

**To where has Modern Science led us in
“Our Quest for Ultimate Reality”**

B V Sreekantan

**NIAS Wednesday Lecture
1 July 2015**

ABSTRACT

The current trend in the 21st century philosophy of science may be summarized as follows (of course, as always, all the scientists and philosophers are not unanimous in this view): There is ONE basic substratum from which the entire Universe with all its contents – space, time, matter, energy, field, force, radiations, inanimate matter and animate beings and all actions associated with them, have arisen and continue as a result of “Spontaneous Fluctuations” of the substratum which is currently identified as “The Quantum Mechanical Vacuum”. This vacuum as normally envisaged is not the absence of everything, but the potential presence of everything in the form of quantum mechanical waves of energy which at the present time extend all over the universe.

Is not this philosophy in ESSENCE though not in detail, the same as the insights from ancient Eastern and Western philosophies?

- First of all, I owe an explanation to the experts in English language to the improper English in the title of my lecture.
- They may ask why “to” before “where”, and why no question mark at the end?
- The answers are in my abstract – There is a definite destination in answer to the quest. This is my contention.

Apart from the Bhagavad Gita and the Full works of Swami Vivekananda, the two books that have influenced me most in my long career which have relevance to our discussion to-day most are:

1. “Quest” the first Biography of Einstein by Leopold Infeld, which I bought as a student in 1944
2. “Something called Nothing” by a Russian author Podlony in 1983.
3. Both the books I bought for Rs. Five each!

The topics I am going to cover in this talk are

1. Introduction to the multiple levels of "reality"
Rainbow to Atoms; Classical to Quantum Physics; Atoms to Quarks – constituents of fundamental particles – the Standard Model of Particle Physics – as of 2015
2. The current ideas on the constituents of the Universe
 - *Big Bang to Dark Energy
 - *Reality as a function of Time
 - *How the basic Concepts – Space, Time, Energy, Radiation have undergone change
 - *Role of "Empty Space" – as Quantum Mechanical Vacuum the "Ultimate Reality"
3. The insights from Upanishads – the Four Maha Vakyas – as illustration of some of the philosophical approaches.

"Sarvam khau Idam Brahma"

Science is dynamic. Keeps changing in the light of newer discoveries and intuitions and insights. That is the characteristic and beauty of science.

Reality too has many facets which keep changing. It is certainly not what is seen and what is obvious. Reality is at many levels. Is there an Absolute Reality? Let us wait till the end of the lecture to form an opinion on it.

*Example of Rainbow



Different Realities when we look at a flower	
A (Physicalism)	B (Mentalism)
What happens in the Brain and Its accessories	What happens in the mind
<ul style="list-style-type: none"> • Formation of 'image' of the flower on the retina. 	<ul style="list-style-type: none"> • Distinctive perception and recognition of the flower as a rose.
<ul style="list-style-type: none"> • Activation of rods and cones in the retina's various layers. 	<ul style="list-style-type: none"> • Evokes sense of beauty - Smell of the rose flower
<ul style="list-style-type: none"> • Generation of action potentials - electrical pulses. 	<ul style="list-style-type: none"> • The awareness and recognition: colour of the flower.
<ul style="list-style-type: none"> • Transmission of pulses through axons in neurons. 	<ul style="list-style-type: none"> • The softness and smoothness of petals on touching the same.
<ul style="list-style-type: none"> • Happenings in Synapses and Dendrites 	<ul style="list-style-type: none"> • Appreciation of symmetry, beauty and aroma.
<ul style="list-style-type: none"> • Releases of Neuro-transmitter chemicals at various locations 	<ul style="list-style-type: none"> • Earlier happy associations flood the mind
<ul style="list-style-type: none"> • Activation of Cortices 	<ul style="list-style-type: none"> • Emotions triggered.
<p>Basically:- Electrical Signals oscillations chemicals time sequence.</p>	<p>in various locations</p> <p>The mind is able to gauge the size, distance, shape and other physical characteristics as well.</p>

The first obvious question is "Reality of What?" The answer is simple.

Reality of everything that comes into our experience directly or indirectly – the UNIVERSE.

Our experiences clubbed together, tell us that there are two kinds of worlds:

1. The External World – Common to all of us – 'the Objective World'
2. The Internal World – that is unique and private to each one of us "Subjective World"

Is the objective world really objective – Independent of us?

The scientists proceed on the basis that it is so.

Our present knowledge of the UNIVERSE can be classified as follows

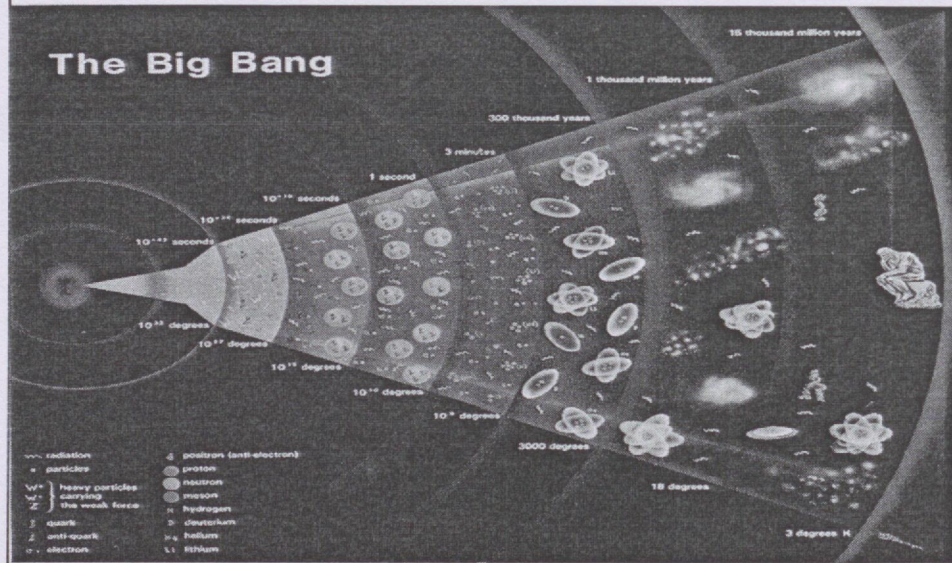
Micro Cosmos	Middle (our level)	Macro Cosmos
(10^{-33} cms- 10^{-8} cms) Molecules, Atoms, Particles, Radiations	10^{-6} – 8 Light minutes Earth and the solar system (Sun + Planets)	(4.3 Light years – 10^{10} Light years)
(High Energy Physics)	<ul style="list-style-type: none"> •Inanimate Matter Elements, Hydrogen to Uranium •Animate Amoeba to Man, DNA, etc. General Science	Stars, Galaxies, Clusters of Galaxies etc. Neutron Stars, Black Holes Expanding, Accelerating Universe, Dark Matter, Dark Energy (Astronomy and Astrophysics)

