinda (re)(ne)cunoasterii de sine Oare va evolua sau se va autodistruge ? O perspectiva a aplicațiilor energetice ale fizicii moderne, DOI: 10.13140/RG.2.2.22311.75681 Sesiune anuala a CRIFST - 13 octombrie 2016

For each of those elements an ITR structure is being built. *In this example, the emergence process is indicating the high need and usefulness in using topological approaches in order to describe in a systematic approach existing results in quantum mechanics, cosmology and biology.*

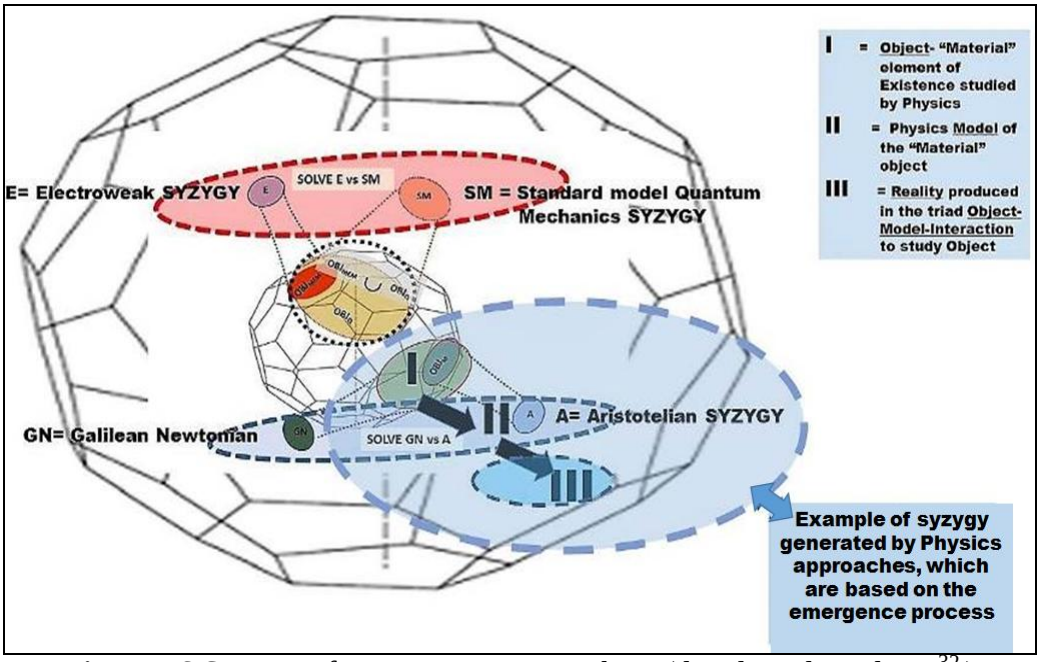


Figure 16 Syzygies for a cosmic energy chain (details and results in[32])

As illustrated in Figure 16, the considered elements for *each energy level of the reality structure* have the following features:

- *It is described in a given syzygy*, i.e. in our example
  - Standard model quantum mechanics (SM)
  - Aristotelian (A)
  - Galilean Newtonian (GN)
  - Electroweak (E)
- *Each element of the structure considered during the emergence process includes a triadic combination of the following:*
  - Object- "material" element of existence studied by physics (I)
  - Physics' model of the "material" object (II)
  - Reality produced in the triad object-model-interaction to study object (III)
- *The syzygies of the ITR structure are described by a generator (GEN)* for which specific optimization actions are performed so that to reach the optimum for the syzygies. In accordance with the Hilbert theorem on syzygies, such optimum exists. An example of generator for the case of Cosmic Energy Chain (CEC) is illustrated in (3) and (4):

$$GEN\ [ITR] = [ENTH, EnI, Sy, Em, NlnCx, Fr] \quad (3)$$

$$Syzygy\ [ITR^{(i)}] = functor\ (GEN[ITR]) \quad (4)$$

Where

[32] Serbanescu D., *Omenirea la răscruce privindu-se în oglinda (re)(ne)cunoașterii de sine. Oare va evolua sau se va autodistruge ? O perspectivă a aplicațiilor energetice ale fizicii moderne*, DOI: 10.13140/RG.2.2.22311.75681, Academia Română, sesiunea anuala CRIFST, Oct 2016.

