RIGOROUS LOGIC IN THE THEORY OF EVOLUTION

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Introduction

Three fundamental transitions are needed in order to go from the vacuum to the Universe, as it is now, with living matter endowed with Reason. These transitions called, *Big Bang-1*, *Big Bang-2* and *Big Bang-3*, are discussed in chapter 1. *Big Bang-1* describes the transition from the vacuum to the Universe made only of inert matter. *Big Bang-2* describes the transition from inert matter to living matter.

Among the million forms of different species of living matter which should be the result of the Living-Matter-Evolution-Process, LMEP, there is one species, and only one, whose existence needs another transition. This one, very peculiar indeed, we call *Big Bang-3*. This is the transition from the status of *living matter* to the status of *living matter endowed with Reason*.

At this point it is necessary – and this we do in chapter 2 – to recall that there are three levels of Galilean Science. An event and its subsequent evolution which happens only once, needs the third level Galilean Science in order not to be out of scientific rigour.

It is therefore necessary to see where these three Big Bangs are in the whole of our intellectual activity, where Complexity comes in.

Evolution and Complexity must be studied. This is the content of chapter 3.

In chapter 4 we review evolution in History and Science, the two opposite asymptotic limits of Complexity.

In chapter 5 our ignorance in the knowledge of the evolution of the Universe is presented in terms of known facts.

In chapter 6 the problems in the study of evolution are presented, pointing out the relevance of first level Galilean Science.

In chapter 7 it is shown why the Biological Evolution of the Human Species (BEHS) is below the third level of Galilean Science. To clarify this the best example of the third level, cosmic evolution, is confronted with BEHS.

In chapter 8 the evolution of Science is studied in terms of its origin and of the results so far achieved.

In chapter 9 the basic point is discussed whose logic is that the hardware governing all forms of matter is the same, despite the fact that the elementary forms of matter have zero interaction with the environment.

The proof that only one form of living matter possesses the privilege of being endowed with Reason is discussed in chapter 10.

A brief recapitulation is the content of chapter 11. The conclusion is in chapter 12.

1. Scientific Rigour, the Three Big Bangs and Their Evolution

When we speak about evolution we should not forget the two basic pillars of Galilean Science: experimental reproducibility and mathematical rigour. A theory can be formulated using words, i.e. Language and its Logic. This Logic allows predictions to be made. These predictions have no mathematical rigour since the Logic at work is based on Language. This was the case before Galilei's arrival.

A theory can be expressed using mathematical formalism and its logic. This allows predictions to be made using the power of mathematical formalism. According to Galilei [1] *Scientific Logic* requires that a key experiment must exist in order to put the theory under experimental test. If no experiment can establish if the theory is *right* or *wrong*, the theoretical structure which describes a certain phenomenon or a series of phenomena remains out of what we call Galileian Science.

The theory of evolution should describe how it happens that we are here, something like $(15\text{-}20) \times 10^9$ years after the classical and famous Big Bang. This Big Bang is in fact the first one, *Big Bang-1*, and refers to the transition from the vacuum to the Universe which now has about 10^{82} protons, neutrons and electrons. These particles are an inert form of matter.

The transition from inert matter to living matter is necessary in order to explain how it happens that we are here. This field of scientific research is called 'minimal life' and has two approaches: the *bottom-up* and the *top-down*. Since this is not my field of research activity I will only limit myself to saying a few words on the two approaches. In the *bottom-up* approach the formation of the minimal form of living cell is studied starting from atoms and molecules. In the *top-down* approach the basic 'pieces', the inert parts of matter, are taken from living matter and the problem is to see how many

pieces are needed to build the minimal living cell. The transition needed to go from inert matter to living matter is to be called *Big Bang-2*. The evolution here has to deal with millions of forms of vegetable and animal matter.

Out of this enormous number of different forms of living matter there is one, and only one, endowed with a special property, called Reason. We are the only form of living matter having this incredible property, which generates Language, Logic and Science (discussed in chapter 10). Another Big Bang is needed to describe the transition from the innumerable number of examples of living matter to the unique one which is us. We call this transition *Big Bang-3*.

The three theories of evolution start therefore with the three Big Bangs, illustrated in figure 1.

THE THREE BIG BANGS

BB1 ⟹ *from Vacuum to the Universe of Inert Matter*

BB2 ⟹ *from Inert Matter to Living Matter*

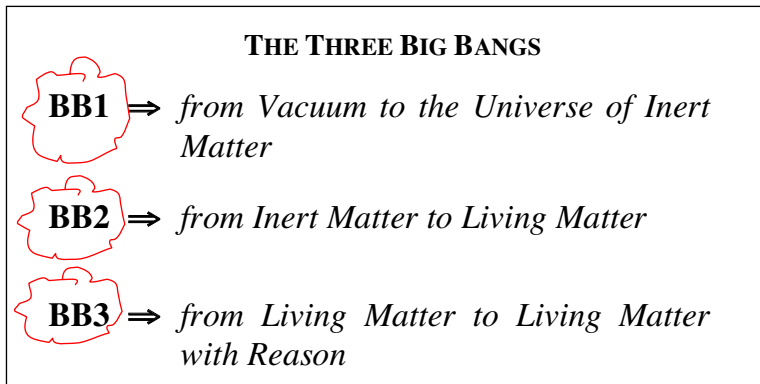**BB3** ⟹ *from Living Matter to Living Matter with Reason*

Figure 1.

The evolution after *Big Bang-1* refers to the evolution of inert matter and therefore the evolution of our Universe: cosmic evolution. This theory of cosmic evolution is founded on the three levels of Galilean Science, discussed in chapter 2.

Big Bang-2, which explains the transition from inert to living matter, is followed by the theory of evolution needed to describe how it happens that a very large number of forms of living matter evolved.

Finally *Big Bang-3*, which explains how Reason emerges from living matter, is followed by the third type of evolution.

The three Big Bangs and the three theories of evolution need both the reference to experimental reproducibility at each step of the evolutionary

process, and the mathematics capable of describing the different process-es. The problem of experimental reproducibility is linked to the three levels of Galilean Science that will be discussed in chapter 2. Here it is necessary to point out that the three evolution processes, following each *Big Bang*, have their roots in the same hardware. In fact the basic constituents and the fundamental laws of Nature, are common to all of them.

In our present Universe we are all made with the same protons, neu-trons and electrons. All forms of matter, inert, inert with life but no Reason, and inert with life endowed with Reason, have therefore the same basic hardware, which will be illustrated in chapters 8 and 9. My body is made with protons, neutrons and electrons which are exactly the same as those needed for a stone, a flower or a bird. All these forms of matter exist in the same Space-Time whose properties we go on studying even today, since many problems need to be solved. For example we do not know if the four dimensions of the Space-Time we see with our senses (3 Space + 1 Time) have their roots in a Superspace-Time with 43 dimensions, as will be dis-cussed in chapter 2. What we are sure of is that Space and Time cannot be separated, and therefore evolution is unavoidable at the fundamental level of our existence. When we move in Space we necessarily move also in Time. Everything which exists in Space-Time must evolve. The only quantities in the world which do not evolve are the fundamental constants of nature: the Planck action, the speed of light and the Newton constant. The basic units of Time, Space and Energy needed to describe the world in all its structures can be derived from these three fundamental constants. These units are called Planck's units. For example the Time needed for *Big Bang-1* is given by this unit, as we will see in chapter 2.

The fundamental property called 'evolution' was not discovered in the study of living matter by Darwin [2], but in the study of the foundations of the Logic of Nature, i.e. in first level Galilean Science. The work of Darwin was aiming at the discovery of the origin of the human species [2] and the property of living matter called 'evolution' was intended to prove what the origin was of the human species.

From the scientific rigorous point of view the origin of all living forms of matter is *Big Bang-2* which is a completely open problem. No one knows how to go from inert matter to living matter. Furthermore, when dealing with the unique form of living matter endowed with Reason, i.e. the human species, the origin is in *Big Bang-3*. There is no doubt that these two Big Bangs need to be understood in addition to the evolutions which follow each Big Bang. No one can claim that *Big Bang-2*, *Big Bang-3* and the evo-

lutions following each of these basic transitions have been scientifically solved by Darwin and his successors. In fact the most interesting discoveries in order to understand the Logic of Nature have been obtained when studying evolution using inert forms of matter, where no change is needed.

In the study of matter with life the definition of the property called 'evolution' is coupled with the fact that the piece of matter evolving must change. Evolution in Space-Time at the fundamental level of our existence does not require a 'change' in the piece of matter being studied.

The first person who studied in a quantitative way the evolution of a 'stone' in Space-Time was Galileo Galilei. Using as a clock the pulses of his heart he measured the evolution of a 'stone' going through a piece of wood having different inclinations thus discovering how to measure the acceleration due to the gravitational attraction of the Earth. This discovery brought him to the incredible prediction that a feather and a piece of lead would evolve in Space-Time exactly in the same way if air friction could be cancelled.

This experiment has been implemented on the Moon, by the astronaut David Scott head of Apollo XV, who exclaimed '*Galileo Galilei was right*'. Studying another form of the evolution of inert matter, a stone bound with a string, Galilei discovered the laws of the pendulum. It was not a trivial discovery. All civilizations during ten thousand years were measuring Time using the sundial. This gave an uncertainty of one second every day.

Now we measure Time with an uncertainty of one second every lifetime of the Universe: 20 billion years. And this just four centuries after Galilei and his pendulum. Another big discovery of Galilei was obtained via the study of the evolution of a stone while moving under gravitational attraction. Measuring the trajectory of a stone launched from a point 'A' to another point 'B', Galilei found that the trajectory is a parabola. This result is a consequence of the fact that motion in a field where gravitational attraction is effective must follow the law dictated by Space-Time being inseparable and 'complex', not real.

We have said that everything which exists in the world cannot be in Space isolated from Time, but in Space-Time, absolutely coupled and inseparable. Another unavoidable condition is the fundamental property of Space-Time, which cannot be 'real' but 'complex': i.e. either Space is real and Time is imaginary or Time is real and Space is imaginary. Their inseparable coupling, Space-Time, needs to be 'complex'. The consequence of this 'complex' property is that the invariant quantity in going from 'A' to 'B' must be the minimum geometric distance in Space minus the maximum Time. The result is the parabola going from A to B.

We will see in chapter 6 that the evolution in complex 'Space-Time' of the first elementary particle ever discovered in the history of Science, the electron, has opened new horizons in the Logic of Nature, such as the existence of antimatter. Going from the evolution of a 'stone', with Galileo Galilei, to the evolution of the most elementary piece of inert matter, with Paul Dirac, we have discovered that the condition required by the specialists who study living matter, i.e. changes, is not necessary in order to understand the basic logic which governs all forms of matter, including *Big Bang-1*, *Big Bang-2*, *Big Bang-3* and the subsequent processes of evolution.

Let us imagine that, instead of Galileo Galilei, the first fellow to study evolution had really been Darwin. All research work with living matter, when brought to the extreme fundamental limit would have produced the Maxwell equations, Quantum ElectroDynamics (QED) and, finally, the hardware which we will discuss in chapters 8 and 9. The fact that all forms of matter, inert, living and living with Reason, have the same hardware would have taken much longer to discover. The most direct way was the one implemented by Galileo Galilei, with the study of the evolution of stones, the simplest form of inert matter. It is from these studies that the three levels of Science were discovered.

2. THE THREE LEVELS OF GALILEAN SCIENCE

Galilei teaches that Science has three levels, synthetically expressed in figure 2. Let me elaborate on these three levels.
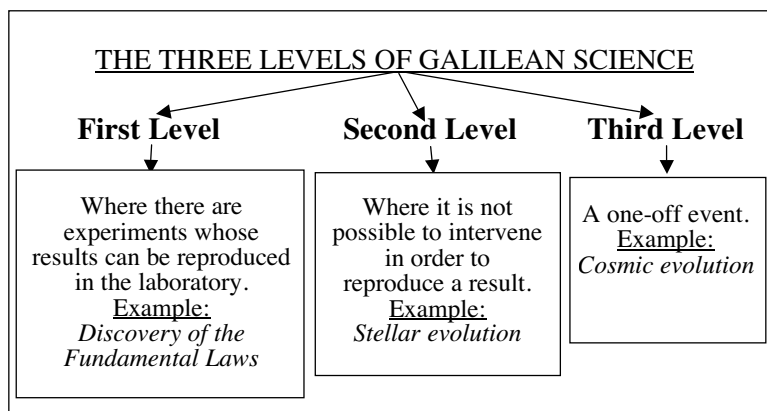

Figure 2.

The first level of Galilean Science is that which entails: (1) logical rigour in the formulation of a problem, (2) the invention of an instrument capable of carrying out the key experiment for giving an answer to the problem, and (3) the reproducibility of the result obtained. The reproducible result is one of the basic foundations of Galilean Science.

The result must be expressed in mathematically rigorous terms. It is this that permits the elaboration of a theory capable of describing not only the reproducible result that is obtained thanks to the invention of the original instrument, but it also points out further experiments to be conducted with new instruments in order to put the new mathematical formulation under the scrutiny of further experimental tests. An example is at the present day frontier of Physics: the Superworld. We think that a description of the phenomena known so far requires a Space-Time with 43 dimensions: 11 bosonic and 32 fermionic. The elaboration of the mathematical structure that describes this reality concludes that new particles must exist; we have dedicated the last decade to the search for these particles without being able to get any reproducible experimental proof. The Superworld theory is an example in which there is mathematical rigour in the formulation of the problem but there is no reproducible experimental proof. Therefore it could be that the Superworld theory is not part of the Logic of Nature. This is what the years to come will tell. The Superworld is an example of first-level Galilean Science to the extent that the experimental tests are susceptible to direct control: in case of doubt it is possible to intervene by repeating the experiments and by inventing new instruments that allow us to overcome doubts that may arise in the course of data analysis for a particular experiment: an experiment that we are able to keep totally under control, here on Earth.

The second level of Galilean Science is that in which it is impossible to keep the experimental test under control. There is mathematical rigour in the formulation of the problem and there is the invention of new instruments for observing the effects searched for, but there is no direct intervention. An example: the theory of stellar evolution. In one part of the sky, we observe the birth of a Star. In another part, the shining of another Star. In yet another part, the death of yet another Star.

Different observations of many Stars being born, of others that are living and still others that are collapsing, allow for the elaboration of a theory of stellar evolution. There is mathematical rigour. Reproducibility is guaranteed by the observation of different examples of Stars as they are being born, during their lifetime and as they are dying. What is missing, however, is the

possibility of direct intervention. In cases of doubt we cannot turn off or turn on a Star. We cannot change the characteristics of a particular Star in order to scrutinize, through experimental tests, an idea that could arise from the theory of stellar evolution's mathematical elaboration itself.

This theory is *strongly linked to the first-level* of Galilean Science. Example: in the theory of stellar evolution no astrophysicist could have imagined the existence of neutron Stars. It was first necessary to discover neutrons here on Earth by conducting Galilean-type experiments at the first level of Science. It was the discovery of the neutron that permitted the elaboration of mathematical models that led to the theoretical hypothesis of the existence of neutron Stars.

Quite recently, the observation of certain stellar phenomena has been interpreted as indicating the possible existence of 'quark Stars'. The existence of this new class of particles, the quarks themselves, however, was discovered here on Earth by conducting Galilean-type experiments at the first level of Science. This is the link that exists between the first and the second level.

The third level of Science refers to phenomena that occur only once. At first glance it could seem that the third level contradicts the notion of 'experimental reproducibility'. This is not so. The third level needs the results obtained at the first level, and in no case can it be in contradiction with the results obtained at the first level where 'reproducibility' is granted.

An example of a phenomenon that happens only once is cosmic evolution. The Cosmos has the Physics of the pre-Big Bang as its initial phase. Then comes the Big Bang whose duration is Planck's Time: 54 billionths of billionths of billionths of billionths of billionths of a second ($54 \cdot 10^{-45}$ sec). Then comes Alan Guth's Time: 10^{-34} sec. At the end of the evolutionary inflation period in addition to the gravitational force the Three Fundamental Forces enter into play: strong subnuclear, weak subnuclear and electromagnetic. And so one arrives at the few seconds necessary for having the Cosmos made essentially with the particles familiar to us: protons, neutrons and electrons.

The plasma composed of these particles in the sea of 'photons' lasts a few hundreds of thousands of years (according to the most recent data, the Time interval is 380 thousand years).

At this point the Cosmos, made essentially of protons, electrons and photons, passes into the phase in which the Stars and the Galaxies are born. According to the most recent theories, it could be that 'Black Holes', made with the very primitive form of elementary particles which existed before those of the 'Standard Model' particles, act as nuclei for the formation of the first galactic structures in which Stars are born. The duration of

this phase of cosmic evolution is millions of years. After 15–20 billion years we reach the present with ourselves, the Sun, the Earth, the Moon, the oceans, the mountains, the sunrises and sunsets. All this is inert matter.

In addition to inert matter, cosmic evolution, thanks to *Big Bang-2*, produced living matter, both vegetable and animal. Among the countless forms of living matter, thanks to *Big Bang-3*, one and only one has been endowed with Reason. It is in fact thanks to Reason that we have Cathedrals, Michelangelo's Pietà and the incredible details that have resulted from the cosmic evolution of inert matter.

It is thanks to *Big Bang-3* that it has been possible to discover Permanent Collective Memory (PCM), which originates from the most primitive form of Language, which, via evolution, produces first PCM, then rigorous Logic and finally Science, as discussed in chapter 10. The evolution which follows *Big Bang-3* produces the whole of our knowledge which we now discuss.

3. The Whole of Our Knowledge: Evolution and Complexity

Figure 3 is a synthesis of all we think we know about the world in which we live. We see where the three Big Bangs, described in figure 1, are located. The content of figure 3 shows how complex it is to study the evolution in the different fields of our knowledge. In fact evolution exists in many fields of our world such as Science and History. The whole of our knowledge comes from *Big Bang-3*.

In the whole of our knowledge, Science is considered the asymptotic limit of Simplicity, while History is taken to be the asymptotic limit of Complexity. Nature allows for the existence of many other structures whose Complexity seems to lie in between these two extreme limits. Figure 4 shows a sample of systems, which, according to the present way of looking at the world, are considered as being complex.

These systems go from the traffic flux, to the internet network, to earthquakes and seismicity, to social and economic systems, to the behaviour of financial markets, to the study of minimal life, of vegetal life, to the study of cosmological structures, and so on.