The Evolution of the Universe

(Big Bang Cosmology Physical – Chemical – Biological – Man)

Note that the entire universe has changed its constituents (capsule of energy) → High Temperature Plasma → Particles → Atoms → Animals. Physical Evolution – Chemical Evolution – Biological Evolution

REALITY OF THE UNIVERSE IS A FUNCTION OF TIME.



Basis of Scientific Explanation

- For any Scientific Explanation at any level, especially at the fundamental level, we need to define first the following parameters:
Space, Time, Matter, Energy, Motion, Force, Medium, Fields, Waves, Electric Charge, Electromagnetic Waves
- The first few concepts are based on common sense, quantified and units defined for enabling measurement, concepts like Mass, Force, Energy are anthropomorphic. Waves are observational. Charge and field are inferential.

Newton's Definition of Space and Time

- Space is an empty (devoid of all matter) container in which objects are put. Space is Absolute and no motion. Same everywhere and does not change with time, Isotropic, homogeneous and three-dimensional.
- Time: The concept comes from succession of events; is continuous and moves in the forward direction (unidirectional). Rate of flow of time is constant and same everywhere, and at all times. Though the concept comes from succession of events, time exists independent of events.
- Without the concept of time we cannot come to any understanding of nature and its laws.
- Space and Time make a rigid frame work on which the world of objects displays its events.

- On the basis of these notions and Newton's laws of Motion and Gravitation, Classical physics got developed and played a major role in explaining many physical phenomena including motion of planets.
- The Corpuscular theory of light proposed by Newton prevailed till the experimentally observed phenomena of interference and diffraction required the wave theory of light as proposed by Huygens and Fresnel. However, the particle aspect was brought back into the picture for the explanation of photoelectric effect by Einstein and later for explaining Compton effect too. This dual nature of light, particle/wave at the same time for the same entity became the starting point of the realization and confirmation of the dual nature of all particles.
- Einstein is reported to have stated toward the end of his life that even after fifty years of his association with it he has not been able to understand what the "photon" is!

The development of the Electromagnetic theory based on Faraday's magnetic induction experiments and Oersted's observation of magnetic deflection of a compass needle when an electric current was passed through a wire in the neighborhood was another major breakthrough in connecting three distinct phenomena: electricity, magnetism and light. In fact this was the first grand unification that was achieved in understanding the intricate realities of nature.

- The Phenomenon of light posed two further problems:

- (i) If light is an electromagnetic wave, then what is it that is waving? (What is the ontology?)

Maxwell tried hard to provide a mechanical explanation by assuming it is the 'ether' that is waving though there was no idea what constituted ether itself!

- (ii) If the ether is there, is it stationary while the earth is moving or is it carried by the earth?

- (iii) The experimental observation of Michelson and Morley showed that the velocity of light is independent of the direction of motion of the earth with report to the source of light. Light does not obey the theorem of addition of velocities as in dynamics.

Relativity which was proposed by Einstein in 1905 to solve these problems changed the concepts of space, time, mass and energy as follows (>1905)

- No Absolute Space
- No Absolute Time
- Space contracts and time elongates at higher and higher velocities
- Reality is in four-dimensional space-time
- What we observe because of our mental limitations is the projection of the four dimensional activity on to 3-dimensional space and one-dimensional time.
- Velocity of light is a constant of Nature and does not change with the motion of the observer or source.

- Energy and Mass are identical with the relation $E=M_0c^2$ where c is the velocity of light and M_0 is the rest mass.
- Relativistic mass has to be added to the rest mass when the particle is moving with velocity $v = \frac{m_0}{\sqrt{1-v^2/c^2}}$

Further, according to General Relativity which Einstein proposed in 1915:

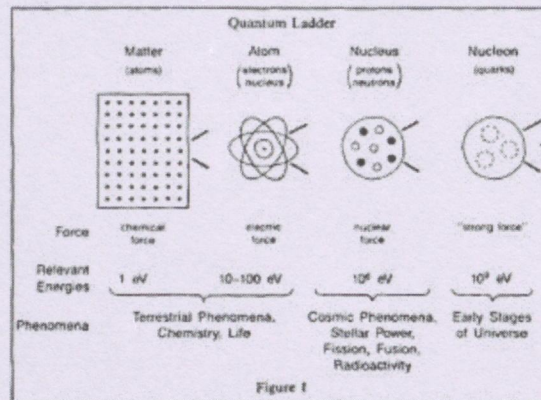
- Gravitational Force is due to curvature of space in higher dimensions.
- Rate of flow of time slows down when space is curved.

- We thus see all the concepts space, time, mass and energy have undergone drastic changes.
- However, these effects are generally very small at low velocities and do not affect our normal observations directly. But, as we shall see, they are important from the point of "reality".

- The Micro-world – Advent of Quantum Mechanics
- Towards the end of the 19th century, the other problems that the electromagnetic radiation (light) from hot bodies had created were
 - (i) the experimentally observed energy distribution as a function of wavelength of emission showed a peak at low wave lengths while the classical theory predicted an increase right upto smallest wave length – uv catastrophe as it was known.
 - (ii) In addition there were discrete spectral lines in the emission characteristic of the chemical nature of the hot body.

- To explain the first feature, Max Planck introduced in 1900, “the quantum hypothesis” according to which energy was emitted in discrete chunks – in multiples of $\hbar\nu$ where ν is the frequency of radiation and \hbar is the Planck constant ($\hbar=h/2\pi$). On the basis of this assumption Planck explained the spectral distribution of the radiation.
- To explain the second feature, Niels Bohr introduced the Bohr Model of the atom according to which the atom existed in discrete energy states only due to the orbital motion of the electrons in quantized orbits and emission of light took place when an electron jumped from an orbit of higher energy to a lower one.