- *The functor* is calculated as a TM in accordance with the process represented in Figure 13.
- Syzygies are:
  Exergy (Ex) for a CEC (defined as the maximum work possible for a process that brings the system to equilibrium with a heat reservoir) as a measure of the process of energy conversion. This generator has the following characteristics:
  - It conserves only when all the processes of the system/environment are reversible
  - It is destroyed when the process is irreversible.

  Entropy (Thermodynamic) (EnTh) as a measure of disorder.
  Information Entropy (EnI) as a measure of the limits of Knowledge itself
  Synergy (Sy) as a measure of a set of CEC that appear from the existence and interaction all its systems and components, leading to a new set of more characteristics for CEC as a whole than for CEC components altogether.
  Emergence (Em) from one level to another (ex from SQ to CSU) as a process in which the entities, patterns and regularities/irregularities are generated by interactions between smaller (or from lower level) entities, which do not have themselves those properties.
  Nonlinearity (even for simple systems) and/or complexity (NlnCx) for a CEC as a source of chaotic behavior of structures of complex systems.
  The features of a SAC considering fractals (Fr) are defined starting from the characteristics of such systems. In the CEC example and its KP structures of ITR type, as topological structures of the knowledge gained for a given system at a given level the fractal behaviors is characteristic for describing all levels and each component in a given level.

The ITAKE process will follow the same steps as illustrated for the example defined by formulas (1) and (2) and by the framework of first two principles presented before. Therefore, there will be the same situation when passing from physics to mathematics and then to philosophy.

It is interesting to notice, that the TOE attempts that took place so far passed apparently through the syzygy phases for physics and mathematics and now they are being quite focused on solutions from the standpoint of philosophy. This interesting situation leads us to an analogy in studying physics as a science during the antiquity and the Aristotelian schools.

However, in order to reach a final conclusion for evaluations, we need to consider the third principle of ITAKE.

The Third Principle of ITAKE – This principle states that *the ITAKE process leads to final state that exists and it is asymptotically stable and complete. However, the final structure that results for the given object cannot be known in its phenomenological detailed characteristics, nor predicted.*

3. Conclusions and further work

Some results of the search for a proposed Integrated Approach on Knowledge and Existence (ITAKE), as perceived from the perspective of the last achievements in Physics, were presented in the paper.

ITAKE is based on the assumption that both knowledge and existence are topological spaces and they are integrated in a unique result, which is actually creating our reality.

The examples presented underline some of the specific features of such an approach, of which the most important are that we have a method to guide us during the process and we can

anticipate that the process of building realities has an asymptotic result. However, we cannot anticipate what this result may be.

Similar conclusions obtained with other methods already exist in other models and theories in natural sciences and philosophy. Nevertheless, for the purposes of physics' type of attempts to reach a better description of the world, it could be of interest to adopt an ITAKE type of approach.

ITAKE leads to a change of the scientific knowledge manifesto of almost four centuries of modern science from "Discours de la méthode" to "Discours de la création de la réalité".

On the other side, the proposed approach may help us to progress from the level of a civilization of less than type I in Kardashev scale, because we have, in our opinion, a very sophisticated multidisciplinary, interdisciplinary and transdisciplinary[33] way to acquire knowledge. This combination could lead our civilization to a sharp and even faster progress than in the last hundred years, by preventing us in the meantime to avoid self-destruction and the irreversible damage of our planet.

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Annex 1 - The Defense Advanced Research Projects Agency (DARPA) solutions would have the effect of "dramatically revolutionizing mathematics and thereby strengthening the scientific and technological capabilities"[34]