Despite the diversity of the fields investigated, the key experimentally observable quantities which allow these systems to share the property called 'Complexity' are the same:

1) The Anderson-Feynman-Beethoven-type phenomena (AFB) i.e. phenomena whose laws and regularities ignore the existence of the Fundamental Laws of Nature from which they originate;
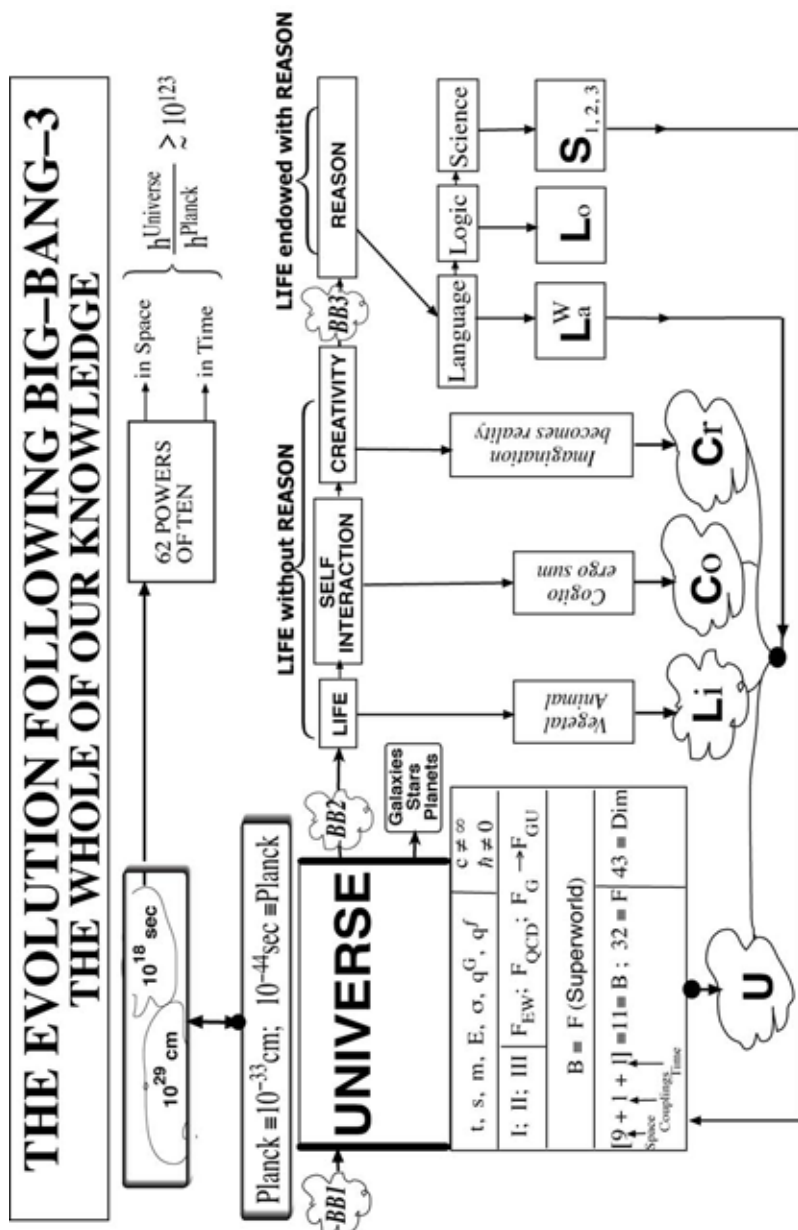
Figure 3.

2) The Sarajevo-type effects, i.e. Unexpected Events of quasi irrelevant magnitude which produce Enormous Consequences (UEEC).

These effects exist at all scales, and therefore Complexity exists at all scales, as illustrated in figure 5 where we see History at the extreme end of a high degree of Complexity and Science at the opposite range where the degree of Complexity is at the minimum value.

AFB and UEEC events are discussed in Appendices I, and II plus III, respectively. Let us discuss the two asymptotic limits: History and Science.
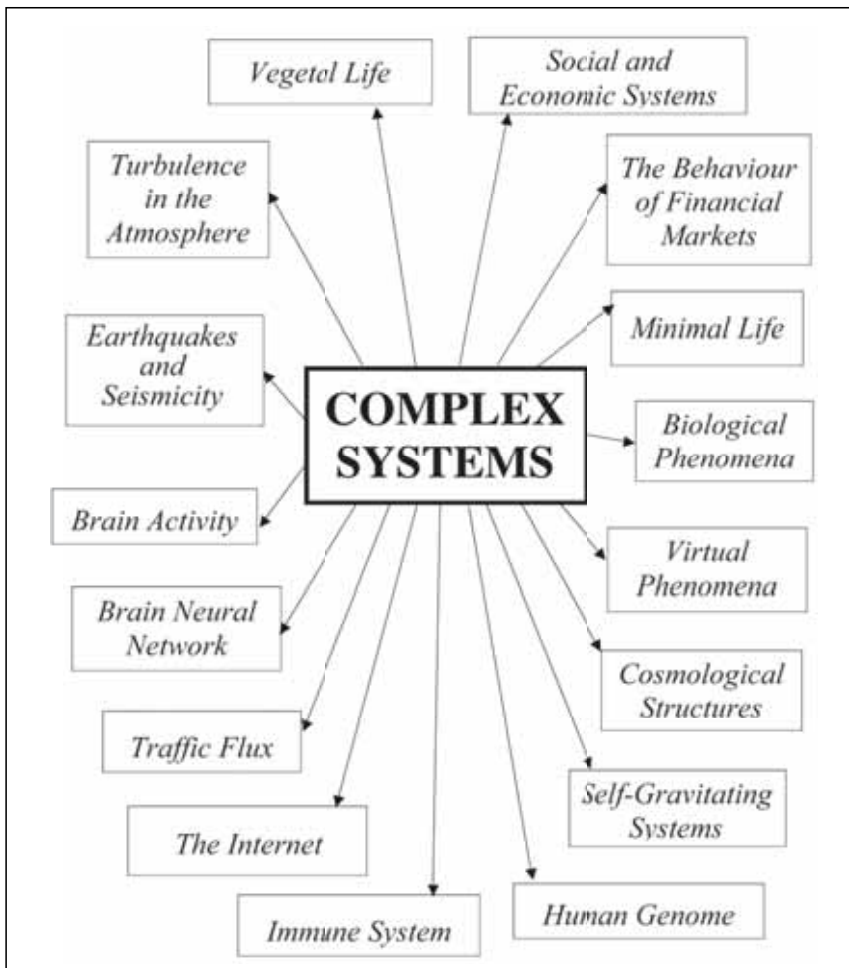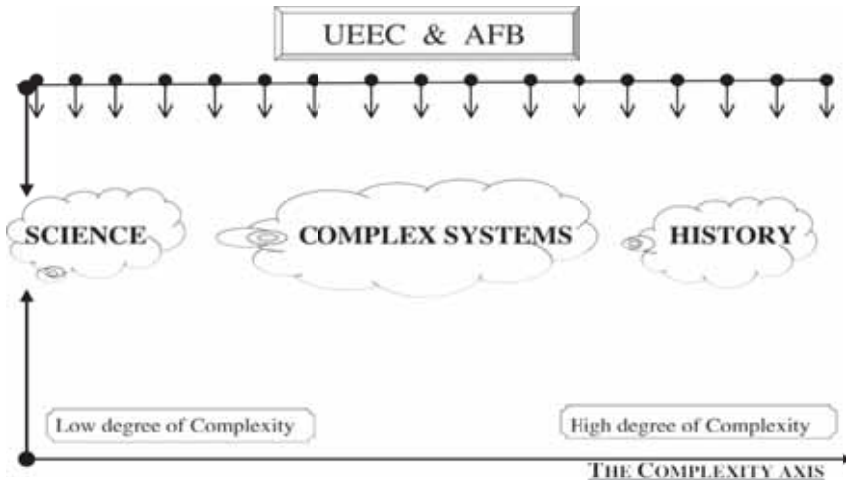

Figure 4.

Figure 5.

4. Evolution In The Two Asymptotic Limits Of Complexity: Science And History

Science (the asymptotic limit of Simplicity) and *History* (the asymptotic limit of Complexity), *share a property, common to both*: evolution.

It is interesting to define *Science* and *History* in terms of this property, *probably the only one*, which they share; i.e. evolution.

- Science is the Evolution of our Basic Understanding of the laws governing the world in its Structure ≡EBUS.
- History is the Evolution of the World in its Real Life ≡EWRL.

The world is characterized by two basic features, which are on the opposite side of one another: *Simplicity* and *Complexity*.

It is generally accepted that *Simplicity* is the outcome of *Reductionism*, while *Complexity* is the result of *Holism*.

The most celebrated example of *Simplicity* is *Science* while the most celebrated example of *Complexity* is *History*.

Talking about asymptotic limits, the general trend – as said before – is to consider *History* the asymptotic limit of *Holism* and of *Complexity*; *Science* as the asymptotic limit of *Reductionism* and of *Simplicity*. This is illustrated in figure 6.
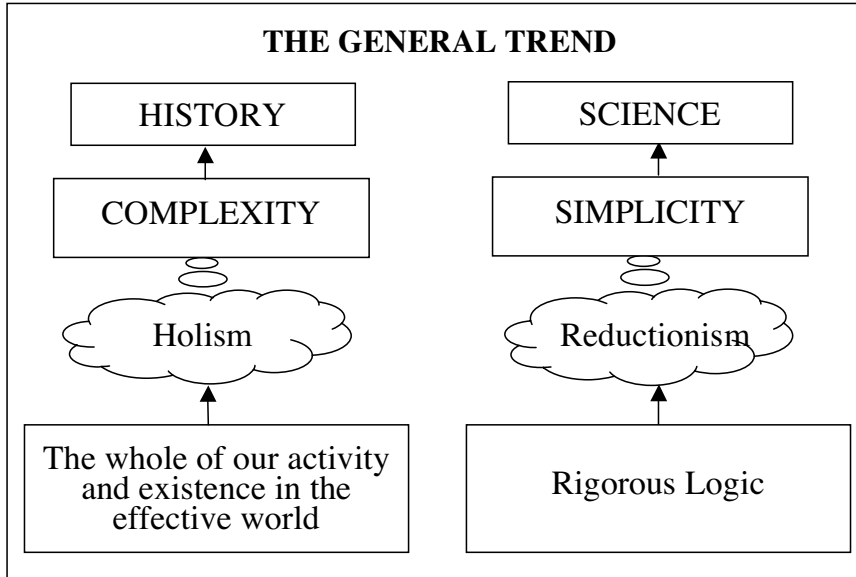
THE GENERAL TREND

HISTORY	SCIENCE

COMPLEXITY   SIMPLICITY

Holism   Reductionism

The whole of our activity and existence in the effective world	Rigorous Logic

Figure 6.

In Table 1 we compare these two asymptotic limits – History and Science – on the basis of 'What if?'; a condition elaborated by the specialists in what is now known as 'virtual history' [3].

On the basis of 'What if?' these specialists conclude that the world would not be as it is, if one, or few, or any number of 'What ifs?' had not been as History tells us. They define this as the 'virtual world'. This is not the case of Science. The world would have exactly the same laws and regularities, whether Galileo Galilei or somebody else had discovered F=mg (F ≡ force; m ≡ mass; g ≡ acceleration due to gravity), and so on for all the other scientific discoveries.

It is in the consequences of 'What if?' that the two asymptotic limits of Simplicity and Complexity seem to diverge, despite the fact that the sequence of 'What if?' in Science belongs to the 'totally unexpected events' (UEEC) exactly like the others listed in the column of History.

Table 1.

	In History = EWRL		In Science = EBUS
	'WHAT IF ?'		
	In History = EWRL		**In Science = EBUS**
I	What if Julius Caesar had been assassinated many years before?	I	What if Galileo Galilei had not discovered that $F = mg$?
II	What if Napoleon had not been born?	II	What if Newton had not discovered that $$F = G\frac{m_1 \cdot m_2}{R_{12}^2}$$?
III	What if America had been discovered a few centuries later?	III	What if Maxwell had not discovered the unification of electricity, magnetism and optical phenomena, which allowed him to conclude that light is a vibration of the EM field?
IV	What if Louis XVI had been able to win against the 'Storming of the Bastille'?	IV	What if Planck had not discovered that $$h \neq 0 ?$$
V	What if the 1908 Tunguska Comet had fallen somewhere in Europe instead of Tunguska in Siberia?	V	What if Lorentz had not discovered that space and time cannot both be real?
VI	What if the killer of the Austrian Archduke Francisco Ferdinand had been arrested the day before the Sarajevo event?	VI	What if Einstein had not discovered the existence of time-like and space-like real worlds? Only in the time-like world, simultaneity does not change, with changing observer.
VII	What if Lenin had been killed during his travelling through Germany?	VII	What if Rutherford had not discovered the nucleus?
VIII	What if Hitler had not been appointed Chancellor by the President of the Republic of Weimar Paul von Hindenburg?	VIII	What if Hess had not discovered cosmic rays?
IX	What if the first nuclear weapon had been built either by Japan before Pearl Harbour (1941) or by Hitler in 1942 or by Stalin in 1943?	IX	What if Dirac had not discovered his equation, which opens new horizons, including the existence of the antiworld?
X	What if Nazi Germany had defeated the Soviet Union?	X	What if Fermi had not discovered weak forces?
XI	What if Karol Wojtyla had not been elected Pope, thus becoming John Paul II?	XI	What if Fermi and Dirac had not discovered the Fermi–Dirac statistics?
XII	What if the USSR had not collapsed?	XII	What if the 'strange particles' had not been discovered in the Blackett Lab?

5. Evolution of the Universe: An Example of Third Level Galilean Science

Cosmic evolution is Galilean Science to the extent that it is formulated in rigorous mathematical terms and linked to the first level. From the pre-Big Bang on, everything is based on what has been discovered at the first level. It is impossible to prove experimentally the reproducibility of cosmic evolution.

No one knows how to make a Big Bang to verify the details that we would like to put under experimental test. We can only conduct experiments to understand what happens as we come close to the Big Bang. Today we have arrived at a tenth of a billionth of a second (10^{-10} sec). At this time we can perform experiments to check our theoretical models. Since Planck's Time lasts $54 \cdot 10^{-45}$ sec, it is wise not to forget the 34 powers of ten, which separate us in terms of Planck's Time from the Big Bang. This is the instant before inflationary expansion bursts forth. These 34 powers of ten are the measure of our ignorance in the rigorous knowledge of that which we call the 'theory of cosmic evolution'.

This theory helps us to understand just how difficult the study of phenomena belonging to the third level of Galilean Science is.

6. Evolution in Terms of Galilean Rigour and Experimental Reproducibility

All the phenomena that happen only once, as it is the case for the Biological Evolution of the Human Species (BEHS), belong, let us repeat once again, to the third level of Galilean Science. Our species being the only form of living matter endowed with Reason, it is important to place the 'theory of Biological Evolution of the Human Species' under the Galilean-type rigour.

There are those who say that this 'theory' represents the frontier of Galilean Science. We would like this to be true. To accomplish this, however, it is necessary to establish a foundation for this theory in terms of mathematical rigour and of experimental reproducibility. Doing this requires an analysis attentive to the phenomenon called 'evolution'. Evolution exists at the level of elementary particles, at the level of aggregates made up of inert matter, and at the level of aggregates of living matter.

The first rigorous study of evolution at the level of elementary particles concerns electrons. The electron is the first example of an 'elementary particle' (discovered by Thomson in 1897).

Dirac, fascinated by the discovery of Lorentz that Space-Time could not be a real quantity but instead a complex one (if Space is real, Time must be

imaginary, and vice versa), decided to study with rigour the evolution of the electron in Time and Space. This was how he discovered his equation.

The rigorous study of evolution at the level of elementary particles brought Dirac to discover a reality that no philosopher, no poet, no thinker of any epoch or civilization was able to imagine. This reality begins with antiparticles and brings us to the discovery of antimatter, antistars and anti-galaxies to arrive at our world, which seems to be made up only of matter, stars and galaxies, without any antistars or antigalaxies. An experiment to be conducted in the International Space Station (ISS) will tell us if it is real-ly true that in the course of cosmic evolution every trace of antimatter was annihilated with matter in order to build up a Universe, like the one in which we are living, that consists only of matter. If in our laboratories we had discovered that antimatter could not exist, the problem of a Universe made only of matter would not exist. This is not so. The existence of anti-matter was established in a rigorously Galilean manner in 1965. Neverthe-less, in the Universe there is probably no antimatter.

It is possible to formulate in a mathematically rigorous way the theory of cosmic evolution that cancels out antimatter at a certain point. Accord-ing to this theory of cosmic evolution, we are here thanks to the fact that, in the process of 'annihilation', a tiny fraction (one part in 10 thousand mil-lion (10^{10})) of matter prevailed over antimatter. No one could say if this the-ory is that which corresponds to the cosmic reality of which we are a min-imal part. The only certainty is that this theory will be scrutinized closely via Galilean-type experimental tests in the years to come, thanks to the AMS experiment in the ISS.

Starting from the evolution of an elementary particle we have arrived at the problems of cosmic evolution. This means that we have passed from typical structures of the subnuclear world (10^{-17} cm) to galactic structures up to the borders of the Universe (10^{29}cm); better still, if the inflationary evolution of Alan Guth is true, to even greater cosmic distances.

All we have discussed so far deals with the theory of evolution in the study of inert matter, from the heart of a proton (10^{-17}cm) to the borders of the Cosmos (10^{29}cm): an interval of space which extends over 46 powers of ten. We have done this using the three levels of Galilean Science.

This is the most rigorous knowledge we have, when dealing with the study of the evolution of inert matter.

Table 2 lists problems encountered in the study of the evolution of inert matter.

Table 2. Evolution in the Study of Inert Matter: *Problems*

EVOLUTION IN THE
FUNDAMENTAL STRUCTURE OF INERT MATTER

<u>The Elementary Particles and</u>
<u>the Macroscopic Structure of Matter</u>

Evolution in Space-Time of the lightest electrically charged lepton: the **Dirac equation**.

Evolution in the description of the elementary processes involving inert matter: the **Feynman diagrams** and the problem of **Renormalization** (i.e. no divergent results in theoretical calculations).

Evolution in the macroscopic structure of inert matter.

The crystals.

Other forms of conglomerate matter and the understanding of their properties.

<u>The Universe</u>

Evolution in the Universe and in its structure.

The Physics of the **pre-Big Bang**.

The Physics of the **Big Bang**.

The basic structure of matter and of the Fundamental Forces in the evolution of the Universe: from the **Planck Scale** to present day (see figure 7).

The origin of Galaxies and their **distribution** in Space-Time.

The origin of a Star and its evolution (Gravitational, Electroweak and Strong Forces).

The origin of condensed forms of cold matter (Planets, Asteroids, Comets and others cosmic objects).

Table 3 lists problems concerning the transition from vegetal to animal forms of living matter. Finally, Table 4 lists problems referring to the evolution which goes from living matter without Reason to living matter endowed with Reason. The key question here is why is there only one form of living matter with Reason: us.

Table 3. EVOLUTION IN LIVING MATTER: *PROBLEMS*

THE TRANSITION FROM
INERT MATTER TO LIVING MATTER

Evolution in the enormous variety of "**vegetal**" forms of Living Matter.

The transition from "vegetal" to "animal" forms of Living Matter.