Era of Fundamental Particles (20th Century)



- Discovery of Cosmic Rays
- Elementary Particles – Positron, mu-meson, pi-meson, k-meson, Hyperon
- Strange, charm: new quantum numbers
- Relativity
- Quark Theory
- Relativistic Quantum Mechanics
- Quantum Field Theory

The Standard Model

		Fermions			Bosons	
Quarks		<i>u</i> up	<i>c</i> charm	<i>t</i> top	γ photon	Force Carriers
		<i>d</i> down	<i>s</i> strange	<i>b</i> bottom	<i>Z</i> Z boson	
Leptons		ν_e electron neutrino	ν_μ muon neutrino	ν_τ tau neutrino	<i>W</i> W boson	
		<i>e</i> electron	μ muon	τ tau	<i>g</i> gluon	

Higgs[®] boson

Source: AAAS

*Yet to be confirmed

The Standard Model of Particle Physics

KNOWN FORCES (Bosons)

FORCE	PARTICLE /QUANTUM	RELATIVE STRENGTH	MASS (GeV)	RANGE (meters)
Strong nuclear	gluon	1	0.14 (?)	10^{-15}
Electromagnetic	photon	7×10^{-3}	none	infinite
Weak nuclear	W^+, W^- & Z bosons	10^{-5}	80-90	10^{-17}
Gravitation	graviton (tentative)	6×10^{-39}	none	infinite

QUARKS (Fermions)

FLAVOR	GENERATION	MASS (GeV)	ELECTRIC CHARGE
Up	First	0.003	+ 2/3
Down	First	0.006	- 1/3
Charm	Second	1.3	+ 2/3
Strange	Second	0.1	- 1/3
Top	Third	175	+ 2/3
Bottom	Third	4.3	- 1/3

LEPTONS (Fermions)

FLAVOR	GENERATION	MASS (GeV)	ELECTRIC CHARGE
Electron (e^-)	First	5.11×10^{-4}	- 1
Electron neutrino	First	$< 10^{-8}$	0
Muon (μ^-)	Second	0.106	- 1
Muon neutrino	Second	$< 3 \times 10^{-4}$	0
Tauon	Third	1.78	- 1
Tauon neutrino	Third	$< 3.3 \times 10^{-2}$	0

Revelations of the Micro-world

In contrast to the Middle world, where we have more or less first hand knowledge of the details of happenings, in the microworld variety of phenomena happen in extremely short intervals of space ($10^{-12} - 10^{-43}$ cms) and time ($10^{-6} - 10^{-33}$ sc) as a consequence, only the results of whatever happened we can see indirectly with the most powerful instruments and as specified by theoretical predictions.

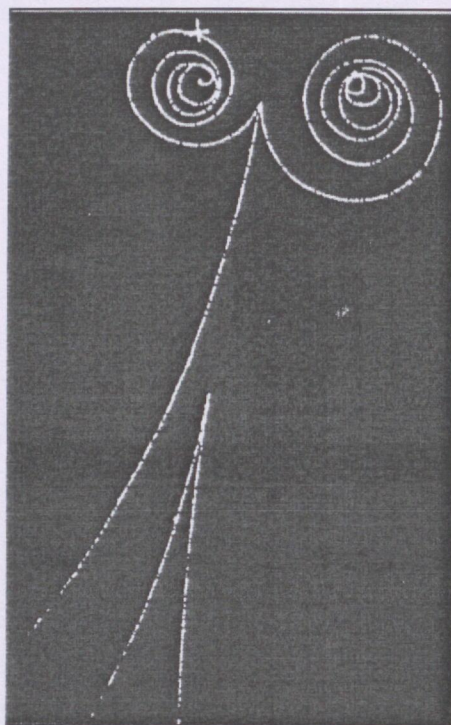
Most consequential happenings are

- Production of high energy radiation by accelerating charged particles
- Production of electron-positron pairs by gamma-rays
- Cascade process – single electron developing into billion electrons and photons – Extensive Air Showers
- production of mesons, hyperons, nucleons, anti-nucleons in high energy collisions
- Spontaneous Decay of Particles
- Production of Resonances which last only for $\sim 10^{-23}$ s
- Production of the Higgs Boson (125 Gev)

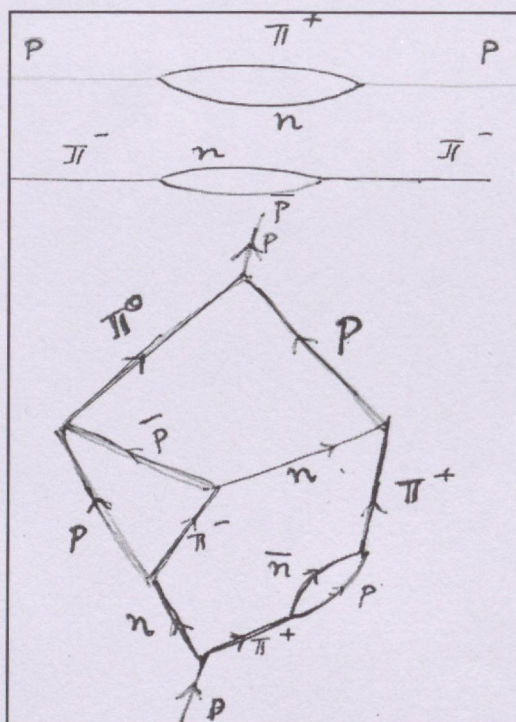


A Proton or a Pi-meson collides with a Silver or Bromine nucleus of the emulsion and produces 6 high energy secondaries and 3 heavy fragments.

A sulphur nucleus ($Z = 16 \pm 1$) collides with one of silver or bromide in the emulsion. As a result of the encounter a fluorine nucleus and twenty-five 'shower' particles-protons and pi-mesons-emerge.