DARPA Mathematical challenge number	Challenge	Short description
1	The Mathematics of the Brain	Develop a mathematical theory to build a functional model of the brain that is mathematically consistent and predictive rather than merely biologically inspired.
2	The Dynamics of Networks	Develop the high-dimensional mathematics needed to accurately model and predict behavior in large-scale distributed networks that evolve over time occurring in communication, biology and the social sciences.
3	Capture and Harness Stochasticity in Nature	Address Mumford's call for new mathematics for the 21st century. Develop methods that capture persistence in stochastic environments
4	: 21st Century Fluids	Classical fluid dynamics and the Navier-Stokes Equation were extraordinarily successful in obtaining quantitative understanding of shock waves, turbulence and solitons, but new methods are needed to tackle complex fluids such as foams, suspensions, gels and liquid crystals
5	Biological Quantum Field Theory	Quantum and statistical methods have had great success modeling virus evolution. Can such techniques be used to model more complex systems such as bacteria? Can these techniques be used to control pathogen evolution?
6	Computational Duality	Duality in mathematics has been a profound tool for theoretical understanding. Can it be extended to develop principled computational techniques where duality and geometry are the basis for novel algorithms?
7	Occam's Razor in Many Dimensions	As data collection increases can we "do more with less" by finding lower bounds for sensing complexity in systems? This is related to questions about entropy maximization algorithms.
8	Beyond Convex Optimization	Can linear algebra be replaced by algebraic geometry in a systematic way?
9	What are the Physical Consequences of Perelman's Proof of Thurston's Geometrization Theorem?	Can profound theoretical advances in understanding three dimensions be applied to construct and manipulate structures across scales to fabricate novel materials?
10	Algorithmic Origami and Biology	Build a stronger mathematical theory for isometric and rigid embedding that can give insight into protein folding.
11	Optimal Nanostructures	Develop new mathematics for constructing optimal globally symmetric structures by following simple local rules via the process of nanoscale self-assembly.
12	The Mathematics of Quantum Computing, Algorithms, and Entanglement	In the last century we learned how quantum phenomena shape our world. In the coming century we need to develop the mathematics required to control the quantum world.
13	Creating a Game Theory that Scales	What new scalable mathematics is needed to replace the traditional Partial Differential Equations (PDE) approach to differential games?

[34] *** https://compmath.wordpress.com/about/10-the-big-picture-darpas-23-challenge-questions

DARPA Mathematical challenge number	Challenge	Short description
14	An Information Theory for Virus Evolution	Can Shannon's theory shed light on this fundamental area of biology?
15	The Geometry of Genome Space	What notion of distance is needed to incorporate biological utility?
16	What are the Symmetries and Action Principles for Biology?	Extend our understanding of symmetries and action principles in biology along the lines of classical thermodynamics, to include important biological concepts such as robustness, modularity, evolvability and variability.
17	Geometric Langlands and Quantum Physics	How does the Langlands program, which originated in number theory and representation theory, explain the fundamental symmetries of physics? And vice versa?
18	Arithmetic Langlands, Topology, and Geometry	What is the role of homotopy theory in the classical, geometric, and quantum Langlands programs?
19	Settle the Riemann Hypothesis	The Holy Grail of number theory.
20	Computation at Scale	How can we develop asymptotics for a world with massively many degrees of freedom?
21	Settle the Hodge Conjecture	This conjecture in algebraic geometry is a metaphor for transforming transcendental computations into algebraic ones.
22	Settle the Smooth Poincare Conjecture in Dimension 4	What are the implications for space-time and cosmology? And might the answer unlock the secret of "dark energy"?
23	What are the Fundamental Laws of Biology?	This question will remain front and center for the next 100 years. DARPA places this challenge last as finding these laws will undoubtedly require the mathematics developed in answering several of the questions listed above.

Annex 2 Sample of challenges in physics [35]