The evolution in the enormous variety of "animal" forms of Living Matter.

Table 4. EVOLUTION IN LIVING MATTER WITH REASON: *PROBLEMS*

THE TRANSITION FROM THE INNUMERABLE
POSSIBILITIES OF LIVING FORMS OF MATTER
WITHOUT THE PRIVILEGE OF REASON TO
THAT OF LIVING MATTER WITH "REASON"

The evolution of the specific form of Living Matter called **"the human species"**.

The discovery of Collective Memory, i.e. **Written Language**.

The discovery of Logic and of its most rigorous form: **Mathematics**.

The discovery of Science: the **Logic of Nature**.

Reflections on how it happens that we are the **only form of Living Matter** with "Reason".

All these problems need to be fully understood before we reach the level where we need to think about how we happen to be the only form of living matter 'Reason'.

In fact, the extraordinary characteristic of the world in which we live is that the *Hardware* is the same for all forms of matter: from the most elementary inert piece of matter to the Universe and finally to the most advanced form of matter with Life and Reason (the Human Species). The *Hardware* will be described in chapter 9.

Since the *Hardware* is the same, the following remarks are in order. It could very well have been that the basic *Hardware* was there, but not Life itself. It could also have been that the basic *Hardware* plus Life were there, but no Reason. These problems are illustrated in Table 5. It happens that Reason is present with its three great achievements: Language, Rigorous Logic and Science, as previously mentioned, and as reported in Table 6.
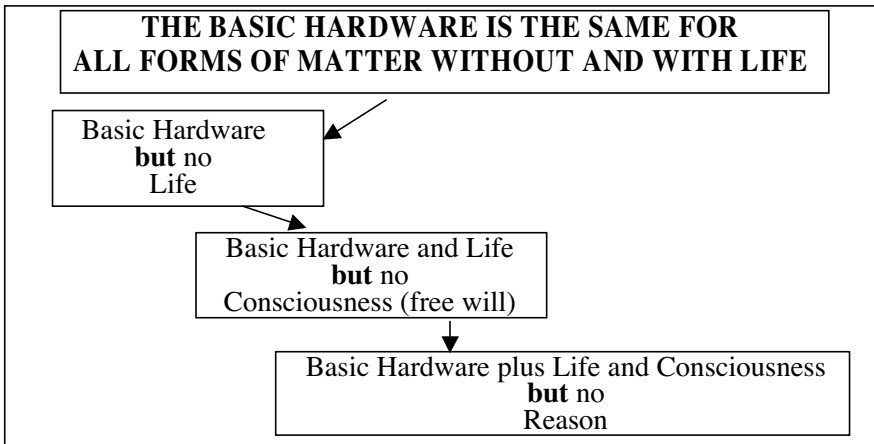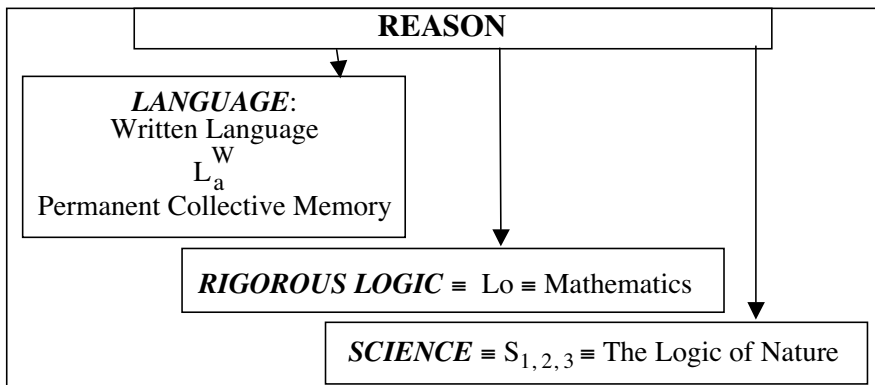
Table 5. *PROBLEMS*

**THE BASIC HARDWARE IS THE SAME FOR
ALL FORMS OF MATTER WITHOUT AND WITH LIFE**

Basic Hardware
but no
Life

Basic Hardware and Life
but no
Consciousness (free will)

Basic Hardware plus Life and Consciousness
but no
Reason

Table 6.

REASON

LANGUAGE:
Written Language
L_a^W
Permanent Collective Memory

RIGOROUS LOGIC $\equiv$ Lo $\equiv$ Mathematics

SCIENCE $\equiv S_{1,2,3} \equiv$ The Logic of Nature

It is thanks to the existence of a rigorous Logic of Nature that the evolution of the Universe can be described as illustrated in figure 7.
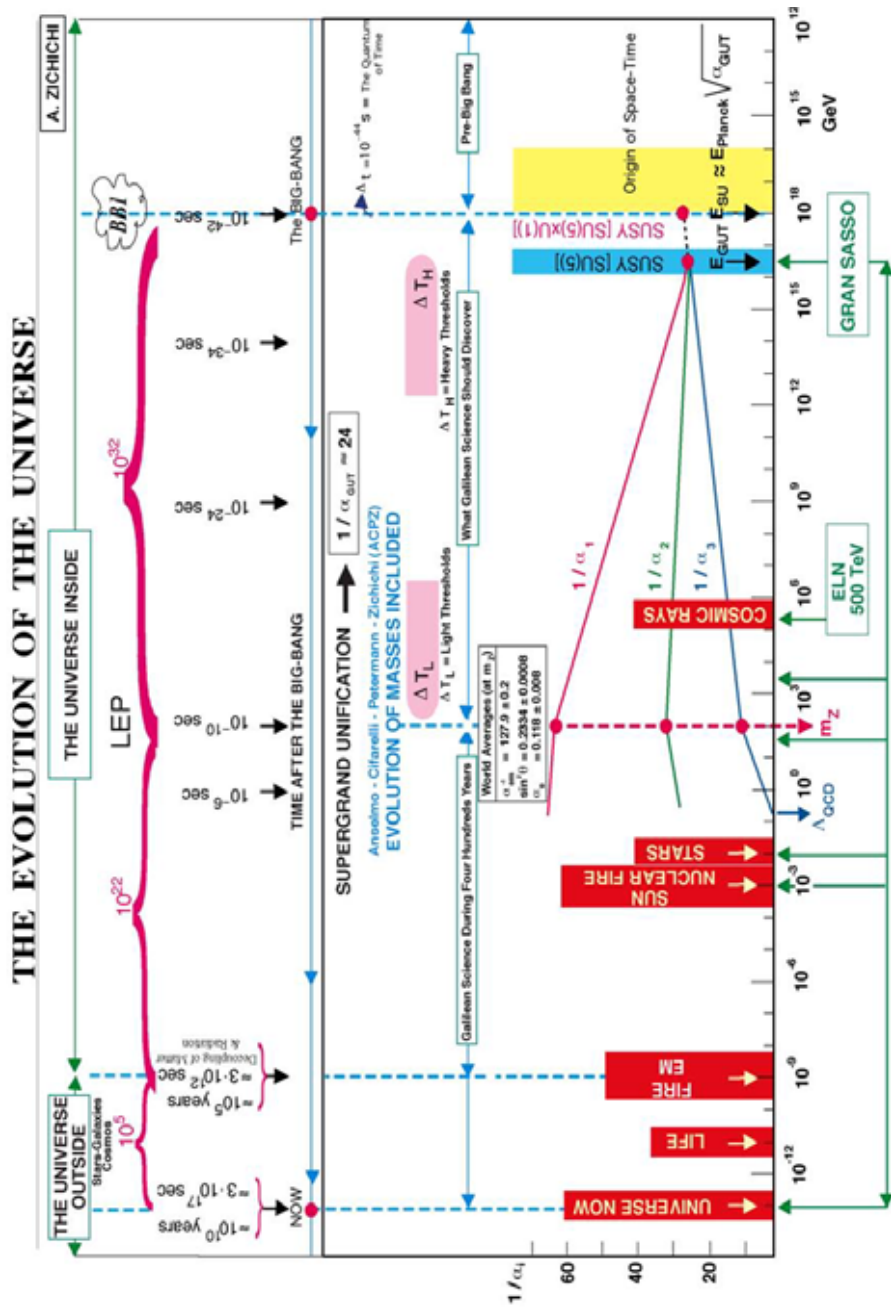
Figure 7.

We see that the 'Universe' illustrated in figure 7 consists of many impor-
tant details. The 'Universe outside' is the one which comes after the decou-
pling of protons, electrons and photons; when atoms started their forma-
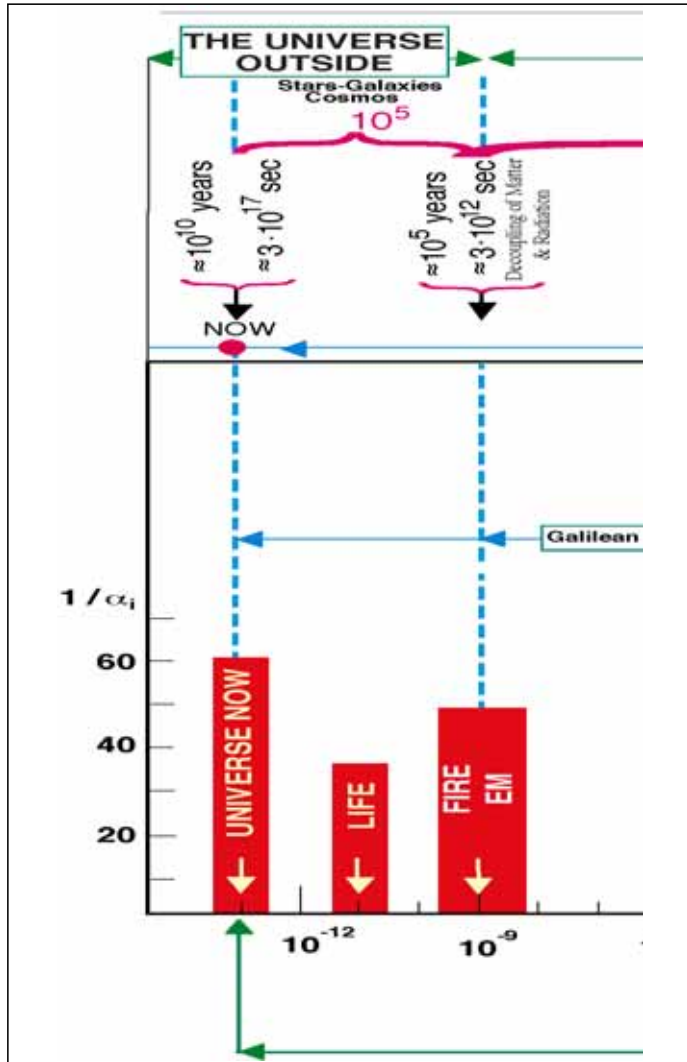tion, 380 thousands years after *Big Bang-1*. This part of figure 7 is shown in
figure 8.

Figure 8.

We could not be here if the Logic of Nature did not allow the formation of Galaxies, Stars and planets. The 'Universe inside' is the one which we study in our Laboratories. The description of the evolution of the Universe, illustrated in figure 7, could never have been conceived without the existence of Science at its first level.

7. The Biological Evolution of the Human Species (BEHS) is Below the Third Level of Galilean Science

Let us start with the facts known about the origin and the evolution of the human species. 1) The Earth has existed for about five billion years; 2) The evidence of living organisms composed of simple cells goes back nearly 3.5 billion years; 3) Multicellular organisms have existed for about seven hundred million years; 4) Vertebrates, for four hundred million years; 5) Mammals, for 200 million years; 6) Primates, for seventy million years.

The group of Hominids starts with the Dryopithecus, about 20 million years ago and splits into two branches. One branch, Pongidae, which produces Chimpanzees, Gorillas and Orangutans. The other branch, Hominidae, produces Homo habilis (stone age), Homo erectus (fire age), and Homo sapiens neanderthalensis, with a brain having a volume larger than our brain.

According to the Biological Theory of Evolution of Human Species (BEHS), Homo sapiens neanderthalensis disappears, but no one knows how. And in an analogous unknown way, Homo sapiens appears, twenty to forty thousands years ago.

This sequence of events is reported in figure 9 which is a very simplified version of the evolution of living matter.

A 'theory' with missing links, extraordinary developments, inexplicable extinctions, sudden disappearances, is far from being Galilean Science. This 'theory' needs the two pillars of Galilean Science: experimental reproducibility and mathematical rigour to describe the observed facts.

According to Darwin, the living matter species, of which we are an example, is the result of small steps in a chaotic series of events where natural selection played a decisive role. Concerning this basic pillar of Darwinistic evolution it has been recently pointed out by Gregory G. Gibson that natural selection is only one, and probably not the most important factor, in the biological evolution of living matter. Recently the Genome sequence of *the*
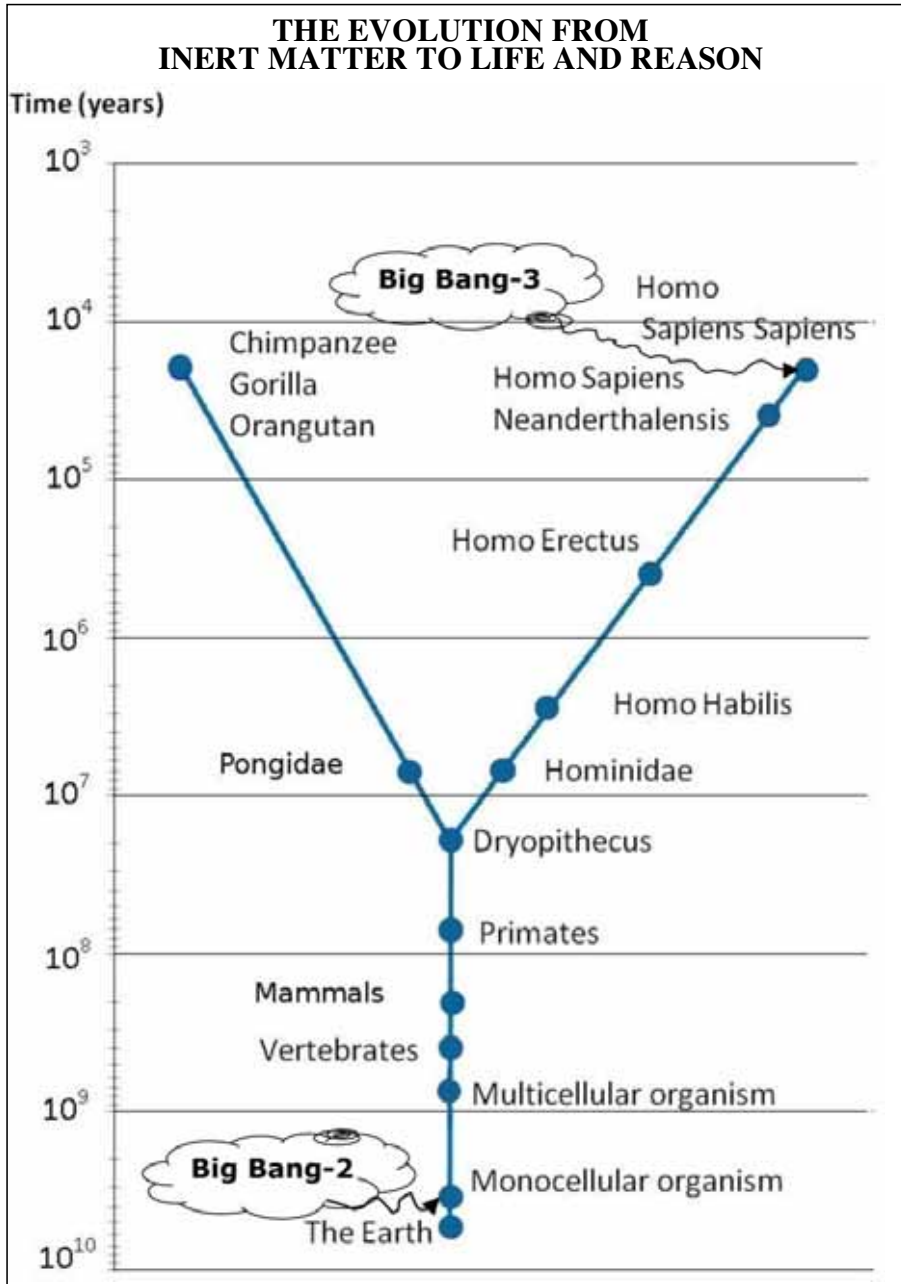
Figure 9.

Ornithorhynchus anatinus[1] has been published [4]. This work, according to some specialists, corroborates the theoretical idea that the evolution of living matter cannot proceed via small steps and random changes.

Concerning the mutations with very low probability, an interesting result has been published [5] by Richard Lenski from the University of Michigan. He has observed a mutation in *Escherichia coli*, after 33,127 generations. The author estimates that the probability of such an event is in the order of 10^{-12}. Despite this very low probability event *Big Bang-3* has not taken place. This will be the case for an even lower probability event, since the only species of living matter where *Big Bang-3* can take place is the Human Species.

Many interesting discoveries have been obtained concerning the evolution of different forms of living matter, but a transition from one species to another has never been observed. The mechanism which produces mutations and the relevance of natural selection are still open problems.

The theory of BEHS has to take in due account the extremely interesting results on the structure of our brain obtained using the NMR technology (Nuclear Magnetic Resonance, now called Resonance Imaging).

These results have opened our eyes to the extraordinary complexity of our brain. This complexity has twisted the 'electromagnetic model' of our brain.

The new model[2] has abandoned the 'circuits' and has adopted the 'antenna'; with this choice the number of electromagnetic interactions between given points in the brain reaches the level of hundreds of powers ten, $10^{>100}$, in order to formulate an original idea.

A further point needs to be put in evidence: to extend to the human species the results obtained in the study of evolution of other forms of living matter is incorrect. In fact, even the lowest probability event observed by R. Lenski (mentioned above) to occur at the 10^{-12} level has not produced any *Big Bang-3*. The reason being that we are the only form of living matter endowed with a unique privilege: Reason. This privilege has allowed our species to reach the three great conquests quoted before: Language, Logic and Science (see chapter 10).

---

[1] A detail concerning the sexual chromosomes. Normal mammals possess a pair of sexual chromosomes, XX for females, XY for males. The living matter species quoted above, *Ornithorhynchus anatinus*, has 10 sexual chromosomes. Five pairs XX for females, 5 X and 5 Y for males, with a total of 52 chromosomes. We need only 46 chromosomes.

[2] Donald Glaser, the inventor of the Bubble Chamber.

It is thanks to Language that Permanent Collective Memory (PCM), better known as Written Language, has been invented. No other form of living matter has left traces of PCM. And no other forms of living matter have been able to discover the most rigorous form of Logic, called Mathematics (for details see chapter 10). Out of all possible forms of rigorous Logic, one has been selected in order to build the world where we are. This special form of Logic is called Science and it is the Logic which governs all forms of inert matter. No other forms of living matter deal with the problems of Science.