Electron-positron pair production. A high-energy gamma-ray coming in from above scatters off an atomic electron, losing some of its energy and producing an energetic recoil electron and an electron-positron pair. The electron and positron paths curve because the chamber is placed in a strong magnetic field. The direction of the curves reveals the signs of the particles' charges.



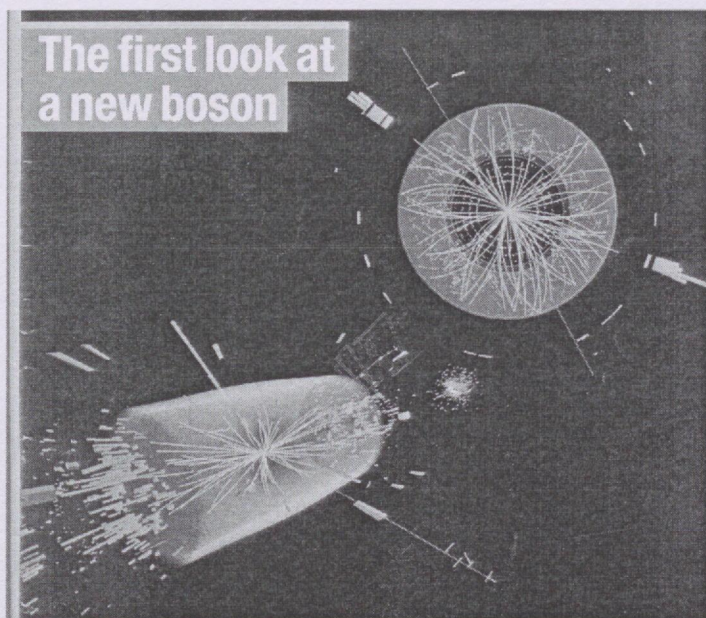
Virtual State

What is Vacuum?

Repository of all fundamental particles (discovered and yet to be discovered) in negative energy states.

Higgs Field – Higgs Boson

- In the Standard Particle Physics Model, it is seen that while the gravitational force and the electromagnetic force are mediated by zero mass particles, the other two forces, the strong and the weak are mediated by particles with a mass.
- The weak force is mediated by W^\pm , Z^0 , Bosons which have mass in the region of 90-100 GeV
- Accelerator experiments showed that the strength of these two forces come closer at higher energies ~ 200 GeV and distance to 10^{-15} cms.
- This led to the possibility that all the four forces could be manifestation of a single unified force at very short distances.
- Higgs and several others proposed a theoretical mechanism in which this single field interaction with another, namely the Higgs Field gave rises to the mass of the particle.
- Higgs Field was to be a universal and present all over the universe with the same intensity.
- The Higgs Field may be the Dark Energy Field which we will consider later.



Source: CERN Courier (Intl. Journal of Higher Energy Physics), Volume 52, No. 7, Sept. 2012

Two important question are

(i) Where were these particles before they became manifest? Did they exist as such or were they created?

(ii) How do they get their specific properties?

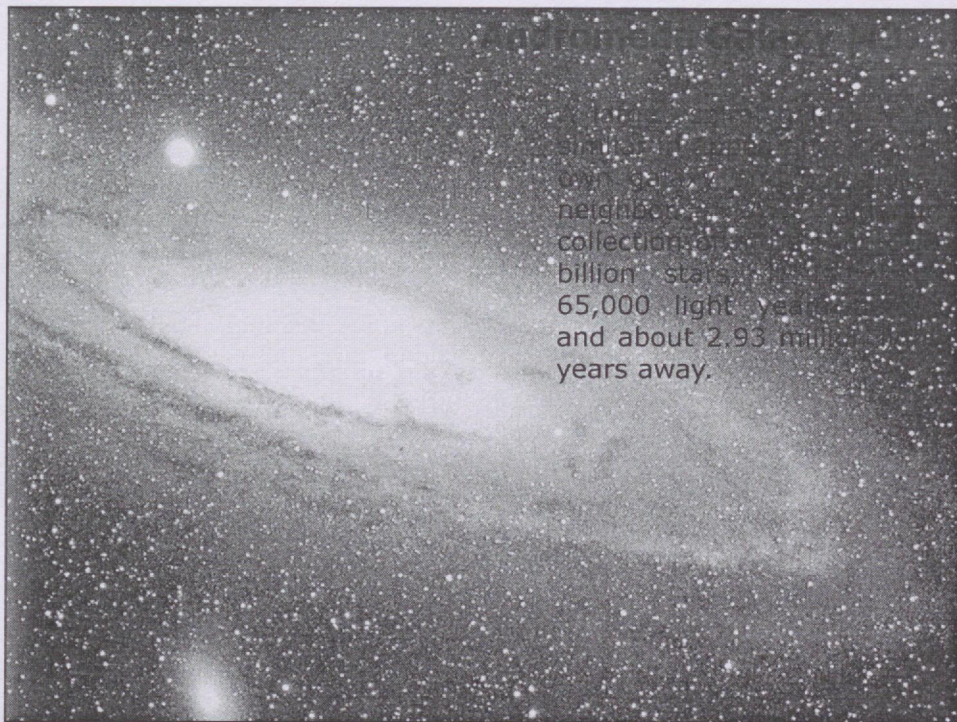
Mass, charge, spin, interaction character etc. and make atoms, molecules etc.

Quantum Field Theories

These fundamental issues could not be solved within the framework of classical theories. It became necessary to extend the quantum mechanical theories developed by Schrödinger , Heisenberg, Dirac, Max Born and others into two further theories known as Quantum Electrodynamics (QED) and Quantum Chromodynamics (QCD) which are essentially field theories.

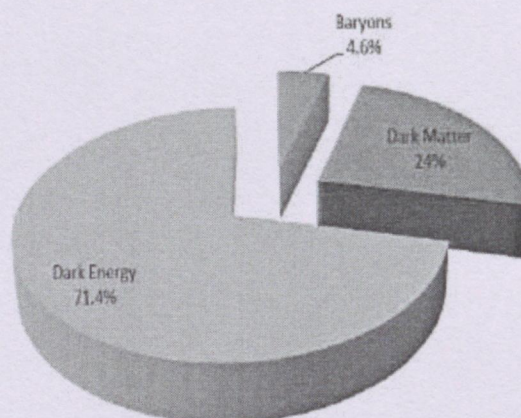
Just to illustrate how this works:

Every particle is associated with a quantum field that is present all over space. The amplitude of the wave function at any point gives the probability of finding the particle at that place. The properties of the particle like mass is a function of the interaction of the wave function with that of another universal field like the Higgs Field. The mass is not given in just one interaction. The electron wave for example has to interact with the Higgs field continually. This calls for the same strength of Higgs field everywhere for interaction, to be constant and give the same mass – be it on the earth or in the Andromeda nebula.