CHALLENGE	DETAILS
General physics/quantum physics	
Entropy (arrow of time)	Explanations on the low entropy in the past of the universe.
	What leads to the possibility to distinguish past and future and how is it correlated with the second law of thermodynamics?
	There are apparently charge parity violations only in some weak force decays.
	It is not clear if the charge parity violations are caused by the second law of thermodynamics or if those violations define themselves a different arrow of time.
	Clarrify if the thermodynamics and quantum arrows correlated
	Define how the principle of causality works in quantum mechanics and if the past is unique
Interpretation of quantum mechanics	Clarify how quantum mechanics is describing reality we perceive, from the perspective of using description elements such as the superposition of states and wavefunction collapse or quantum decoherence.
	Define what means "measurement", that apparently causes the wave function to collapse into a definite state
	It is established that, unlike classical physical processes, some quantum mechanical processes (ex quantum teleportation based on quantum entanglement) cannot be simultaneously "local", "causal", and "real". In this case either some of those properties must be sacrificed in trying to understand quantum mechanics , or not to try to use at all such cathegories for quantum level understanding, because an attempt to understand it by using such notions does not have any meaning for quantum mechanics.
Grand Unification Theory ("Theory of everything")	Attempt to define a theory, that explains the values of all fundamental physical constants. A possible choice for such a theory could be the string theory
	Search for a theory, that can explain why the gauge groups of the standard model are as they are and the existence of 3 spatial dimensions and 1 temporal dimension for observed spacetime. Search for an explanation of the existence of the established so far laws of physics in such format and not in a different one.
	Establish how constant in time are the "fundamental physical constants".
	Search for a theory that can define how to establish if any of the fundamental particles in the standard model is actually a composite particle, for which it is impossible at the stage of present experimental basis to decide if they are too bound together.
	Search for a theory based on which we can decide on the completeness of the list of particles as they are now and/or the search for new ones considering a set of properties to be looked for.
	Establish based on such theory if there are new unobserved fundamental forces.
Yang–Mills theory	Destablish the existence of the non-trivial quantum Yang–Mills theory with a finite mass gap for a given an arbitrary compact gauge group
	The problem is also a Millennium Prize Problems in mathematics.
Physical information	Clarrify if there are physical phenomena, as for instance wave function collapse or black holes, that destroy information about their prior states
	Define how the quantum information is stored as a state of a quantum system. Clarrify if the information entropy notions operate at the quantum level.
Dimensionless physical constant	Define an approach that allows the definition of dimensionless physical constants by calculation, not only by physical measurement
	What is the minimum number of dimensionless physical constants from which all other dimensionless physical constants can be derived?
	Clarrify if the dimensionful physical constants are actually necessary
	Establish the validity of the Dirac large numbers hypothesis (The ratios of size scales in the Universe to that of force scales are very large, dimensionless numbers of about 40 orders of magnitude for this cosmological period), i.e. that (1) The strength of gravity, as represented by the gravitational constant, is inversely proportional to the age of the universe: $G \propto 1/t$ and (2) The mass of the universe is proportional to the square of the universe's age: $M \propto t^2$
Fine-tuned Universe	Clarrify the validity of the anthopic principle, i.e. how can be explained the fact that the fundamental physical constants are set in auch a narrow range, that allows to support carbon-based life

35 *** https://en.wikipedia.org/wiki/List_of_unsolved_problems_in_Physics

Cosmology and general relativity	
Problem of time	Reconciliation of time concept between quantum mechanics and general relativity.In general relativity there is no time concept, because in general relativity, the Hamiltonian is an energy constraint that must vanish to allow for general covariance (time is a classical background parameter, external to the system itself). On the other side in the theories of quantum mechanics, the Hamiltonian generates the time evolution of quantum states.
Cosmic inflation	Decide on the validity of the theory of cosmic inflation and describe based on it the specifics of the present cosmic period.
	Define the hypothetical inflaton field, that gives rise to inflation.
	Clarrify tha validity of the fact that if we assume that inflation theory is correct and inflation happened at one point, then the inflation is a self-sustaining process taking place through quantum-mechanical fluctuations, and therefore ongoing in some extremely distant place of the cosmos.
Horizon problem	Explain high homogenenity of the universe, which is in apparent conflict with the Big Bang theory predicting larger measurable anisotropies of the night sky than those observed. In accordance with the Big bang theory different regions of the universe cannot get in contact with each other, because of the great distances between them. However it appears that they have the same temperature and other physical properties, what is not possible, given that the transfer of information (or energy, heat, etc.) can occur at a limited speed (speed of light that is constant)
	Establish the validity of other explanation for the homogenity as for instance a variable speed of light.
Origin and future of the universe	Define the validity of uthe scanarios for the universe future (Big Freeze, a Big Rip, a Big Crunch, a Big Bounce or an infinitely recurring cyclic model)
Size of universe	Evaluate the size of the whole universe, not only of the observable universe (which has a diameter of about 93 billion light-years)
	Evaluate validity of multiverses theories
Baryon asymmetry	Explain why there is far more matter than antimatter in the observable universe.
Cosmological constant problem	Explain the reasons why does the zero-point energy of the vacuum does not cause a large cosmological constant, as if somethig (what would it be?) is annulating it.
Dark matter/Galaxy rotation curve	Define the identity of the dark matter (a particle or the lightest superpartner (LSP))
	Verify the hypothesis that the phenomena attributed to dark matter indicate not some form of matter, but actually an extension of gravity
Dark energy	Define the cause of the observed accelerated expansion (de Sitter phase) of the Universe
	Explain the reasons why the energy density of the dark energy component is of the same magnitude as the density of matter at present, even if the two evolve quite differently over time. Veriify the assumption that this happens because we are observing the two phenomena at the right time
	Establish to what degree the dark energy is a pure real cosmological constant or it is a result of the models we apply.
Dark flow	Verify hypothesis that a non-spherically symmetric gravitational pull from outside the observable Universe is responsible for some of the observed motion of large objects (such as galactic clusters in the universe)
Ecliptic alignment of Cosmic Microwave Background (CMB) anisotropy	Some large features of the microwave sky at distances of over 13 billion light years appear to be aligned with both the motion and orientation of the solar system.
	Is this due to systematic errors in processing, contamination of results by local effects, or an unexplained violation of the Copernican principle?
Shape of the Universe	The shape of the universe (3-manifold of comoving space, i.e. of a comoving spatial section of the Universe). Define the curvature, the topology.
	Verify validity of either of the hypotheses: (1) the shape of the Universe may be unmeasurable, (2) the universe is of Poincaré dodecahedral space (as suggested since 2003 by Jean-Pierre Luminet et al., and other groups) or (3) the universe is another type of 3-manifold