It would be a remarkable step forward to establish what experiments should be performed in our laboratories in order to discover the experimental reproducible basis underlying the BEHS theory. At present no one knows the mathematical structure – corroborated by reproducible experimental results – capable of describing the transition from inert matter to the various forms of living matter (*Big Bang-2*). And no one knows how to go from the innumerable forms of living matter to the one and only one, which is capable of producing Language, Logic and Science (*Big Bang-3*).

Waiting for this formidable result to be achieved, it is necessary to call attention to the fact that BEHS is an activity of study and research, deprived of experimentally reproducible results and of mathematical rigour in the description of these results. In fact BEHS has neither first level nor second level Galileian Science and the third level has no formulation in terms of mathematical rigour, as it is the case for the cosmic evolution, illustrated in figure 10, which is a simplified version of figure 7. This is why BEHS is below the third level of Galilean Science.
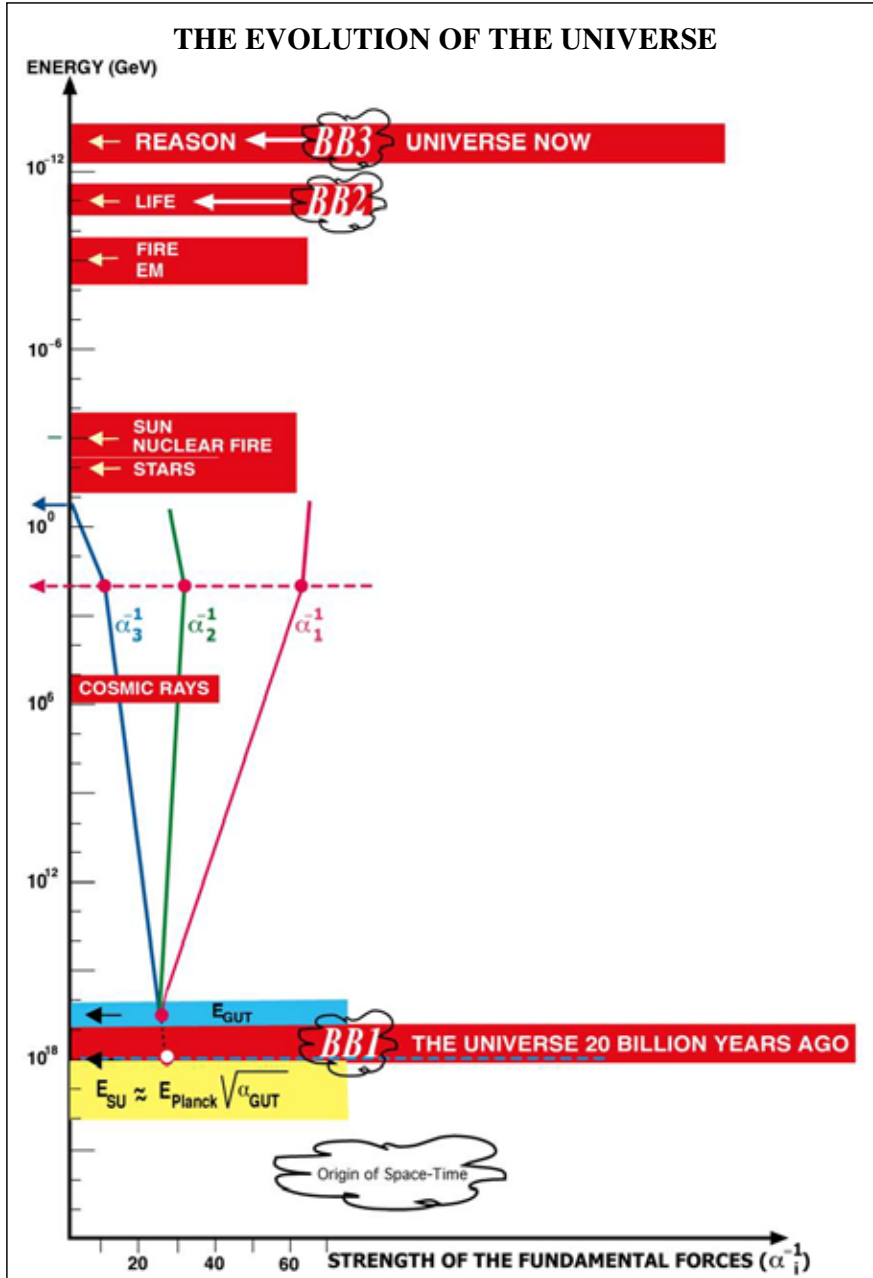
Figure 10.

8. The Hardware Which Governs All Matter, Inert and Living, is Dominated by Ueec Events Which Represent the Evolution of Science

In this chapter we briefly recall the sequence of UEEC events from Galilei to 1947, already used to compare History and Science on the basis of 'What if?' (Table 1).

Point XIV refers to the period which lasted about 3/4 of a century; to be more precise it started in the early 1930s with Yukawa whose apparently very simple proposal to explain the reason why protons and neutrons can stay glued in a nucleus, gave rise to an impressive series of discoveries defined 'The Yukawa goldmine' [6].

This brought us to realize that the two particles called proton and neutron (and thought to be elementary) do in fact contain in their intimate structure a world totally different from the one we are familiar with, i.e. the subnuclear world.

It is from this UEEC sequence of events (figure 11) that we have reached the Hardware which governs all matter, inert and living. This Hardware is the synthesis of all scientific knowledge [called the *SM&B* (see chapter 9)].

"UEEC"
TOTALLY UNEXPECTED DISCOVERIES
FROM GALILEI TO FERMI-DIRAC, THE "STRANGE" PARTICLES
AND THE YUKAWA GOLDMINE

I	Galileo Galilei: F = mg .
II	Newton: $F = G \dfrac{m_1 \cdot m_2}{R_{12}^2}$
III	Maxwell: the unification of electricity, magnetism and optical phenomena, which allows to conclude that light is a vibration of the EM field.
IV	Becquerell: radioactivity.
V	Planck: $h \neq 0$.
VI	Lorentz: space and time cannot both be real.
VII	Einstein: the existence of time-like and space-like worlds. Only in the time-like world, simultaneity does not change, with changing observer.
VIII	Rutherford: the nucleus.
IX	Hess: cosmic rays.
X	Dirac discovers his equation, which opens new horizons, including the existence of the antiworld.
XI	Fermi: weak forces.
XII	Fermi–Dirac and Bose–Einstein discover two completely different statistical laws.
XIII	The "strange particles" are discovered in the Blackett Lab.
XIV	The Yukawa goldmine.

Figure 11.

9. THE HARDWARE OF EVOLUTION: FROM BASIC QUANTITIES TO THE SM&B

My field of scientific activity is subnuclear physics. It is thanks to this field of Science that it has been possible to identify the Basic Quantities needed to build the world where we live, as shown in figure 12.
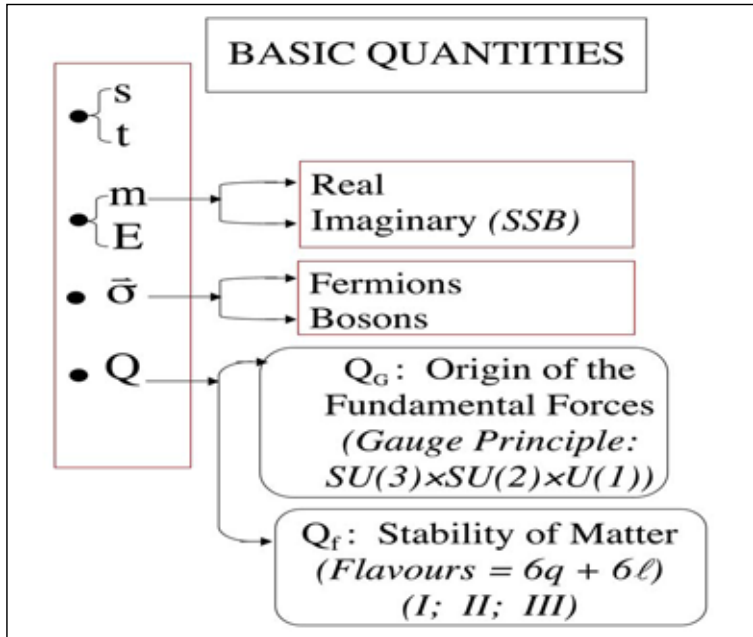

Figure 12.

From these '*Basic Quantities*' the evolution of our knowledge brings us to the most advanced synthesis of scientific knowledge called *SM&B*, i.e. the Standard Model and Beyond. The steps needed in this evolution of our knowledge are reported in Appendices I and II plus III. The *SM&B* is the Logic which governs the basic hardware of the fundamental constituents of all forms of matter.

If the present ideas on the *SM&B* are valid, the result is that we know how, from the origin of Space-Time the Superworld started, then by evolution in Space and Time became our world.

The three lines in figure 13 are taken from figure 7. They represent the strengths, respectively α_1, α_2, α_3, of the three Fundamental Forces of Nature as a function of energy.

The three forces are: the electromagnetic, the weak subnuclear and the strong subnuclear.

These three forces meet at the energy level called E_{GUT}, where GUT stands for Grand Unified Theory, if the number of expanded Space-Time dimensions is (3 Space + 1 Time).

If other dimensions are expanded, it could be that E_{GUT} goes down by many orders of magnitude (for example at the 10^4 GeV level) as indicated in figure 13.

The evolution we have so far discussed refers to inert matter where the interaction with the environment has no effect at all.

When we go from Basic Quantities, Atoms and Molecules to Proteins, Genes, Living Cells (C) and more complex forms of Living Matter (L), the interaction with the environment cannot be neglected, as shown in figure 14.

The most intense interaction with the environment and its evolution is described by History, which is in fact the asymptotic limit of Complexity, as discussed in chapter 4.
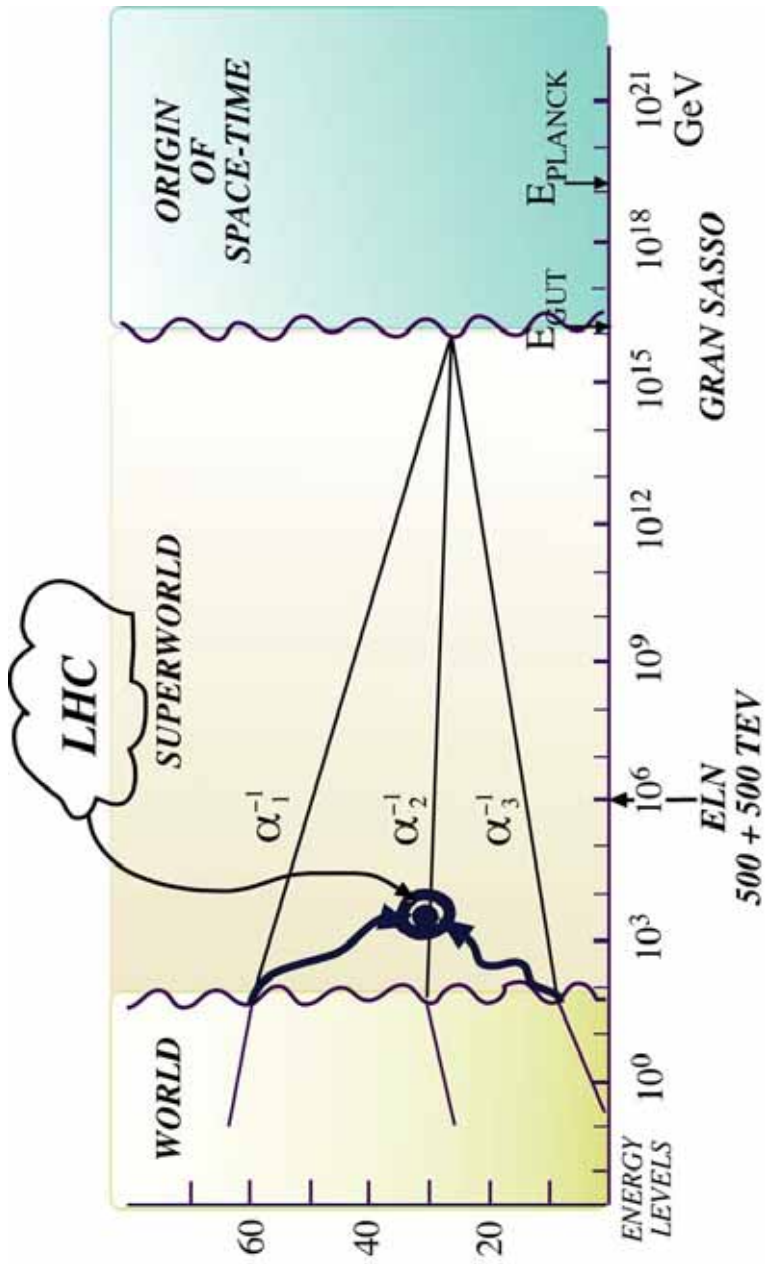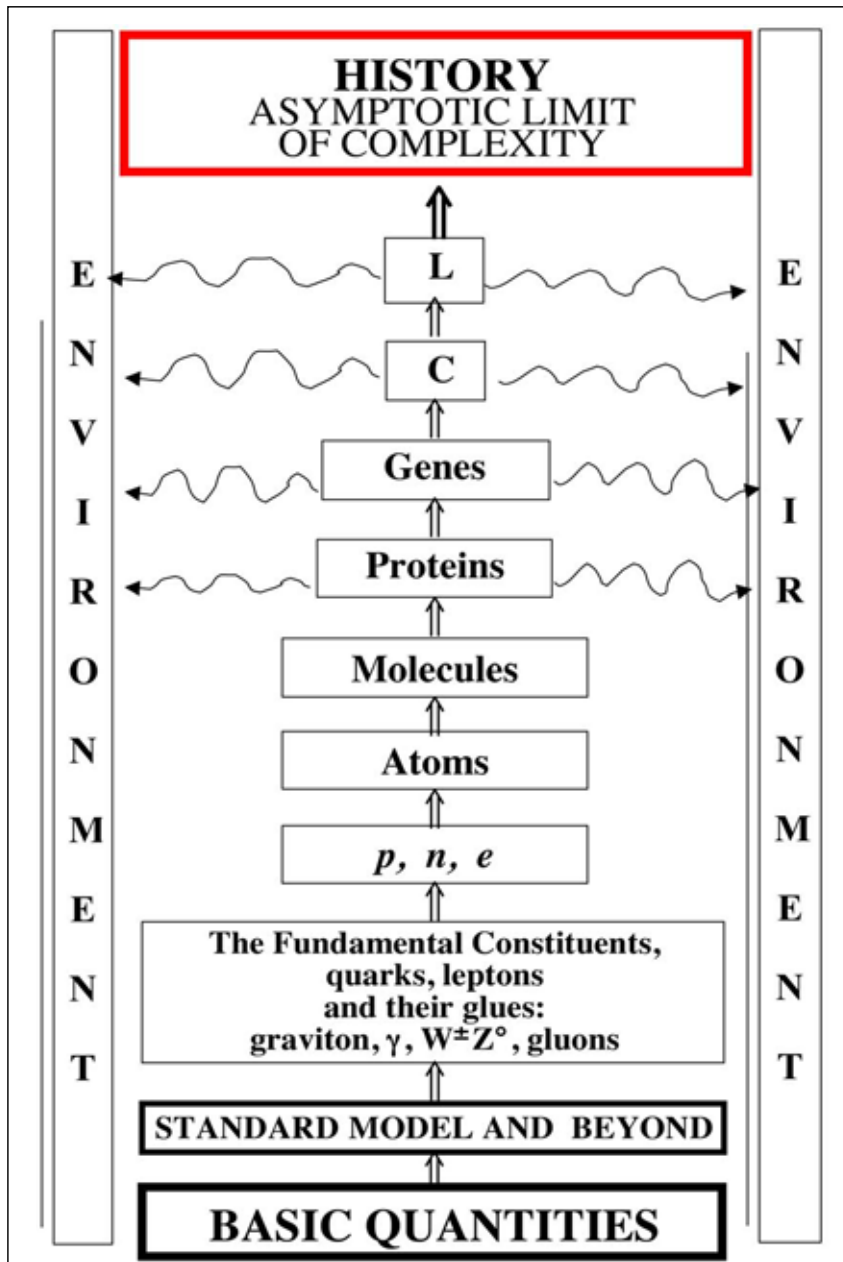
Figure 13.

Figure 14.

10. PROOF THAT ONLY ONE SPECIES OF LIVING MATTER IS ENDOWED WITH REA-
SON: LANGUAGE, LOGIC AND SCIENCE

As stated previously, we are the only form of living matter endowed with
Reason, the proof being that no other forms of living matter have been able
to discover the three conquests of Reason: Language, Logic and Science. The
time-evolution of Language, Logic and Science is reported in figure 15. The
lowest level of Language is the one needed in order to understand a 'message'
(i.e. a group of words constructed on the basis of appropriate rules).

We can call this level 'Language-understanding'. The next level is at a
much higher degree of intellectual ability. It is the one needed in order to elab-
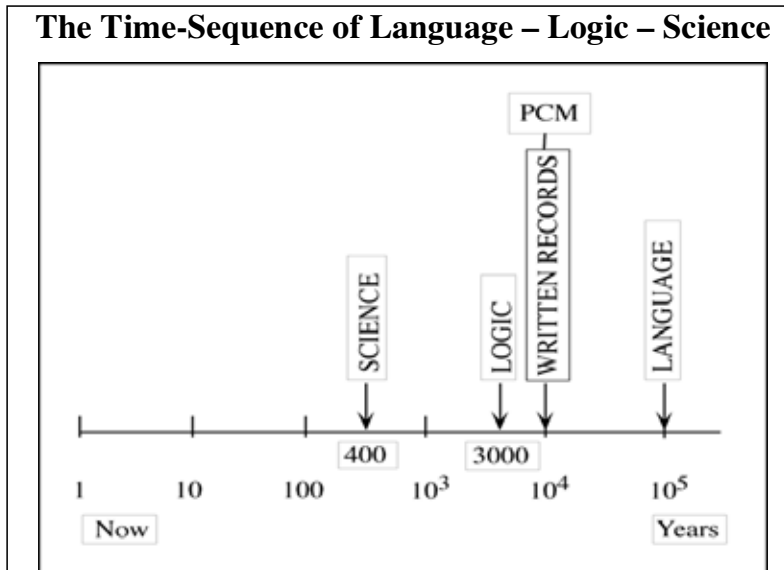orate a 'message'. Our species is the only species able to elaborate 'messages'.

Figure 15.

In figure 16 we report the intellectual achievements due to Language at
its highest level.