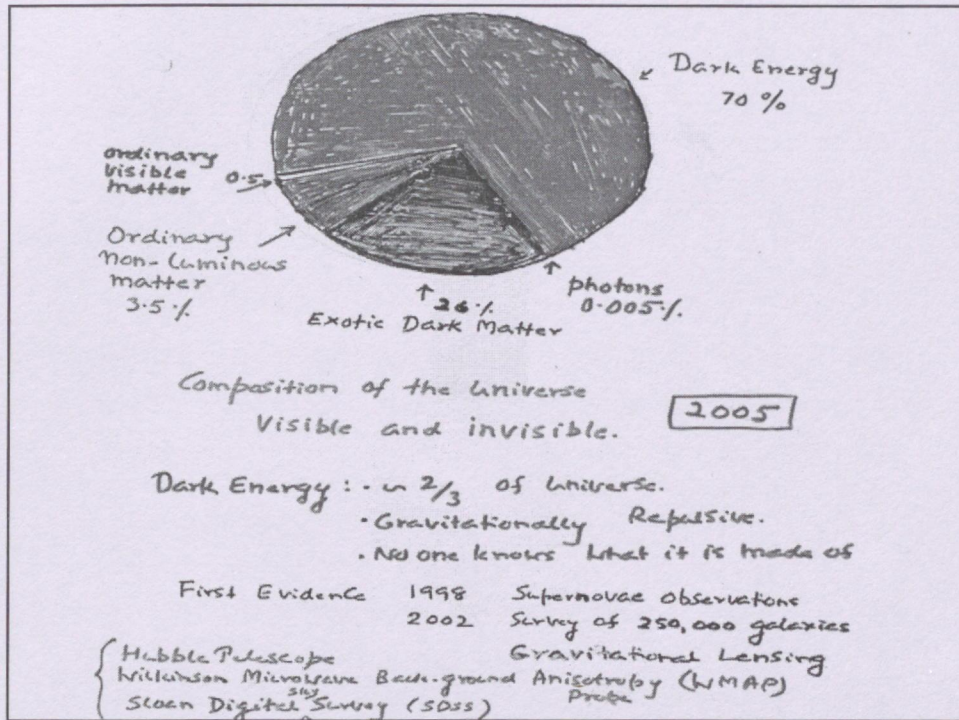
Highlights of 20th century Astronomy and Astrophysics – Cosmology

- Installation of 100" and 200" telescopes
- Hubble's Discovery of External Galaxies Increasing separation of galaxies – Expanding universe
- The Big Bang theory of creation – Inflation
- Advent of Radio Astronomy
- Quasars
- Discovery of 3^o Microwave Radiation
- Structure of Microwave Radiation
- Discovery of x-ray Sources
- Discovery of Pulsars – Neutron Stars
- Compact x-ray binaries – Black Holes
- Giant Black Holes – Cosmic Ray Sources
- Dark Matter
- Dark Energy



Dark Matter

(Ref. Dark matter in our Universe by Chandan Hati & Raghavan Rangarajan, Planex Newsletter, Vol. 4(3), July 2014, Physical Research Laboratory, Ahmedabad)



John Wheeler

“Physical Reality has thus moved from Matter → Molecules → Atoms → protons, Neutrons and Electrons → quarks and leptons → Space or Vacuum and Geometry of Space → Matter. We have seen that matter and radiation are equivalent and transform to each other. So, ultimately, the physical substratum of everything is just one entity – quantum mechanical vacuum. The question arises – does it help to reduce life, consciousness, mind etc., to the motions of subatomic particles similar to matter? It looks that such a step even if realized is not likely to give any different insight into reality. All that again will be reduced to “empty space”.

The first moments of the Big Bang scenario is explained by (Weisskopf, 1989), in his popular article "The origin of the universe" in *New York Review*, 1989, p. 10-14 as follows.

First he defines "true vacuum" as empty space, empty of matter and empty of energy and "false vacuum" as empty of matter, but not of energy. This energy is not of the known form like gravitational or electric but of a new kind of field – type that is encountered in the current theory of radioactive processes. The most characteristic feature of the false vacuum follows directly from General Theory of Relativity according to which a region filled with energy, but not matter is bound to expand suddenly and explosively filling more and more space with false vacuum.

Weisskopf Says:

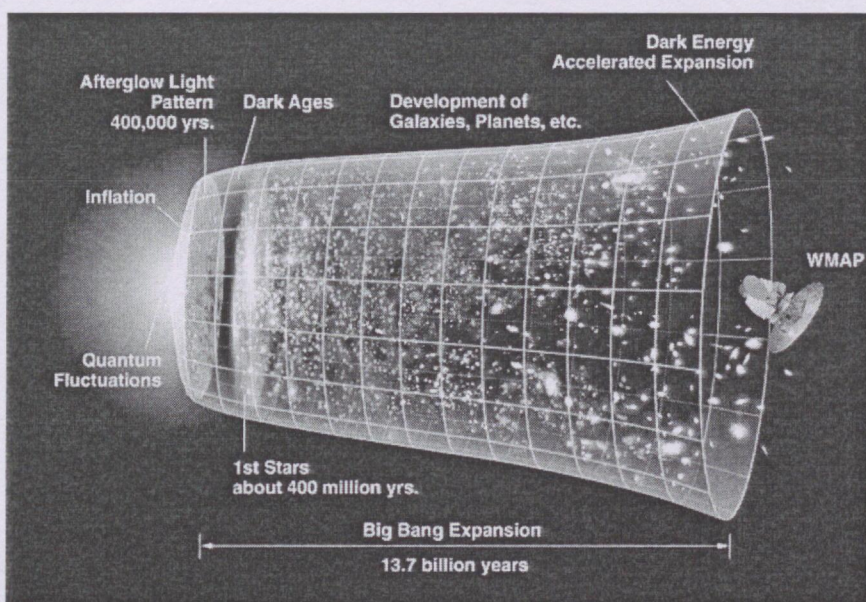
"According to the fundamental tenets of this well established theory, there is nothing in nature that remains quiet. Everything including the true vacuum is subject to fluctuations, in particular to energy fluctuations. The field that provides energy to the false vacuum is absent in the true vacuum but not completely. There must be fluctuations of the field. Thus at one moment a small region somewhere in space must have fluctuated into a false vacuum. It would happen rarely, but not excluded. That region almost instantly expands tremendously and creates a large space field with energy according to the properties of false vacuum. This is supposed to be the Big Bang. One might wonder, where the energy comes from that fills the expanding false vacuum.