Quantum gravity	
Vacuum catastrophe	Explain why the predicted mass of the quantum vacuum has little effect on the expansion of the universe
Quantum gravity	Develop quantum mechanics and general relativity as a fully consistent theory (for instance as a quantum field theory)
	Verify if the spacetime is fundamentally continuous or discrete
	Define the type of elements of a consistent theory to consider either a force mediated by a hypothetical graviton, or as a product of a discrete structure of spacetime itself (as in loop quantum gravity)
	Verify where the deviations from the predictions are located for the general relativity: at very small or very large scales, or in other extreme circumstances that flow from a quantum gravity theory
Black holes, black hole information paradox, and black hole radiation	Verify if one of the following theories is valid for black holes: (1)they produce thermal radiation containing information about their inner structure (as per gauge–gravity duality) (2) they do not produce thermal radiation (Hawking's original calculation) in the latter case they can evaporate away, in which case it is to be clarrified what happens with the information stored in them or (3) the radiation stops at some point leaving black hole remnants
	Develop alternative experiments to probe black holes internal structure somehow (assuming that such a structure exists)
Extra dimensions	Define the number of dimensions of nature in order to know if it has more (and how manyif more) than four dimensions.
	Establish if by any theory existence of dimensions is a fundamental property of the universe or an emergent result of other physical laws
	Develop experimental ways to be able to observe evidence of higher spatial dimensions
Locality	Clarrify the existence of non-local phenomena in quantum physics and under what circumstances are non-local phenomena observed; and if confirmed that they exist, clarrify if non-local phenomena are limited to the entanglement revealed in the violations of the Bell inequalities, or can information and conserved quantities also move in a non-local way.
	Define issues related to the non-local phenomena: (1) the relationship between the existence or absence of non-local phenomena and the fundamental structure of spacetime. (2) the relationship with the quantum entanglement (3) the correlation of no-local phenomena with the interpretation of the fundamental nature of quantum physics