The most clear way to realize what are the activities defined by the word
'Language' can be obtained by pointing out that all these activities would
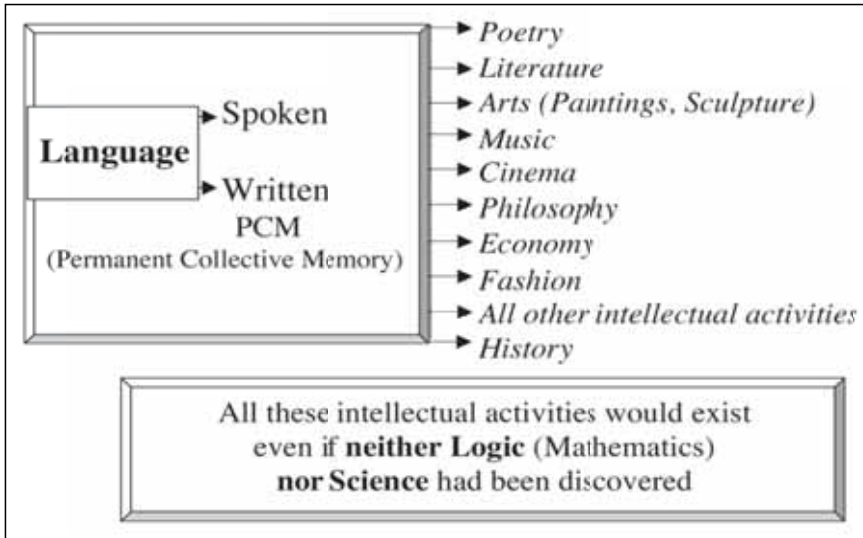exist even if neither Rigorous Logic nor Science had been discovered.

Figure 16.

In figure 17 the main achievements of Rigorous Logic are reported. All these achievements would exist even if Science had never been discovered.
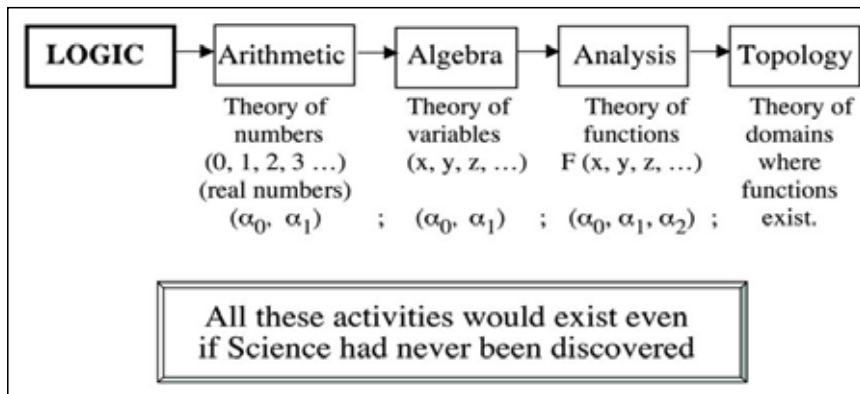

Figure 17.

In the following figures (18, 19, 20) the point to notice is the vital condition which allows the three achievements to exist; i.e. 'to be fascinating' for Language,[3] the 'non-contradiction' for Logic and the 'the real world' for Science.

In figure 18 there is an attempt to express Language in terms of a mathematical formalism. The symbols refer to sum '$\sum$' and product '$\prod$' of the various functions 'f' describing the large number of constituents of a linguistic structure, as indicated by the symbols R, Cr, Co, Li and U, whose meaning is reported.

$$La \equiv F_{La}(R, Cr, Co, Li, U) \equiv \sum_{j,k,l,m,n}\left[f^j_{La}(R) \oplus f^k_{La}(Cr) \oplus f^l_{La}(Co) \oplus f^m_{La}(Li) \oplus f^n_{La}(U)\right] \oplus$$

$$\oplus \prod_{j,\ k,\ l,\ m,\ n}\left[f^j_{La}(R) \otimes f^k_{La}(Cr) \otimes f^l_{La}(Co) \otimes f^m_{La}(Li) \otimes f^n_{La}(U)\right] \Rightarrow$$

$$\Rightarrow \boxed{\text{Be Fascinating}}$$

Reason	$\blacksquare$	R	$\Rightarrow$	j	=	$1, 2, 3, \ldots\ldots n_j$
Creativity	$\blacksquare$	Cr	$\Rightarrow$	k	=	$1, 2, 3, \ldots\ldots n_k$
Self Conscience	$\blacksquare$	Co	$\Rightarrow$	l	=	$1, 2, 3, \ldots\ldots n_l$
Life	$\blacksquare$	Li	$\Rightarrow$	m	=	$1, 2, 3, \ldots\ldots n_m$
Universe	$\blacksquare$	U	$\Rightarrow$	n	=	$1, 2, 3, \ldots\ldots n_n$

LANGUAGE

Figure 18.

[3] Jorge Luis Borges says: with Language we can say anything including its opposite. The result is 'nothing'. This 'nothing' must be fascinating. Poetry is the supreme expression of Language. Let me give you an example of a poem whose purpose is to say nothing, but possesses the privilege of being 'fascinating': '*… Pellegrina colomba immaginaria che accendi nel cuore gli ultimi amori, anima della musica e dei fiori, pellegrina colomba immaginaria'. (Imaginary wandering dove lighting final loves in the heart, spirit of music and of flowers, imaginary wandering dove).* Jorge Luis Borges in *Conversazioni*, Tascabili Bompiani 2000, p. 19.

$$Lo \equiv F_{Lo} \; (Arithmetic; \; Algebra; \; Analysis; \; Topology) \Rightarrow$$

$$\Rightarrow \boxed{\textbf{Non-Contradiction}}$$

$$\boxed{\text{LOGIC}}$$

Figure 19.

$$S_{1,2,3} \equiv F_{S_{1,2,3}} \; (Inventions; \; Discoveries; \; Measurements) \Rightarrow$$

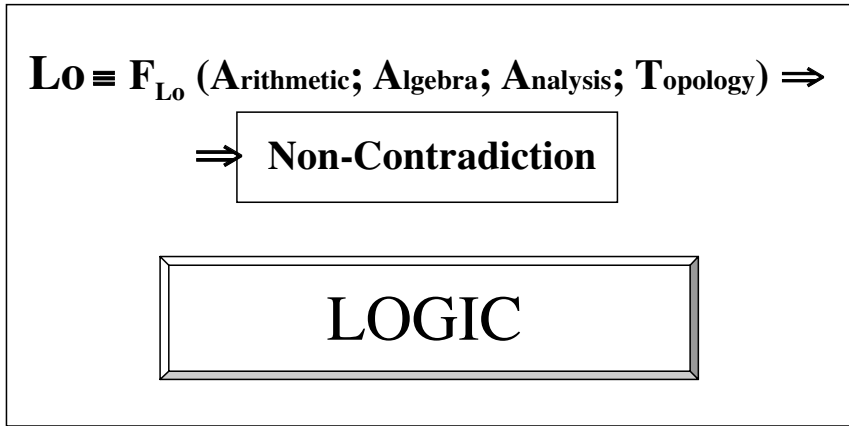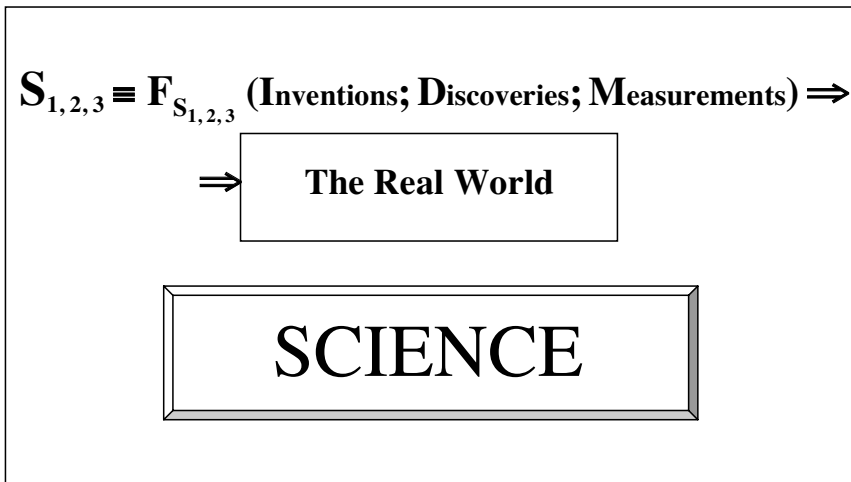$$\Rightarrow \boxed{\textbf{The Real World}}$$

$$\boxed{\text{SCIENCE}}$$

Figure 20.

As pointed out in chapter 2 there are three levels of Galilean Science, S_1, S_2 and S_3. The most spectacular example of third level Science is the evolution of the Universe.

11. Brief Recapitulation

No matter what, everything which exists in Space and Time is subject to the process of evolution. This can be rigorously studied for elementary particles, for example the 'electron', with results which go beyond the power of human imagination, as is the existence of antiparticles, antimatter, antiworld. It is from these studies that the various theories of cosmic evolution have been formulated, including *Big Bang-1*, which describes the transition from the vacuum to the Universe of inert matter. Evolution also affects very complex systems; the asymptotic example of Complexity being History. Here evolution is dominated by UEEC (Unexpected Events with Enormous Consequences, called Sarajevo-type events by historians). The experimentally observable quantities, for Complexity to exist, are UEEC events and AFB phenomena. The most famous example of AFB is Beethoven who was able to compose masterpieces of music while having never studied QED (Quantum ElectroDynamics). But if QED laws were not there, neither music nor mankind could exist. Examples of complex systems have been reviewed together with the three levels of Galilean Science, whose third level is needed to describe events which happen only once. The Biological Evolution of Human Species (BEHS) needs two such events: *Big Bang-2*, to describe the transition from inert matter to living matter, and *Big Bang-3*, to describe the transition from living matter without reason to living matter endowed with reason. A comparison between cosmic evolution and the evolution of the human species shows that BEHS is below the third level of Galilean Science. It is to be pointed out that there is one, and only one, form of living matter endowed with Reason. It is therefore not obvious that results obtained with other forms of living matter can be extended to the human species. A theory of evolution, no matter in what field, cannot ignore the pillars of Galilean Science: experimental reproducibility and mathematical rigour. Where this is not the case, no one can claim that the research work being implemented is Galilean Science.

12. Final Conclusion

The most spectacular example of third level Galilean Science is the evolution of the Universe illustrated in figure 7 of chapter 7. Let us not forget that it is thanks to Galilean Science that the Logic of Nature has been discovered. This corroborates the famous Statement by John Paul II: '*Science*

has its roots in the Immanent but leads man towards the Transcendent'. In fact if there is a Logic, the Author of this Logic must exist. We have seen that far from having a rigorous, Galilean-type, scientific foundation, the Biological Evolution of the Human Species (BEHS), illustrated in figure 9 of chapter 7, is below the third level of Galilean Science.

We would like to encourage our colleagues engaged in the study of biological evolution to reach the goal of bringing BEHS (the Biological Evolution of the Human Species) to the third level of Galilean Science, as it is the case for the evolution of the Universe, cosmic evolution.

The impressive series of problems discussed, and awaiting a rigorous scientific solution, point to the conclusion that probably help from the transcendental sphere of our existence is needed.

Let me close with the first 'Easter Vigil' (15 April 2006) of Benedict XVI where in the Homily of His Holiness the words 'evolution' and 'mutation' are introduced in a context which refers to the transcendental sphere of our existence:

> Christ's Resurrection is something more, something different. If we may borrow the language of the theory of evolution, it is the greatest 'mutation', absolutely the most crucial leap into a totally new dimension that there has ever been in the long history of life and its development: a leap into a completely new order which does concern us, and concerns the whole of history (…) It is a qualitative leap in the history of 'evolution' and of life in general towards a new future life, towards a new world which, starting from Christ, already continuously permeates this world of ours, transforms it and draws it to itself.

APPENDIX I

AFB Phenomena From Beethoven To The Superworld

Beethoven and the laws of acoustics

Beethoven could compose superb masterpieces of music without any knowledge of the laws governing acoustic phenomena. But these masterpieces could not exist if the laws of acoustics were not there.

The living cell and QED

To study the mechanisms governing a living cell, we do not need to know the laws of electromagnetic phenomena whose advanced formulation is QED. All mechanisms needed for life are, to a great extent, examples of electromagnetic processes. If QED was not there, Life could not exist.

Nuclear physics and QCD

Proton and neutron interactions appear as if a fundamental force of nature is at work: the nuclear force, with its rules and its regularities. These interactions ignore that protons and neutrons are made with quarks and gluons.

Nuclear physics does not appear to care about the existence of Quantum ChromoDynamics (QCD), the fundamental force acting between quarks and gluons at the heart of the subnuclear world.

Nuclear physics ignores QCD but all phenomena occurring in nuclear physics have their roots in the interactions of quarks and gluons.
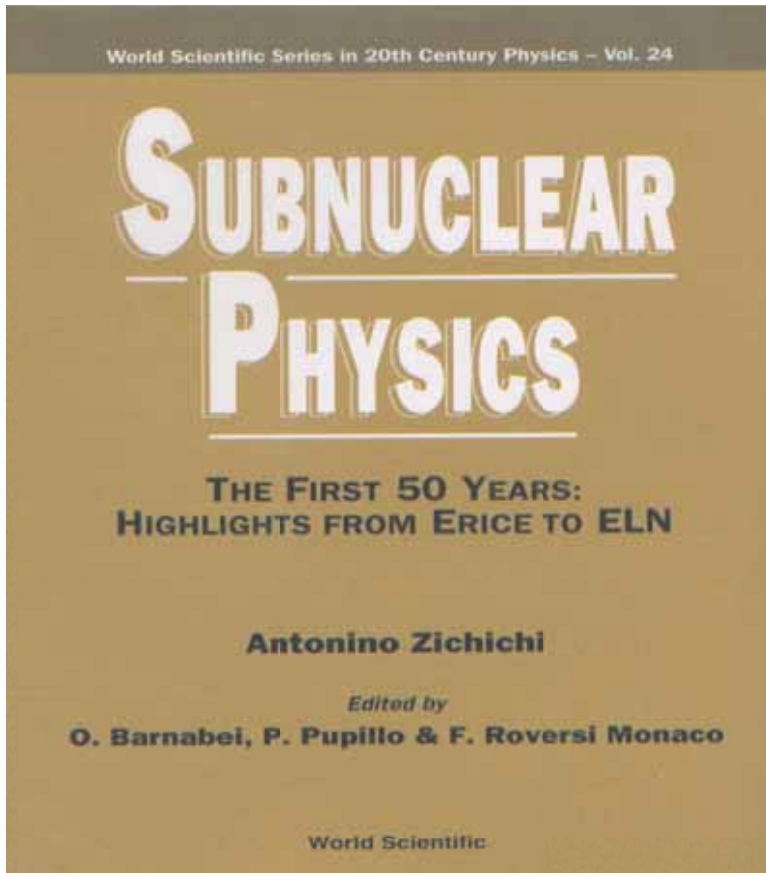
In other words, protons and neutrons behave like Beethoven: they interact and build up nuclear physics without 'knowing' the laws governing QCD.

The most recent example of an Anderson-Feynman-Beethoven-type phenomenon: *apparently the World could not care less about the existence of the Superworld*.

APPENDIX II

UEEC EVENTS, FROM GALILEI UP TO SM&B

In figure 11 there is a sequence of *UEEC* events from Galilei to Fermi-Dirac and the 'strange particles'. This figure has already been reported in chapter 8 and it is here for the convenience of the reader. In figures 21, 22, 23 there is the sequence of *UEEC* from Fermi-Dirac to the construction of the Standard Model. These figures (21, 22, 23) cover the first fifty years of Subnuclear Physics, whose detailed description can be found in my book whose front cover is reproduced here. In figure 24 there is a synthesis of the UEEC events in what we now call the Standard Model and Beyond (*SM&B*).

|	**"UEEC"** **TOTALLY UNEXPECTED DISCOVERIES** **FROM GALILEI TO FERMI-DIRAC, THE "STRANGE" PARTICLES** **AND THE YUKAWA GOLDMINE**
I	Galileo Galilei: F = mg .
II	Newton: $F = G\dfrac{m_1 \cdot m_2}{R_{12}^2}$
III	Maxwell: the unification of electricity, magnetism and optical phenomena, which allows to conclude that light is a vibration of the EM field.
IV	Becquerell: radioactivity.
V	Planck: $h \neq 0$.
VI	Lorentz: space and time cannot both be real.
VII	Einstein: the existence of time-like and space-like worlds. Only in the time-like world, simultaneity does not change, with changing observer.
VIII	Rutherford: the nucleus.
IX	Hess: cosmic rays.
X	Dirac discovers his equation, which opens new horizons, including the existence of the antiworld.
XI	Fermi: weak forces.
XII	Fermi–Dirac and Bose–Einstein discover two completely different statistical laws.
XIII	The "strange particles" are discovered in the Blackett Lab.
XIV	The Yukawa goldmine.