There is no need to worry about conservation of energy. According to Einstein energy is subject to gravity. The newly created energies interact via gravity that produces Negative Energy so that the net energy remains constant.

When a certain large size is reached the inflationary expansion stops and a true vacuum emerges. But the vast amount of energy contained in the false vacuum shows up in some form. It fills the true vacuum with hot light, quarks-anti-quark pairs, electron-positron pairs, neutrinos etc. In other words with all the stuff that we have described as filling the space at a microsecond after Big Bang. Our universe is born, the slow expansion takes over, the temperature falls, the pre observable history develops and is followed by observable history."

This shows the potentialities of the false and true vacuums with the requisite fields to be able to create the entire universe with all its constituents and forces. Ours is perhaps just one such case. There may be many others with constituents and forces very different from ours

History of the Universe from the Big Bang to the Present Day



The Vedanta Philosophy:

Many versions. But the three main versions – Advaita, Dvaita and Vishistadvaita. The essential difference between them is the relation between Brahman, Self and Reality.

The four Mahavakyas spell out Brahman as follows.

• Prajnanam Brahman (Consciousness is Brahman)	Rig Veda	Aitareya Upanishad
• Aham Brahmasmi (I am Brahman)	Yajur	Brihadaranyaka Upanishad
• Ayam Atma Brahma (The Self is Brahma)	Atharva	Mandukya Upanishad
• Tat Tvam Asi (that thou art)	Sama	Chandogya Upanishad

According to Advaita philosophy of Shankara, we have essentially to consider two view points – Vyavaharika and Adhyatmika.

Vyavaharika – transaction point of view – the world exists and is real for all of us.

- **Adhyatmika** – Transcendental point of view – for the realized soul, there is only Brahman and no world.
- Brahman is Absolute Consciousness
- Individual Consciousness arises when this Absolute Consciousness interacts with the individual mind

- The overriding conclusion is “Sarvam Khalu Idam Brahma” – Everything is Brahman.
- This is elaborated by Shankara in Viveka Chudamani as follows

वेदान्तसिद्धान्तनिरुक्तिरेषा

ब्रह्मैव जीवः सकलं जगच्च ।

अखण्डरूपस्थितिरेव मोक्षो

ब्रह्माद्वितीये श्रुतयः प्रमाणम् ॥ ४७८ ॥

478. The verdict of all discussions on the Vedānta is that the Jiva and the whole universe are nothing but Brahman, and that liberation means abiding¹ in Brahman, the indivisible Entity. The Shrutis themselves are authority (for the statement) that Brahman is One without a second.

- All this points to ONENESS as the basic ultimate reality.

- To me, what is exciting is the parallelism with Plato's philosophy, namely :
 - Ideas are the intangible substrate of all that is tangible
 - True structure of the world is revealed not by the senses, but by the intellect which has direct access to Ideas that govern Reality.
 - The Archetypal realm, far from being unreal abstraction or imagining metaphor for the concrete world, is the very basis of reality – that which renders order and renders it knowable.
- Direct experience of transcendental Ideas is the philosopher's primary goal and ultimate destination.

यदा भूत पृथक् भावं एकस्थं अनुपश्यति ।
ततः एव च विस्तारं ब्रह्म संपद्यते तदा ॥
भगवद्गीता 13:30

When one sees the plurality of differentiated phenomena of all things and beings as inherent, embedded or nested in ONE, and also the emergence of all phenomena from that ONE only, then one becomes ONE.

Bhagavad Gita XIII:30

Thank you

Prof. V S Sreekantan



Science, Spirituality and Consciousness

B V Sreekantan

National Institute of Advanced Studies, Bangalore

7th All India Students conf. on Science and Spiritual Quest, 1 Sept. 2012, JN Tata Auditorium, Indian Institute of Science; Organizer: Bhaktivedanta Institute, Kolkata

- Spirituality has many dimensions. Has different implications to different people.
- In this talk, I will focus on one aspect of spirituality :
That is the search for ultimate reality, which is also one of the objectives of science, in particular fundamental science.
- Immediately, the question arises, "Reality of What?"
- Our experience reveals essentially two different realities :
(i) the external world which we perceive through our senses;
(ii) the internal world of thoughts, feelings, emotions, etc.,
- With both these aspects our 'consciousness' is very much involved.

- The external world consists of three parts
 - What we experience in our daily life – on the earth and its immediate surroundings
 - The vast universe consisting of planets, stars, galaxies, clusters of galaxies, etc. ...as revealed by variety of telescopes
 - The micro universe of molecules, atoms, particles, microbes, DNA, ... revealed by a variety of instruments – microscopes, accelerators, etc.
- When we talk of reality, we have to consider all these – and many more subtle issues we shall become familiar during the course of this lecture.

First, let me consider the question of reality from the point of view of “Spirituality”.

The most transcendent and the most profound statements I have come across regarding “ultimate reality” are the following Maha Vakyas from the four Upanishads :

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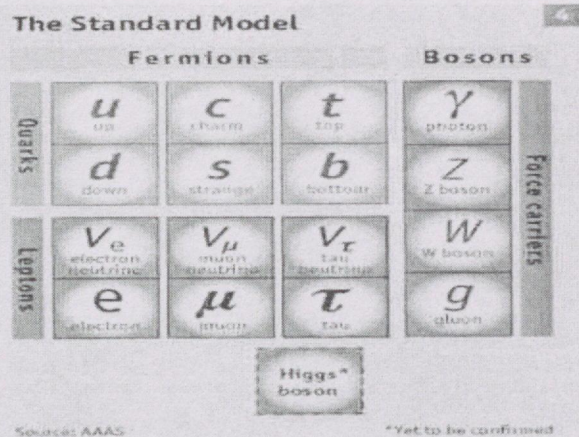
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- Direct experience of transcendental Ideas is the philosopher's primary goal and ultimate destination.