High-energy physics/particle physics	
Higgs mechanism	Verify and clarrify (1) if the branching ratios of the Higgs boson decays are consistent with the standard model (2) How many types of Higgs boson exist
Hierarchy problem	Clarrify thereasons (1) why gravity is such a weak force and why it becomes strong for particles only at the Planck scale (around 10^{19} GeV, much above the electroweak scale, which is of 100 GeV - the energy scale dominating physics at low energies) and (2) why the two scales are so different from each other
	Clarrify the reasons that prevent quantities at the electroweak scale (as for instance the Higgs boson mass) from getting quantum corrections on the order of the Planck scale
	Verify what type is the solution to the hierarchy problem: (1) supersymmetry (2) extra dimensions or (3) anthropic fine-tuning?
Planck particle	Clarrify questions on the Planck mass (issue important in mathematical physics): (1) it exists a fundamental particle with mass equal to or close to that of the Planck mass (taht has an enormous mass compared to any detected particle even compared to the Higgs particle) (2) a particle with Planck mass likely had existed but that most of its mass had radiated away (Lloyd Motz at Rutherford Laboratory) (3) particles with close to the Planck mass are micro black holes
	Solutions to Planck mass are indirectly connected with the hierarchy problem
Magnetic monopoles	Clarrify if particles that carry magnetic charge existed some time in the past period (of higher energies) and if it existed if anything of them is still present
	Verify the existence of some types of magnetic monopoles, that could explain charge quantization (as assumed by Paul Dirac)
Proton decay and spin crisis	Clarrify if the proton is fundamentally stable, or if it decay with a finite lifetime (see some extensions to the standard model)
	Explain how do the quarks and gluons carry the spin of protons
Supersymmetry	Clarrify at what scale spacetime supersymmetry is realized (TeV?) and if it takes place at this scale then what is the mechanism of supersymmetry breaking
	Clarrify if supersymmetry stabilizes the electroweak scale, preventing high quantum corrections
	Clarrify if lightest supersymmetric particle (Lightest Supersymmetric Particle) includes dark matter
Generations of matter	Clarrify if there are three generations of quarks and leptons
	Search for a theory able to explain the masses of particular quarks and leptons (for instance generations from first principles) - as a kind of theory of the Yukawa couplings
Neutrino mass	Clarrify the mass of neutrinos (in the sense to establish if they follow Dirac or Majorana statistics)
	Verrify if the mass hierarchy is normal or inverted
	Verrify if the Charge Parity (CP) is violating phase 0
Colour confinement	Explain why free quark or gluon were never been measured , but only objects that are built out of them (mesons and baryons)
	Explain how color confinement emerge from QCD
Strong CP problem and axions	Explain the reasons why strong nuclear interaction invariance to parity and charge conjugation
	Verrify if the Peccei–Quinn theory is the solution to the CP problem and if the axions may be considered the main component of dark matter
Anomalous magnetic dipole moment	Explain the reasons of the significant differences between the experimentally measured value of the muon's anomalous magnetic dipole moment ("muon g−2") and the theoretically predicted value of that physical constant
Proton radius puzzle	Explain the meanings of (1) the electric charge radius of the proton (2) difference of the electric charge of the proton from the gluonic charge
Pentaquarks and other exotic hadrons	Search a theory to explain which combinations of quarks are possible
	Explain the reasoons in the difficulties to discover pentaquarks and clarrify if these reasons are tightly-bound system of five elementary particles, or a more weakly-bound pairing of a baryon and a meson