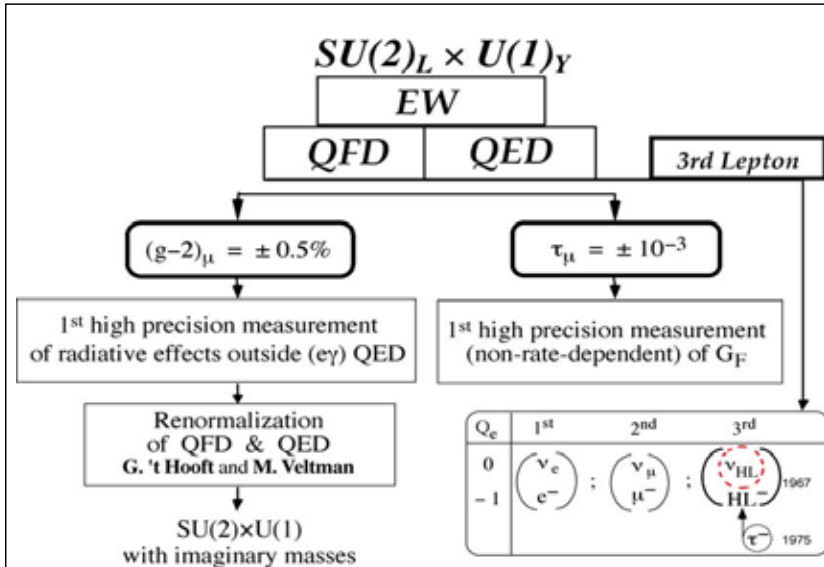Figure 11 (from page 128).
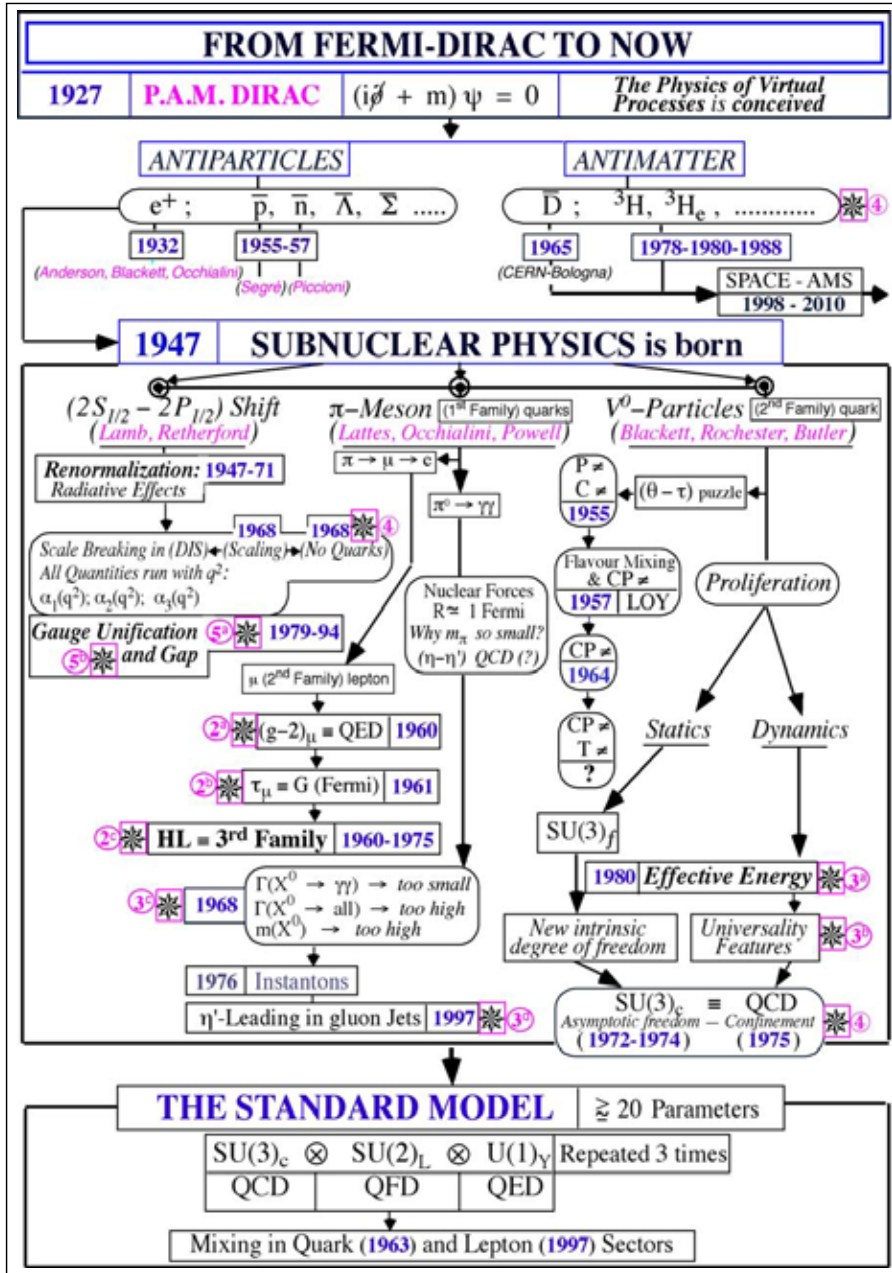
Figure 21.

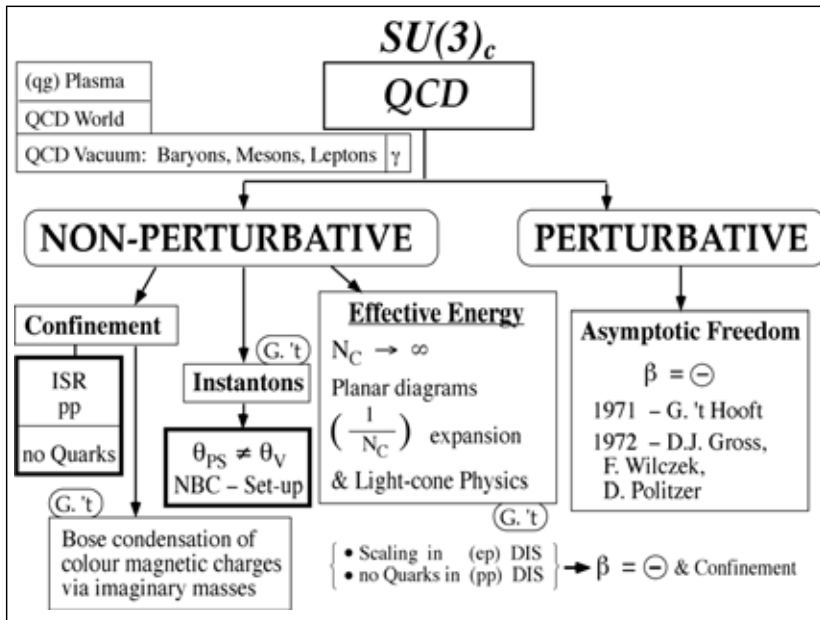Figure 22. Details from figure 21, concerning $SU(2)_L$ and $U(1)_Y$.

Figure 23. Details from figure 21, concerning $SU(3)_c$.

SM&B

THE STANDARD MODEL AND BEYOND

①   RGEs $(\alpha_i \,(i = 1, 2, 3);\ m_j \,(j = q,\ l,\ G,\ H))$; $f\,(k^2)$.
- GUT $(\alpha_{GUT} = 1/24)$ & GAP $(10^{16} - 10^{18})$ GeV.
- SUSY (to stabilize $m_F/m_P = 10^{-17}$).
- RQST (to quantize Gravity).

②   Gauge Principle (hidden and expanded dimensions).
— How a Fundamental Force is generated: SU(3); SU(2); U(1) and Gravity.

③   The Physics of Imaginary Masses: SSB.
— The Imaginary Mass in SU(2)×U(1) produces masses ($m_{W^\pm}$; m_{Z^0}; m_q; m_l), including $m_\gamma = 0$.
— The Imaginary Mass in SU(5) $\Rightarrow$ SU(3)×SU(2)×U(1) or in any higher (not containing U(1)) Symmetry Group $\Rightarrow$ SU(3)×SU(2)×U(1) produces Monopoles.
— The Imaginary Mass in SU(3)$_c$ generates Confinement.

④   Flavour Mixings & CP $\neq$, T $\neq$.
— No need for it but it is there.

⑤   Anomalies & Instantons.
— Basic Features of all Non-Abelian Forces.

Note: q = quark and squark; m_F = Fermi mass scale;
        l = lepton and slepton; m_P = Planck mass scale;
       G = Gauge boson and Gaugino; k = quadrimomentum;
       H = Higgs and Shiggs;   C = Charge Conjugation;
   RGEs = Renormalization Group Equations;   P = Parity;
   GUT = Grand Unified Theory;   T = Time Reversal;
  SUSY = Supersymmetry; $\neq$ = Breakdown of Symmetry Operators.
  RQST = Relativistic Quantum String Theory;
   SSB = Spontaneous Symmetry Breaking.

The five basic steps in our understanding of nature. ① The renormalization group equations (RGEs) imply that the gauge couplings (α_i) and the masses (m_j) all run with k^2. It is this running which allows GUT, suggests SUSY and produces the need for a non point-like description (RQST) of physics processes, thus opening the way to quantize gravity. ② All forces originate in the same way: the gauge principle. ③ Imaginary masses play a central role in describing nature. ④ The mass-eigenstates are mixed when the Fermi forces come in. ⑤ The Abelian force QED has lost its role of being the guide for all fundamental forces. The non-Abelian gauge forces dominate and have features which are not present in QED.

Figure 24.

Let me devote some attention to the discussion of UEEC events in nuclear physics.

Nuclear Physics and UEEC events

It is considered standard wisdom that nuclear physics is based on perfectly sound theoretical predictions. People forget the impressive series of UEEC events discovered in what I have decided to call the 'Yukawa goldmine' [6].

Let me quote just three of them:

1 The first experimental evidence for a cosmic ray particle believed to be the Yukawa meson was a lepton: the muon.

2 The decay-chain: $\pi \rightarrow \mu \rightarrow e$ was found to break the symmetry laws of Parity and Charge Conjugation.

3 The intrinsic structure of the Yukawa particle was found to be governed by a new fundamental force of Nature, Quantum Chromo Dynamics: QCD.

As you know 2007 was the centenary of the birth of Hideki Yukawa, the father of theoretical nuclear physics. In 1935 the existence of a particle, with mass intermediate (this is the origin of 'mesotron' now 'meson') between the light electron, m_e, and the heavy nucleon (proton or neutron), m_N, was proposed by Yukawa [7].

This intermediate mass value was deduced by Yukawa from the range of the nuclear forces. Contrary to the general wisdom of the time, Yukawa was convinced that the particles known (electrons, protons, neutrons and photons), could not explain how protons and neutrons are bound into the extremely small dimensions of a nucleus.

In order to make this 'prediction', Yukawa needed the Heisenberg uncertainty principle: a totally unexpected theoretical discovery. The origin of it was the totally unexpected discovery of the dual nature of the electron (wave and particle) and of the photon (wave and particle). Heisenberg himself tried to explain the binding forces between the proton and the neutron, via the exchange of electrons, in order not to postulate the existence of a new particle. The very light electron, m_e, could not stay in the very small dimension of the nucleus.

The author of the uncertainty principle and father, with Dirac and Pauli, of Quantum Mechanics, did not realise this contradiction. The need for a new 'particle' was the reason. What no one was able to predict is the 'goldmine' hidden in the production, decay and intrinsic structure of this new 'particle'. This 'goldmine' is still being explored nowadays and its present frontier is the Quark-Gluon-Coloured-World (QGCW) [8].

I have recently described [6] the unexpected conceptual developments coming from the study of the production, the decay and the intrinsic structure of the Yukawa particle.

Let me just quote the most relevant UEEC events: chirality–invariance, spontaneous symmetry breaking, symmetry breaking of fundamental invariance laws (P, C, T), anomalies, and 'anomaly-free condition', existence of a third family of fundamental fermions, gauge principle for non-Abelian forces, instantons and existence of a pseudoscalar particle made of the quanta of a new fundamental force of Nature acting between the constituents of the Yukawa particle.

The *SM&B* is the greatest synthesis of all times in the study of the fundamental phenomena governing the Universe in all its structures. The basic achievements of the *SM&B* have been obtained via UEEC events; moreover the *SM&B* could not care less about the existence of Platonic Simplicity. An example is shown in figure 25 where the straight line (small dots) would be the Platonic simple solution towards the Unification of all Fundamental Forces.

The points have a sequence of 100 GeV in energy. The last point where the "ideal" platonic straight line intercepts the theoretical prediction is at the energy of the Grand Unification. This corresponds to $E_{GU} = 10^{16.2}$ GeV. Other detailed information on the theoretical inputs: the number of fermionic families, N_F, is 3; the number of Higgs particles, N_H, is 2. The input values of the gauge couplings at the Z^0-mass is $\alpha_3 (M_Z) = 0.118 \pm 0.008$; the other input is the ratio of weak and electromagnetic couplings also measured at the Z^0-mass value: $\sin^2 \theta_W (M_Z) = 0.2334 \pm 0.0008$.
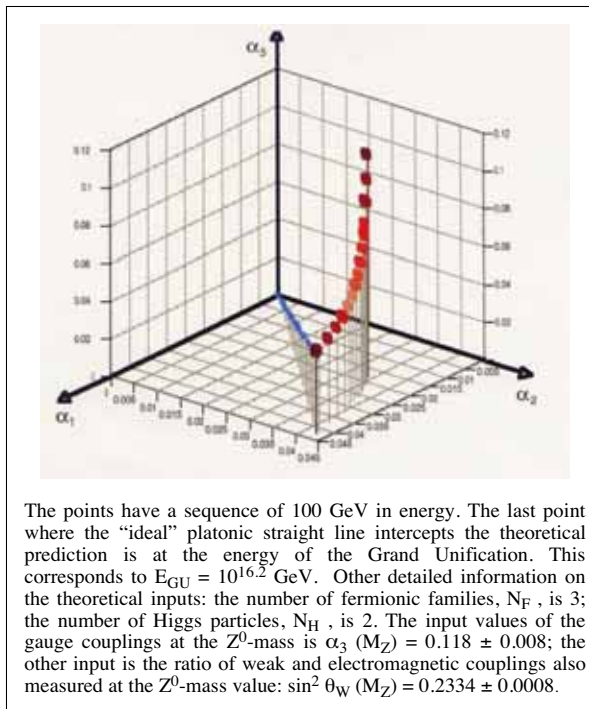
Figure 25.

Nevertheless the effective unification is expected to be along the sequence of points (the big ones) computed using the Renormalization Group Equations (*RGEs*) [9].

APPENDIX III

EXAMPLES OF UEEC EVENTS IN THE CONSTRUCTION
OF THE STANDARD MODEL AND BEYOND: A PERSONAL EXPERIENCE

There are many *UEEC* events in the construction of the Standard Model and Beyond (*SM&B*). In some of them I have been directly involved. They are summarized in figure 26.

Each *UEEC* event (except the last one) is coupled with a *despite*, in order to emphasize the reason why the event is unexpected. The no. 7 event has only the unexpected details.

**UEEC EVENTS
IN THE CONSTRUCTION OF THE
SM&B = MY PERSONAL EXPERIENCE**

① **The 3rd lepton, HL** (now called τ) with its own neutrino, ν_{HL} (now called ν_{τ}),
despite the abundance of neutrinos: ν_e and ν_{μ}.

② **Antimatter**
despite S-matrix and C, P, CP, T breakings.

③ **Nucleon Time-like** EM structure
despite S-matrix

④ **No quarks** in violent (pp) collisions
despite scaling.

⑤ **Meson mixings**
$\theta_V \neq \theta_{PS} : (51^o) \neq (10^o) \neq 0$ *despite* $SU(3)_{uds}$.

⑥ **Effective energy:** the Gribov QCD-light
despite QCD.

⑦ **The running** of $\alpha_1 \ \alpha_2 \ \alpha_3$ versus **energy**:
the EGM effect, the GAP between E_{GUT} and E_{SU}, and the absence of the Platonic straight line convergence.

Figure 26.

Let me explain some of these UEEC events. 1) *Antimatter*: the mass $\neq$ matter problem; 2) *Meson mixings*; 3) *Effective energy*: the Gribov QCD-light; 4) *The running of $\alpha_1 \ \alpha_2 \ \alpha_3$ versus energy*: the gap between the GUT energy and the string unification energy.

APPENDIX III.1

FROM THE ANTIELECTRON TO ANTIMATTER THE MASS ≠ MATTER PROBLEM

Seven decades of totally unexpected discoveries were needed to go from the antielectron to antimatter in order to understand a fundamental property which guarantees our existence: the stability of matter.

The fact that mass and matter had to be two different physical quantities, i.e. the mass ≠ matter problem, started with Einstein's discovery that $E = mc^2$. The symbol 'm' was originally considered to represent 'matter' and thus the famous Einstein equation became the problem of explaining the stability of matter.

The meaning of 'm' had to be different from 'matter'. This is how the distinction between 'matter' and 'mass' came to the forefront of fundamental physics. Einstein proposed to solve the problem mass ≠ matter, saying that matter is coupled with a 'charge', the electromagnetic one. Since this 'charge' is a conserved quantity, matter cannot transform itself into energy. Thus the famous Einstein equation is valid, provided that mass is not coupled with an electric charge, and the stability of matter is granted.

Figure 27 shows the final result of seven decades of experimental and theoretical research work. The solution of the mass ≠ matter problem
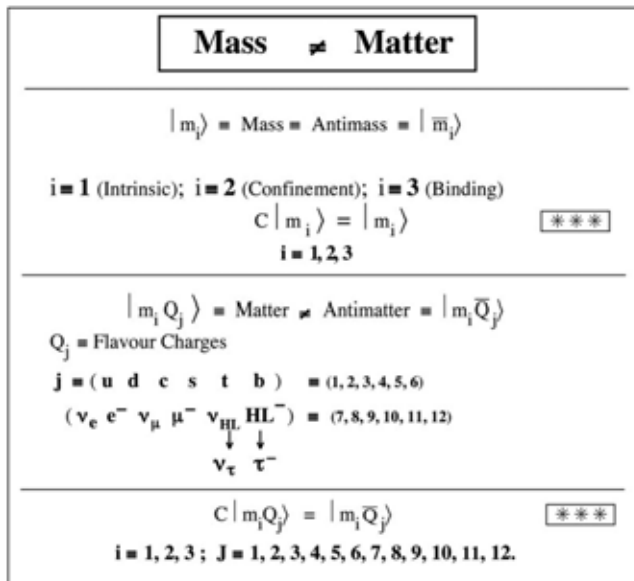

Figure 27.

THE INCREDIBLE SERIES OF UEEC EVENTS
NEEDED TO EXPLAIN THE STABILITY OF MATTER
*SEVEN DECADES: FROM THE ANTIELECTRON TO ANTIMATTER
AND THE UNIFICATION OF ALL GAUGE FORCES*

- **The validity of C invariance from 1927 to 1957.**
  After the discovery by Thomson in 1897 of the first example of an elementary particle, the Electron, it took the genius of Dirac to theoretically discover the Antielectron thirty years after Thomson.

1927	→	Dirac equation [10]; the existence of the antielectron is, soon after, theoretically predicted. Only a few years were needed, after Dirac's theoretical discovery, to experimentally confirm (Anderson, Blackett and Occhialini [11]) the existence of the Dirac antielectron.
1930-1957	→	**Discovery of the C operator** [(charge conjugation) H. Weyl and P.A.M. Dirac [12]]; discovery of the P Symmetry Operator [E.P. Wigner, G.C. Wick and A.S. Wightman [13, 14]]; discovery of the T operator (time reversal) [E.P. Wigner, J. Schwinger and J.S. Bell [15, 16, 17, 18]]; discovery of the CPT Symmetry Operator from RQFT (1955-57) [19].
1927-1957	→	Validity of C invariance: e^+ [11]; $\bar{p}$ [20]; $\bar{n}$ [21]; $K_2^0 \to 3\pi$ [22] but see LOY [23].

- **The new era starts: $C \neq$; $P \neq$; $CP \neq$** [*].