- According to current ideas, (Standard Model of Physics) each proton (neutron) consists of three subunits called quarks held together by the exchange of mass less particles called gluons.
- Thus the fundamental units of all matter are quarks and electrons and force particles gluons.



- According to Quantum Mechanics, each elementary particle is actually represented by a quantum field that extends all over the universe, the amplitude of the wave that characterizes the field being highest where the particle is located (observed).
- If we consider a single atom of hydrogen at a given location there are three quark fields, an electron field, several gluon fields and the electromagnetic field, all interesting within distances of 10^{-12} cm and 10^{-8} cms, corresponding to Nuclear and Atomic sizes respectively.

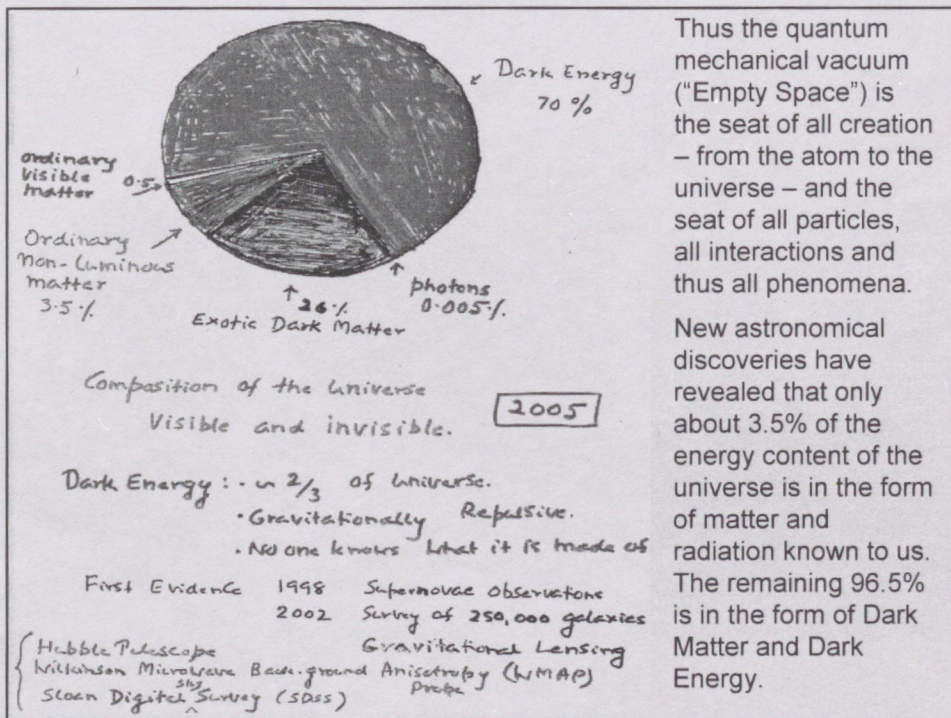
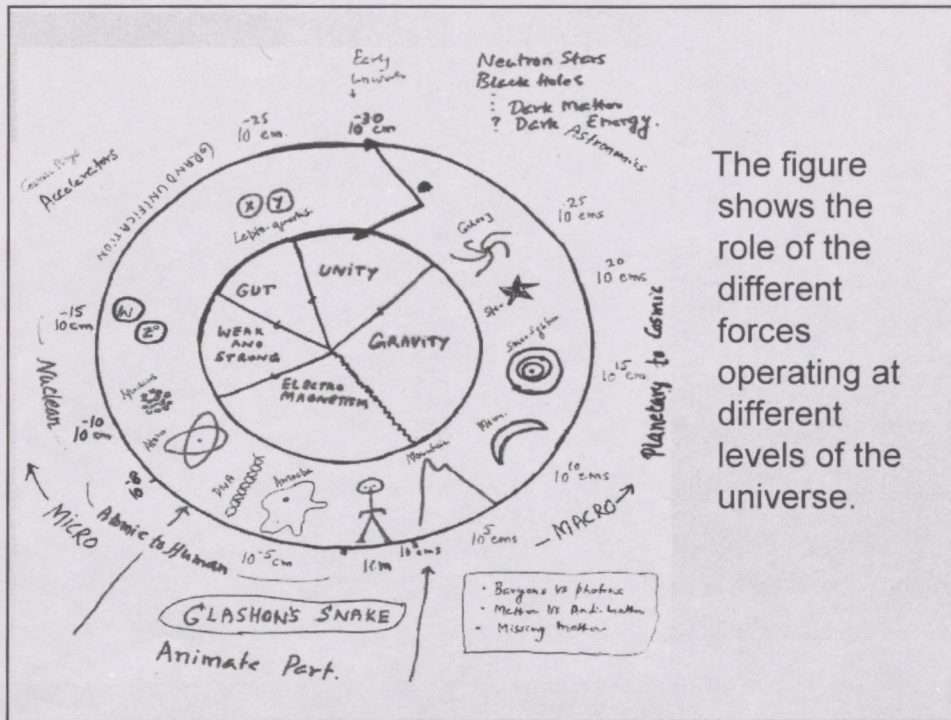
- When the atom moves from one place to another place what is happening is a readjustment of the amplitudes of the fields in successive space domains so that their maxima move accordingly.
- These fields and many other fields are the actual constituents of what we regard normally as “empty space” or vacuum – it is the quantum mechanical vacuum that fills all space through out the universe, with in matter and outside.
- It is the geometrical and dynamical properties of this quantum vacuum that determines all the physical properties of the particles and the radiations.

Right now an experiment is going on at Geneva in Switzerland with an accelerator called LHC built at a cost of 10 billion dollars to detect a very heavy mass (~125 GeV) particle called the Higgs Boson. (God Particle ! ??)