Astronomy and astrophysics	
Relativistic jet	Verify that the environment around the active galaxy the relativistic plasma is collimated into jets escaping along the pole of the supermassive black hole
Astrophysical jet	Clarrify the reasons why the phenomena take place: (1) the accretion discs surrounding certain astronomical objects (for instance nuclei of active galaxies) emit relativistic jets along their polar axes (2) the existance of quasi-periodic oscillations in many accretion discs (3) the period of these oscillations scale is the inverse of the mass of the central object (4) existance of overtones, that appear at different frequency ratios in different objects
Solar cycle	Clarrify phenomena related to the Sun: (1) generation of its periodically reversing large-scale magnetic field (2) the similar phenomena in other Sun like stars (3) explanation of the causes of the Maunder Minimum and other grand minima and of the solar cycle mechanism to recover from a minima state
Coronal heating problem	Explain the reasons for the Sun's corona (atmosphere layer) to be much hotter than the Sun's surface and of the fact that the magnetic reconnection effect is by many orders of magnitude faster than the one predicted by standard models
Diffuse interstellar bands	Explain the cause for the numerous interstellar absorption lines detected in astronomical spectra. If they are of molecular origin, then which molecules are responsible for theis phenomena and the mevchanism of their appearance.
Supermassive black holes	Explain the origin of the M-sigma relation between supermassive black hole mass and galaxy velocity dispersion and how the most distant quasars grow their supermassive black holes (up to 10^{10} solar masses) so early in the history of the Universe
	Explain the phenomenon that between the rotation curve of a typical spiral galaxy (predicted and observed) there is a discrepancy and verify if that can be due to the dark matter
Kuiper cliff	Explain the reason for rapid and unexpectedly fall off beyond a radius of 50 astronomical units of the number of objects in the Solar System's Kuiper belt
Flyby anomaly	Explain the difference (sometimes by a minute) between the observed energy of satellites flying by Earth and the value predicted by theory
Galaxy rotation problem	Clarrify if the dark matter is responsible for differences in observed and theoretical speed of stars revolving around the centre of galaxies
Supernovae	Explain the mechanism by which an implosion of a dying star becomes an explosion
Ultra-high-energy cosmic ray	Clarrify ultra high energy cosmic phenomena: (1) some cosmic rays appear to possess energies that are impossibly high (considering the fact that there are no sufficiently energetic cosmic ray sources near the Earth) (2) there are apparemntly other cosmic rays (emitted by distant sources) that have energies above the Greisen–Zatsepin–Kuzmin limit
Rotation rate of Saturn	Explain the slowly changing periodicity of the Saturn magnetosphere close to that at which the planet's clouds rotate and what is actually in the light of such explanation the true rotation rate of Saturn's deep interior
Origin of magnetar magnetic field	Explain the origin of magnetar magnetic field
Large-scale anisotropy	Clarrify if the Universe is at very large scales anisotropic, making the cosmological principle an invalid assumption, considering inputs from various measurements / theories (1) The number count and intensity dipole anisotropy in radio (as per NRAO VLA Sky Survey (NVSS) catalogue) is inconsistent with the local motion as derived from cosmic microwave background and indicate an intrinsic dipole anisotropy (2) NVSS radio data also shows an intrinsic dipole in polarization density and degree of polarization in the same direction as in number count and intensity (3)The optical polarization from quasars shows polarization alignment over a very large scale of Gpc. (4) The cosmic-microwave-background data shows several features of anisotropy (inconsistent with the Big Bang model)

Astronomy and astrophysics	
Space roar	Explain why is space roar six times louder than expected and what is its source
Age–metallicity relation in the Galactic disk	Clarrify the existence of an universal age–metallicity relation (AMR) in the Galactic disk (both "thin" and "thick" parts of the disk), considering inputs as the following (1) Even if in the local (primarily thin) disk of the Milky Way there is no evidence of a strong AMR a sample of 229 nearby "thick" disk stars was used to investigate the existence of an AMR in the Galactic thick disk and the results indicated that there is an AMR present. (2) Stellar ages as considered in asteroseismology confirm the lack of any strong AMR in the Galactic disc
The lithium problem	Explain the discrepancy between the amount of lithium-7 predicted to be produced in Big Bang nucleosynthesis and the amount observed in very old stars
Solar wind interaction with comets	Explain the mechanis of the solar wind interaction with comets (an example of such phenomena is given by the findings of the Ulysses spacecraft in 2007, that passed through the tail of the comet C/2006 P1 (McNaught) and found such interactions)
Ultraluminous pulsar	Explain how a a pulsar (as established by a NASA's space-based X-ray telescope NuStar indicated that M82 X-2 in October 2014), that was thought to be a black hole (ultraluminous X-ray source M82 X-2) appeared that even if it is not a black hole (as thought before) it is many times brighter than the Eddington limit
The injection problem	Clarrify how to correlate the theory based on which the Fermi acceleration is thought to be the primary mechanism that accelerates astrophysical particles to high energy with the mechanism that causes those particles to initially have energies high enough for Fermi acceleration to work on them
Fast radio bursts	Develop a generally accepted theory to explain the phenomena of transient radio pulses lasting only a few milliseconds, even if they come from emission regions thought to be no larger than a few hundred kilometres and they are estimated to occur several hundred times a day
Nature of KIC 8462852	Explain the source of unusual luminosity changes of the star KIC 8462852
Fermi paradox	Explain how is it possible to mostly agree that extraterrestrial civilizations exist, but to be unable to see them
Nature of Wow! signal	Explain the nature, credibility and if it really existed the source of the wow signal
Solar systems	Explain the mechanism by which accretion formed solar systems and the Earth's water source