1956	→	Lee & Yang $P \neq$; $C \neq$ [24].
1957	→	Before the experimental discovery of $P \neq$ & $C \neq$, Lee, Oehme, Yang (LOY) [23] point out that the existence of the second neutral K-meson, $K_2^0 \to 3\pi$, is proof neither of C invariance nor of CP invariance. Flavour antiflavour mixing does not imply CP invariance.
1957	→	C.S. Wu et al. $P \neq$; $C \neq$ [25]; CP ok [26].
1964	→	$K_2^0 \to 2\pi \equiv K_L$: $CP \neq$ [27].
1947-1967	→	QED divergences & Landau poles.
1950-1970	→	The crisis of RQFT & the triumph of S-matrix theory (i.e. the negation of RQFT).
1965	→	Nuclear antimatter is (experimentally) discovered [28]. See also [29].
1968	→	The discovery [30] at SLAC of Scaling (free quarks inside a nucleon at very high q^2) but in violent (pp) collisions no free quarks at the ISR are experimentally found [31]. Theorists consider Scaling as being evidence for RQFT not to be able to describe the Physics of Strong Interactions. The only exception is G. 't Hooft who discovers in 1971 that the β-function has negative sign for non-Abelian theories [32].
1971-1973	→	$\beta = -$; 't Hooft; Politzer; Gross & Wilczek. The discovery of **non-Abelian** gauge theories. Asymptotic freedom in the interaction between quarks and gluons [32].
1974	→	All gauge couplings $\alpha_1 \, \alpha_2 \, \alpha_3$ run with q^2 but they do not converge towards a unique point.
1979	→	A.P. & A.Z. point out that the new degree of freedom due to SUSY allows the three couplings $\alpha_1 \, \alpha_2 \, \alpha_3$, **to converge towards a unique point** [33].
1980	→	QCD has a 'hidden' side: the multitude of final states for each pair of interacting particles: $(e^+e^-$; $p\bar{p}$; πp; Kp; νp; pp; etc.) The introduction of the Effective Energy allows to discover the Universality properties [34] in the multihadronic final states.
1992	→	All gauge couplings converge towards a unique point at the gauge unification energy: $E_{GU} \simeq 10^{16}$ GeV with $\alpha_{GU} \simeq 1/24$ [35, 36] .
1994	→	The Gap [9] between E_{GU} & the String Unification Energy; $E_{SU} \simeq E_{Planck}$.
1995	→	**CPT loses its foundations at the Planck scale (T.D. Lee)** [37].
1995-1999	→	**No CPT theorem from M-theory (B. Greene)** [38].
1995-2000	→	A.Z. points out the need for new experiments to establish if matter-antimatter symmetry or asymmetry are at work.

(*)   The symbol $\neq$ stands for 'Symmetry Breakdown'.

Figure 28.

proved to be very different from what Einstein had in mind. There are three classes of 'masses': intrinsic, confinement and binding. There are 12 'flavour' charges to distinguish 'matter'

from 'mass'. These 'flavour charges' are the basic quantities which guarantee the stability of matter.

The incredible series of UEEC events needed to discover the origin of the fundamental forces and of the stability of matter is described in figure 28.

During these seven decades it has been discovered that the same word 'charge' corresponds to two basic properties of Nature. This is why the word 'charge' has been coupled with another term, either 'gauge' or 'flavour'. The 'gauge charge', in recent times also called 'colour charge', generates a Fundamental Force of Nature, while the 'flavour charge' is responsible for the stability of matter.

APPENDIX III.2

MESON MIXINGS THE PSEUDOSCALAR AND VECTOR MESONIC MIXINGS

The problem started when experimental physics was dominated by bubble chambers and the 'mixing' was determined using mass-formulae: i.e. a tautology. I designed and built a non-bubble-chamber detector, NBC; it consisted of an original neutron missing mass spectrometer coupled with a powerful electromagnetic detector which allowed to clearly identify all final states of the decaying mesons into (e^+e^-) or $(\gamma\gamma)$ pairs. The mass of the meson (be it pseudoscalar or vector) was measured by the neutron missing mass spectrometer. The two 'mixing angles', the pseudoscalar θ_{PS} and the vector θ_V, were directly measured (without using the masses) to be, not as expected by SU(3)$_{uds}$, i.e. $\theta_{PS}=\theta_V=0$, but, $\theta_{PS}\neq0$, $\theta_V\neq0$ and totally different $\theta_{PS}\neq\theta_V$. Many years were needed and Gerard 't Hooft instantons to explain why $\theta_{PS}\simeq10°$ and $\theta_V\simeq51°$.
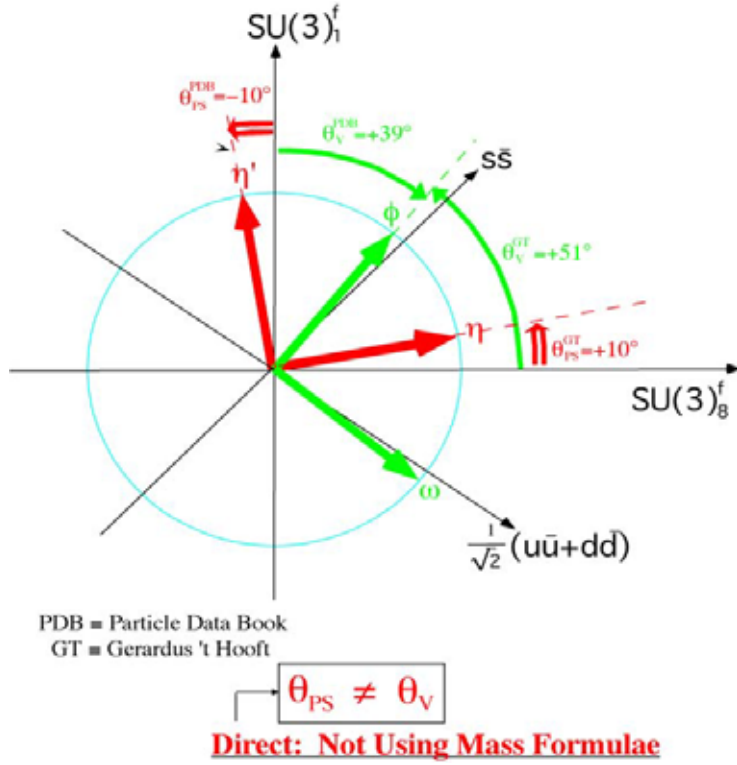
Figure 29.

APPENDIX III.3

EFFECTIVE ENERGY THE GRIBOV QCD LIGHT

When the physics of strong interactions finally became the physics of quarks and gluons, QCD had a problem, defined by Gribov as being its 'hidden QCD side': i.e., the large number of different final states produced by different pairs of interacting particles, such as (πp, pp, pp, Kp, e$^+$e$^-$, p, μp, ep, etc.). I did not limit myself to suggesting that a totally different approach was needed to put all these final states on the same basis. I found what this basis could be and this is how the 'Effective Energy' became the correct quantity to be measured in each interaction.

The 'Effective Energy' was not predicted by QCD. To perform this study, it was necessary to analyze tens of thousands of (pp) interactions at the ISR. This was done despite all the difficulties to overcome. And this is how what Vladimir Gribov defined the 'QCD light' was discovered (figures 30 and 31). Gribov pointed out what follows. Newton discovered that QED light is the sum of different colours. In QCD we have quarks and gluons interacting and producing Jets made of many pions, as for example in the (pp) reaction

$$pp \to \pi + X$$

whose spectrum is shown in figure 30. The horizontal axis is for the fractional energy of the pion (also called Feynman x), while the vertical axis is for the number of pions having fractional energy x_F. The spectrum in figure 30 is the sum ($\sum$) of all spectra shown if figure 31 where each one corresponds to a single value of the 'Effective Energy' (defined in terms of $2E_{had}$).

$$p\text{-}p \to \pi^+ + X$$
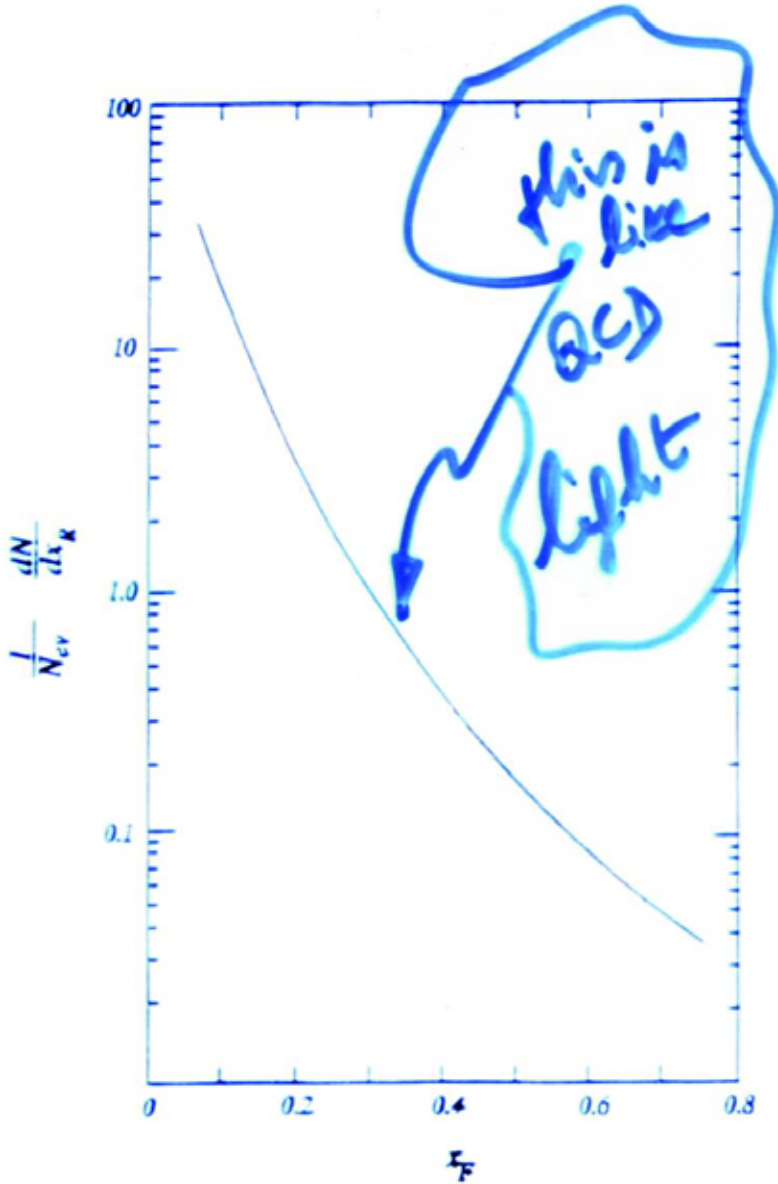$$\text{Nominal Energy of the (pp) collision} = \sqrt{s} = 24 \ GeV$$
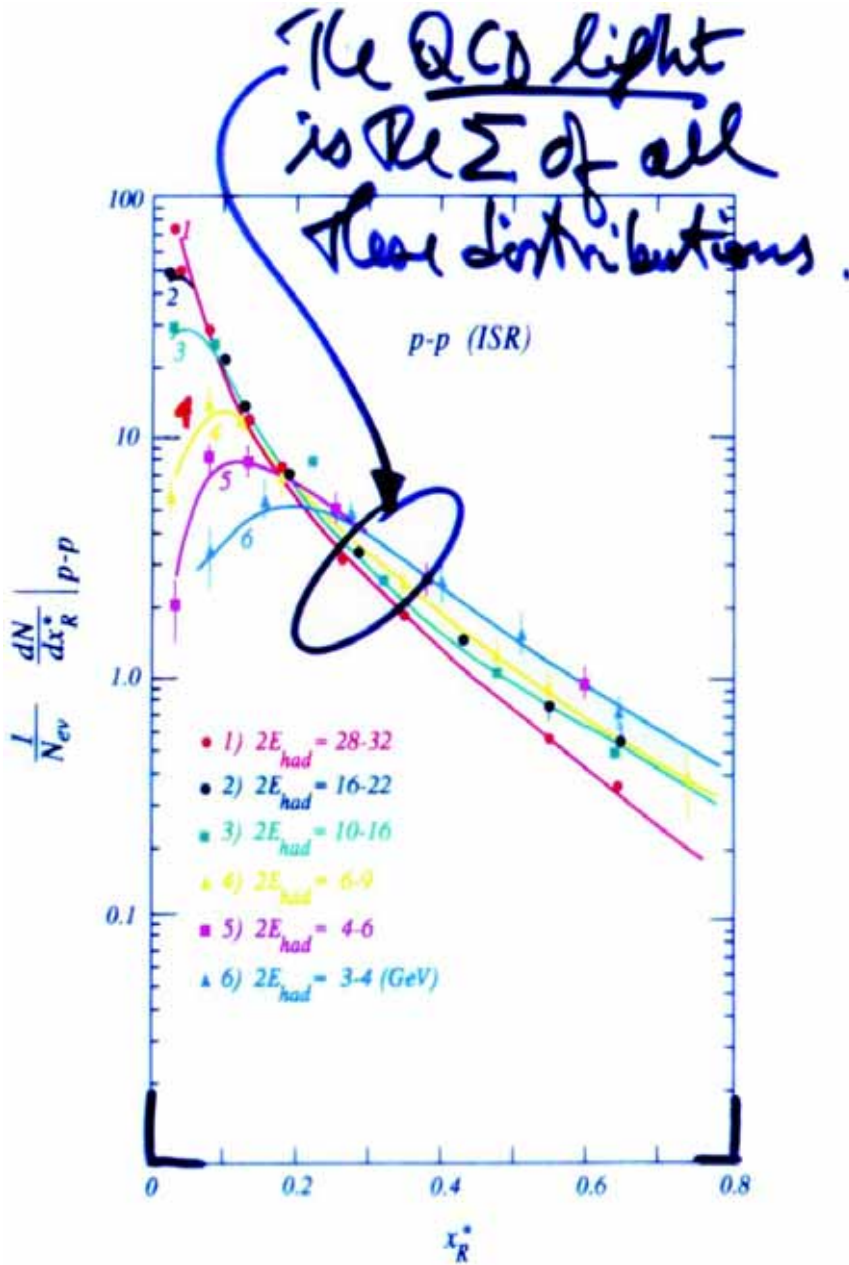

Figure 30.

Figure 31.

APPENDIX III.4

THE RUNNING OF (α_1 α_2 α_3) VERSUS ENERGY THE GAP BETWEEN E_{GUT} AND E_{SU}

The exact use of the Renormalization Group Equations, RGEs, for the running of the three gauge couplings (α_1 α_2 α_3) has given many interesting results. One of these is the existence of a gap between the energy E_{GUT} where the three gauge couplings converge and the String Unification Energy E_{SU}.

The value of E_{GUT} is two powers of ten below E_{SU}. This is shown in figure 7 (which is the same as figure 7 of chapter 6).

The details which refer to the Gap between E_{GUT}, E_{SU} and E_{Planck} are shown in figure 32.

The lines are the result of calculations executed with a supercomputer using a system of three weakly coupled differential non-linear equations:

$$\mu \frac{d\alpha_i}{d\mu} = \frac{b_i}{2\pi} \alpha_i^2 + \sum_j \frac{bij}{8\pi^2} \alpha_j \alpha_i^2$$

describing the evolution of all phenomena including the superworld, from the maximum level of energy, E_{GUT}, to our world at the minimum of energy.
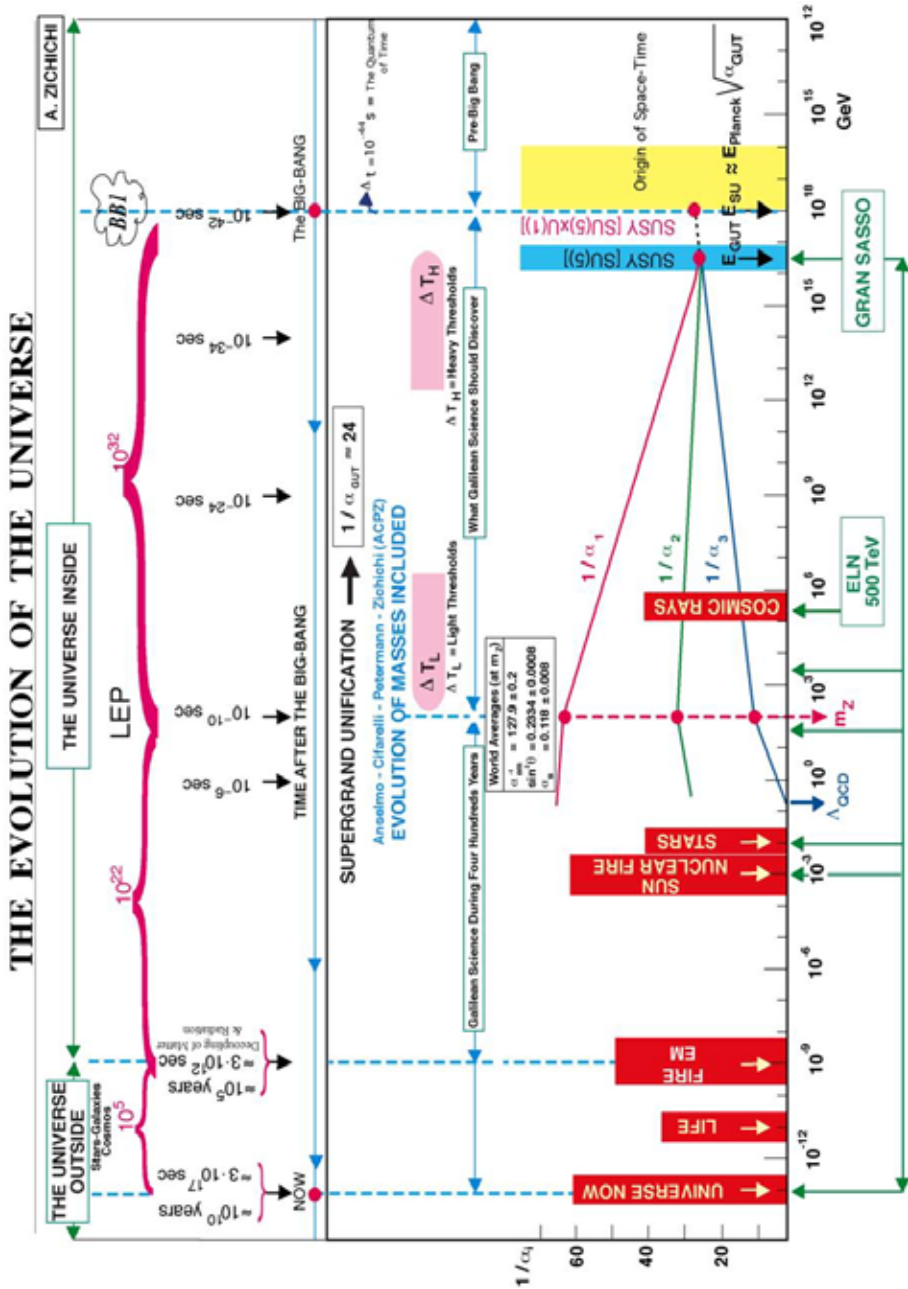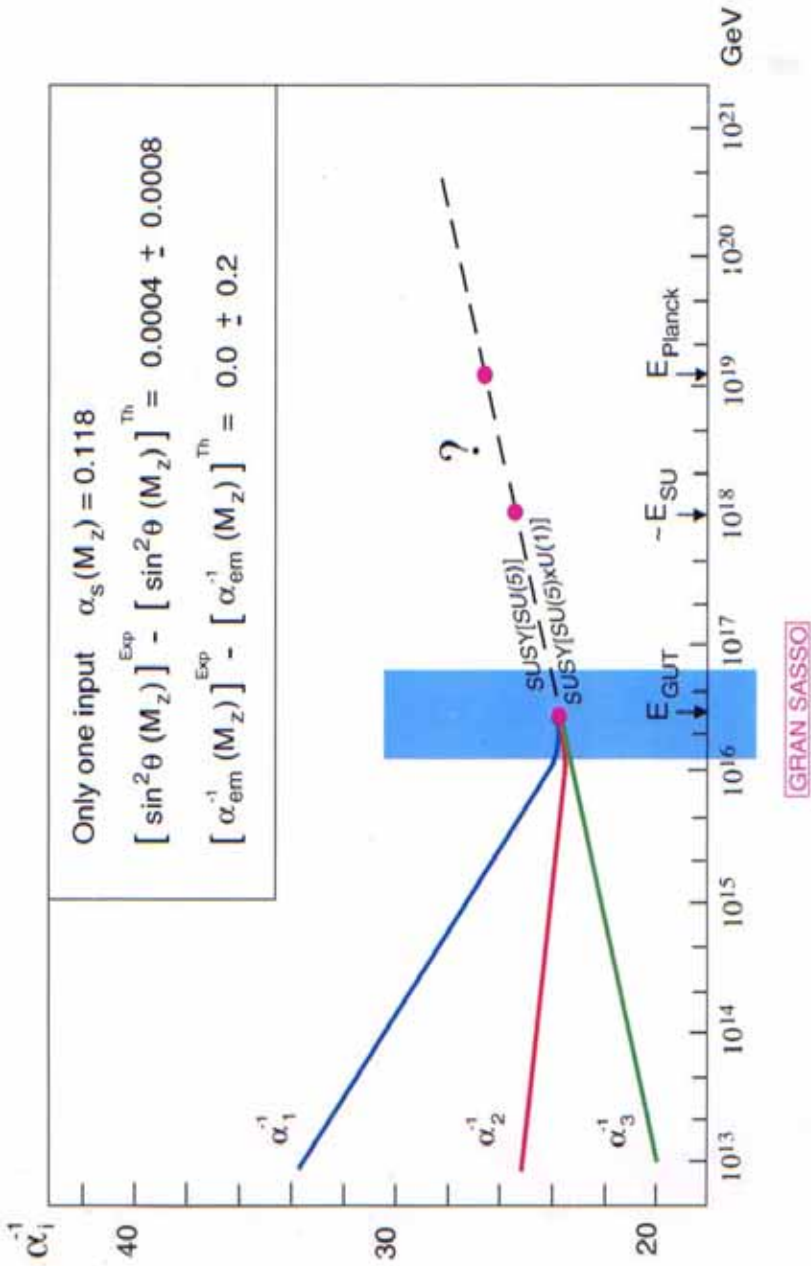
Figure 7 (from p. 120).

Figure 32.

APPENDIX IV

THE PLATONIC GRAND UNIFICATION

Let us look at figure 25 from Appendix II again, since this is the best example of Platonic Grand Unification. The points have a sequence of 100 GeV in energy. The last point where the 'ideal' platonic straight line intercepts the theoretical prediction is at the energy of the Grand Unification. This corresponds to $E_{GUT} = 10^{16.2}$ GeV. Other detailed information on the theoretical inputs: the number of fermionic families, N_F, is 3; the number of Higgs particles, N_H, is 2. The input values of the gauge couplings at the Z^0-mass is α_3 $(M_Z) = 0.118 \pm 0.008$; the other input is the ratio of weak and electromagnetic couplings also measured at the Z^0-mass value: $\sin^2 \theta_W (M_Z) = 0.2334 \pm 0.0008$.

The Platonic Grand Unification should be along the straight line, small dots (blue), but Nature seems to follow the big dots (red).
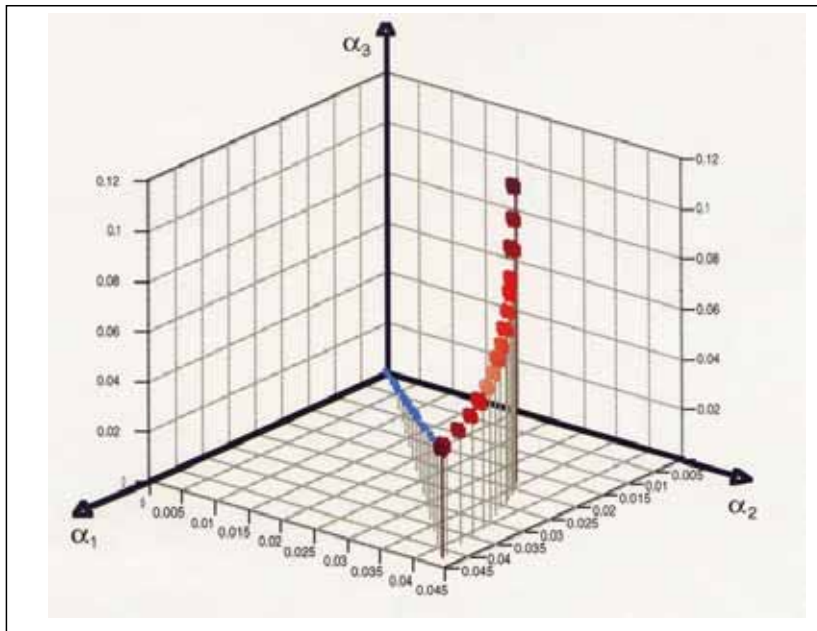
Figure 25 (from p. 146).

APPENDIX V

THE PLATONIC SUPERSYMMETRY

THE PLATONIC CONCEPT OF SUPERSYMMETRY

The **Gauge Principle** should generate a
Gauge Force ⟶ **Gauge Bosons**
If *NATURE* was platonically *SUPERSYMMETRIC*
Supersymmetry Transformation should generate **Gauginos**

1st **DEVIATION FROM PLATONIC SIMPLICITY**
OUR FERMIONS ARE NOT THE GAUGINOS

2nd **DEVIATION FROM PLATONIC SIMPLICITY**
*THE FUNDAMENTAL FERMIONS ARE OF TWO
DIFFERENT CLASSES: LEPTONS AND QUARKS*

3rd **DEVIATION FROM PLATONIC SIMPLICITY**
*THERE IS NOT ONLY ONE BUT THREE FAMILIES
OF FUNDAMENTAL FERMIONS*

4th **DEVIATION FROM PLATONIC SIMPLICITY**
*THE FUNDAMENTAL FERMIONS BECOME MIXED WHEN THE
WEAK FORCES ARE SWITCHED ON: MIXINGS EXIST*

5th **DEVIATION FROM PLATONIC SIMPLICITY**
THERE ARE DIFFERENT MIXINGS
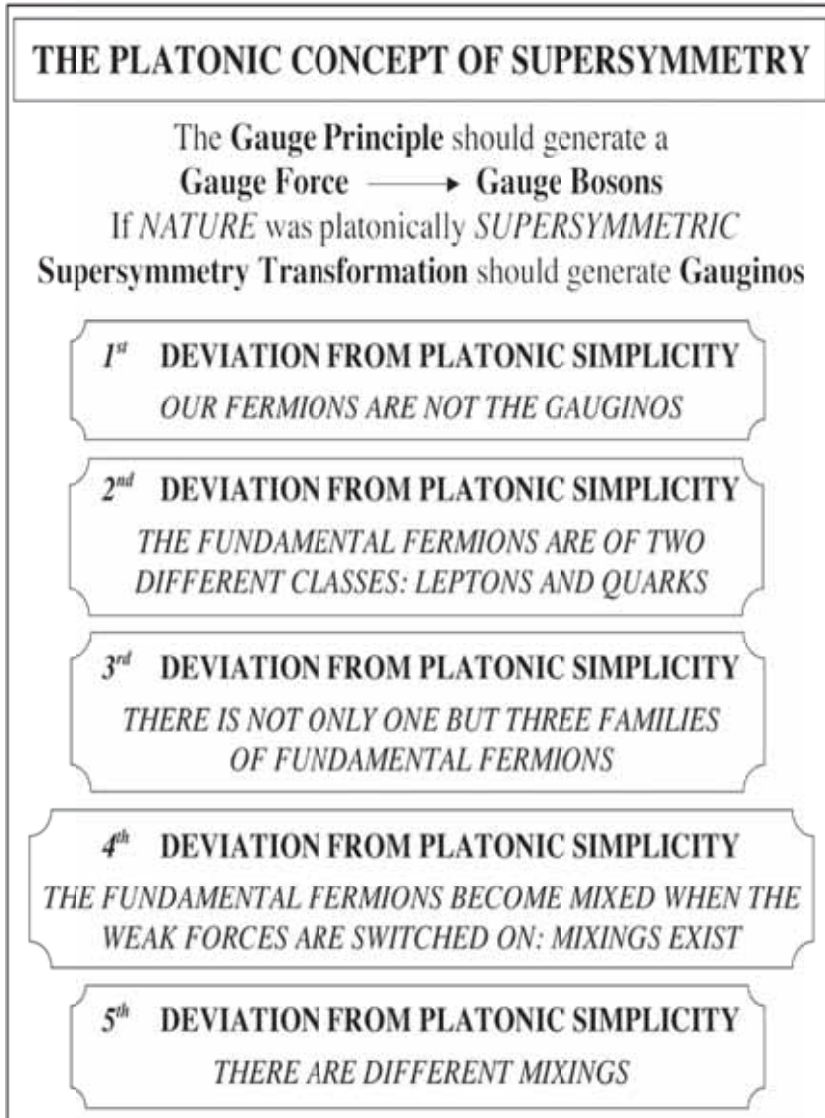
Figure 33.

APPENDIX VI

SEVEN DEFINITIONS OF COMPLEXITY

People speak of 'Complexity' as a source of new insights in physics, biology, geology, cosmology, social sciences, evolution of the human species and in all intellectual activities which look at the world through the lens of a standard analysis in terms of either Simplicity or Complexity. *But* 'Complexity' is ill-defined, as shown by the existence of at least seven definitions of Complexity.

Definition Number 1

Complexity is a property of systems that are somewhere in between a completely random and a completely regular state, often described by a highly non linear set of equations but sometimes not describable by equations at all.

Definition Number 2

Bad ones:
1) Chaos.
2) The need for lengthy calculations.
3) The need for many distinct variables.
Better ones:
4) Unexpected difficulty when attempting to describe something in a precisely formulated theory.
5) What is left over after all systematic approaches failed.
But it could also be that: Complexity is an excuse for sloppy thinking.

Definition Number 3

The Complexity of a theory (problem) is the minimum amount of computer time and storage required to simulate (solve) it to a specified level of precision.

Definition Number 4

If we admit that biological or linguistic evolution, or financial dynamics are complex phenomena, then their typical dynamics are somehow between strong chaos (i.e. positive Lyapunov exponents) and simple orbits (i.e. negative Lyapunov exponents). In other words, Complexity (or at least some form of it) is deeply related to the edge of chaos (i.e. vanishing maximal Lyapunov exponent). Since the edge of chaos appears to be related paradigmatically to an entropy index 'q' different from unity, there must be some deep connection between Complexity and generalized entropies such as 'Sq'.

Definition Number 5

From the mathematical point of view:
- A problem can be polynomial, which means that it is not to hard to predict surprises.
- A problem can be NP or NP-complete, which represent different degrees of difficulty in predicting surprises.
- • Surprises means: UEEC event (see later).
- • That degree of difficulty can be associated with the level of Complexity.

Definition Number 6

A system is 'complex' when it is no longer useful to describe it in terms of its fundamental constituents.

Definition Number 7

The simplest definition of Complexity: '*Complexity is the opposite of Simplicity*'. This is why we have studied the platonic Grand Unification (Appendix IV) and its extension to the platonic Superworld (Appendix V), in order to show that Nature does not follow Platonic Simplicity.

APPENDIX VII

THE BASIC POINTS ON THE CORRELATION BETWEEN PREDICTIONS AND UEEC

It is often stated that scientific predictions are the most advanced frontiers of our exact knowledge.

It is therefore necessary to clearly establish the relation which exists between scientific predictions and progress at the frontier of our knowledge which, as we have emphasized on several occasions, is based on UEEC events.

It is also necessary to clarify the experimental evidence for the existence of predictions and how predictions are correlated with UEEC. *Predictions*.

The experimental evidence for the *existence* of *predictions* is the result of many scientific reproducible experiments.

Quantum ElectroDynamics, QED, is the best example. The anomalous magnetic moments, in symbols (g–2), of the electron (e) and of the muon (μ):

$$(g–2)_{e,\,\mu}$$

are theoretically computed at an extraordinary level of precision (few parts in ten billion parts for the electron) and are experimentally verified to be correct. Could the

$$(g–2)_{e,\,\mu}$$

be theoretically predicted before the discovery of the Maxwell equations and the existence of Quantum ElectroDynamics (QED)? The answer is obviously no.

The sequence which correlates UEEC events and predictions is very clear.

Predictions at the *fundamental level of scientific knowledge* depend on *UEEC events*.

For example: it is the discovery of the laws governing electric, magnetic and optical phenomena (all totally unpredicted) which produced the mathematical structure called QED.

The mathematical structure was not discovered before the innumerable series of UEEC events was found in electricity, magnetism and optics. This series of UEEC events allowed Maxwell to express 200 years of experimental discoveries in a set of 4 equations.

Mathematical formalism comes *after* a totally unexpected discovery: an *UEEC event* which no one was able *to predict*.

In the whole of our knowledge rigorous predictions exist only in Science. These predictions are based on the mathematical description of a single UEEC event or a series of UEEC events. This description can either be the result of new mathematics (for example the Dirac δ-function) or the use of existing mathematical formalism (example: Einstein's use of the Ricci tensor calculus). The UEEC event at the origin of the Dirac equation is the fact that the electron was not a 'scalar' particle but a spin ½ object.

The UEEC events at the origin of Einstein's mathematical formulation of the gravitational forces are the discoveries of Galilei (F = mg), of

$$\text{Newton } \left(F = G \frac{m_1 \cdot m_2}{R_{12}^2} \right),$$

and of Lorentz that Space and Time could not be both real and that all electromagnetic phenomena obeyed a new invariance law, now called Lorentz-invariance. These are just two examples of the fact that the greatest steps in the *progress of Science* come from totally unpredicted discoveries. It is the mathematical formulation of these discoveries which allows predictions to be made. Once made, these predictions need experimental checks.

Even when we have a mathematical formalism coming from a series of UEEC events, if this formalism opens a new frontier, as it is in the case for the Superworld, experimental proof is needed to verify the validity of the new theoretical frontier.

Today we have a reasonable mathematical formalism to describe the *Superworld*, but in order to know if the Superworld exists we need, as pointed out in previous chapters, the experimentally reproducible proof of its existence. And it could be that, while searching for the Superworld, a totally unexpected discovery (UEEC) is found. This is the reason why we need to perform experiments, as Galileo Galilei realized 400 years ago.

APPENDIX VIII

The Ten Challenges in the Evolution of Our Understanding the Basic Hardware of All Forms of Matter

Here is the list

1. Non-perturbative QCD.
2. Anomalies and Instantons.
3. The Physics of NSSB (non-Spontaneous Symmetry Breaking: CP≠,T≠, CPT≠ [4] Matter-Antimatter Symmetry).
4. The Physics of Imaginary Masses: SSB (part of this is the Higgs particle/particles).
5. The Physics of 43 dimensions (part of this is Supersymmetry).
6. Flavour mixing in the quark sector.
7. Flavour mixing in the leptonic sector.
8. The problem of the missing mass in the Universe.
9. The problem of Hierarchy.
10. Physics at the Planck scale and the number of expanded dimensions. Here the most interesting consequence would be that, given the best value for an expanded dimension, it could be that the E_{GUT} scale goes down to the range of the Fermi scale, as illustrated in figure 13 of chapter 9.

---

[4] The symbol ≠ means that a Symmetry law is non spontaneously broken as it happens with C, P, CP and T). [C (charge conjugation, i.e. interchange of charges with anti-charges); P (parity, i.e. interchange of left and right); T (inversion of the arrow of Time)].The products CP and CPT mean the simultaneous Symmetry laws for all operations CP and CPT, respectively. The existence of Matter-Antimatter Asymmetry would be a proof of CPT ≠ .

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[30] The first report on 'scaling' was presented by J.I. Friedman at the 14th International Conference on *High Energy Physics* in Vienna, 28 August-5 September 1968. The report was presented as paper n. 563 but not published in the Conference Proceedings. It was published as a SLAC preprint. The SLAC data on scaling were included in the Panofsky general report to the Conference where he says '...the apparent success of the parametrization of the cross-sections in the variable ν/q^2 in addition to the large cross-section itself is at least indicative that point-like interactions are becoming involved'. W.K.H. Panofsky, Low q^2 Electrodynamics, Elastic and Inelastic Electron(and Muon) Scattering', *Proceedings of 14th International Conference on High Energy Physics*, Vienna 1968, J. Prentki and J. Steinberger (eds.), p. 23, published by CERN (1968). The following physicists participated in the inelastic electron scattering experiments: W.B. Atwood, E. Bloom, A. Bodek, M. Breidenbach, G. Buschhorn, R. Cottrell, D. Coward, H. DeStaebler, R. Ditzler, J. Drees, J. Elias, G. Hartmann, C. Jordan, M. Mestayer, G. Miller, L. Mo, H. Piel, J. Poucher, C. Prescott, M. Riordan, L. Rochester, D. Sherden, M. Sogard, S. Stein, D. Trines, and R. Verdier. For additional acknowledgements see J.I. Friedman, H.W. Kendall and R.E. Taylor, Deep Inelastic Scattering: Acknowledgements, *Les Prix Nobel 1990*, Almqvist and Wiksell, Stockholm/Uppsala (1991), also *Rev. Mod. Phys.* 63, 629 (1991). For a detailed reconstruc-

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[33]   A. Zichichi, New Developments in Elementary Particle Physics, *Nuovo Cimento*, 2, n. 14, 1 (1979). The statement on p. 2 of this paper, '*Unification of all forces needs first a Supersymmetry. This can be broken later, thus generating the sequence of the various forces of nature as we observe them*', was based on a work by A. Petermann and A. Zichichi in which the renormalization group running of the couplings using supersymmetry was studied with the result that the convergence of the three couplings improved. This work was not published, but perhaps known to a few. The statement quoted is the first instance in which it was pointed out that supersymmetry might play an important role in the convergence of the gauge couplings. In fact, the convergence of three straight lines ($\alpha_1^{-1}\alpha_2^{-1}\alpha_3^{-1}$) with a change in slope is guaranteed by the Euclidean geometry, as long as the point where the slope changes is tuned appropriately. What is incorrect about the convergence of the couplings is that, with the initial conditions given by the LEP results, the change in slope needs to be at $M_{SUSY} \sim 1$ TeV as claimed by some authors not aware in 1991 of what was known in 1979 to A. Petermann and A. Zichichi.

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