The Higgs Boson field which fills the entire universe and has the same intensity everywhere, is the MASS GIVER to all the particles that have a mass. The fields corresponding to various particles have to keep on interacting with the Higgs field to retain their mass. If the Higgs Field is not there, then there are no particles with mass, so we are not there, the universe will be just a fast stream of mass less particles.

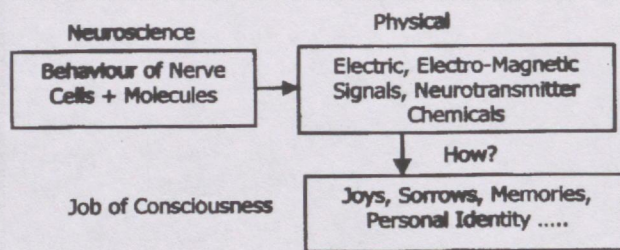
The Higgs Field is also responsible for creating the four different types of fields at the time of creation of the universe – the gravitational, strong, weak and electromagnetic.

The Higgs Field is also responsible for the recently discovered phenomenon of acceleration of the expanding universe.




- The Neuroscientists are attempting to explain "consciousness", essentially under the following dictum spelled out by the Nobel Laureate Francis Crick.

Astonishing Hypothesis: "Your joys, your sorrows, your memories and your ambitions, your sense of personal identity your free-will are all in fact no more than the behaviour of a vast assembly of nerve cells and their associated molecules"



The Table illustrates the two kinds of experiences generated in an individual when he looks at say a rose flower

A (Physicalism)		B (Mentalism)
What happens in the Brain and Its accessories		What happens in the mind
• Formation of 'image' of the flower on the retina.		• Distinctive perception and recognition of the flower as a rose.
• Activation of rods and cones in the retina's various layers.		• Evokes sense of beauty - Smell of the rose flower
• Generation of action potentials - electrical pulses.		• The awareness and recognition: colour of the flower.
• Transmission of pulses through axons in neurons.		• The softness and smoothness of petals on touching the same.
• Happenings in Synapses and Dendrites		• Appreciation of symmetry, beauty and aroma.
• Releases of Neuro-transmitter chemicals at various locations		• Earlier happy associations flood the mind
• Activation of Cortices		• Emotions triggered.
<u>Basically:-</u> Electrical Signals } oscillations chemicals } in various time sequence. } locations		The mind is able to gauge the size, distance, shape and other physical characteristics as well.

The Left Hand Side of the above table depicts the electrical and chemical activities in the sensors, neurons and the cortices. The Right Hand side shows what is experienced by the mind – These are entirely different types of experience. How to relate them? That is the so called Hard Problem of Consciousness – requiring transcendence.

In my view, this problem also has to be resolved by appealing to the QM fields in the vacuum – known or yet to be known. The following statement of Prof. John Wheeler is relevant in this connection.

John Wheeler

“Physical Reality has thus moved from Matter → Molecules → Atoms → protons, Neutrons and Electrons → quarks and leptons → Space or Vacuum and Geometry of Space → Matter. We have seen that matter and radiation are equivalent and transform to each other. So, ultimately, the physical substratum of everything is just one entity – quantum mechanical vacuum. The question arises – does it help to reduce life, consciousness, mind etc., to the motions of subatomic particles similar to matter? It looks that such a step even if realized is not likely to give any different insight into reality. All that again will be reduced to “empty space”.

- John Wheeler: He contends that the physics of the world is fully determined by the geometrical shape of space and says:

“Einstein, above his work and writings, held a long term vision. There is nothing in the world except curved empty space. Geometry bent one way here described gravitation; rippled another way somewhere else it manifests all the quantities of an Electro-magnetic wave. Excited at still another place, the magic material that is space shows itself as a particle. There is nothing that is foreign and physical, immersed in space. Everything that is, is constructed out of geometry....”

May I conclude by saying

“ Sarvam Khalu Idam Quantum vacuum “ ?

Thank you

Science, Reality and Consciousness

B V Sreekantan
National Institute of Advanced Studies
Bangalore

National Symposium on "Matter, Mind and Consciousness—
Recent Trends in Philosophy and Science"
Kaivalyadhama Yoga Institute, Lonavala
28th & 29th November 2014

It is indeed a great pleasure and privilege for me to deliver this talk at this National Symposium organized by the prestigious Yoga Institution Kaivalyadham. The theme of the symposium is given as "Matter, Mind and Consciousness". I have chosen the theme of my talk as "Science, Reality and Consciousness" with the specific purpose) – to highlight the fact that the current trend in the 21st century among at least some of the leading scientists is the grand unification scheme:

Matter = Energy = Mind = Consciousness = Reality = Quantum Vacuum = Multi-dimensional Space-Time – all parameters that define the ontology and epistemology of the universe.

The title of
my talk is
chosen

This is not based on mere speculation. It is based on solid experimental new facts emerging from very sophisticated experiments in the fields of physics and astrophysics, particularly in the 19th, 20th and 21st centuries and the interpretation of these results by ingenious theories that incorporate mind-boggling mathematical ideas and theories. It is also important to point out the role of the Science- Technology spiral that has led to the feasibility of carrying out the needed experiments and the budgetary support given by the enlightened governments from all over the World, which runs into tens of billion dollars. The equivalence of consciousness and Quantum Vacuum is heralding the advent of new field of quantum vacuum biology.

In that Grand Equivalence equation that I have written there are many subtle concepts that are involved, and many more are implicit:

Space, Time, Matter (animate and inanimate), Motion, Force, Energy, Wave, Radiation, Mind, Brain, Consciousness, Creation Annihilation, Vacuum, Quantum etc. and most importantly "Reality".

According to Newton 'Physical reality' was characterized by the concepts: Space, Time, Material point and Force. Material Point is our only mode of representing Reality (atomistic and mechanistic). All happenings are motions of material points, Newton regarded light as material points.

All these Newtonian concepts have radically changed since the beginning of 20th Century. Also our concepts of the contents size, types of phenomena and the forces responsible for the variety of phenomena have changed. Let us see how these changes have come about.

Our Present Knowledge of the UNIVERSE can be Classified as Follows

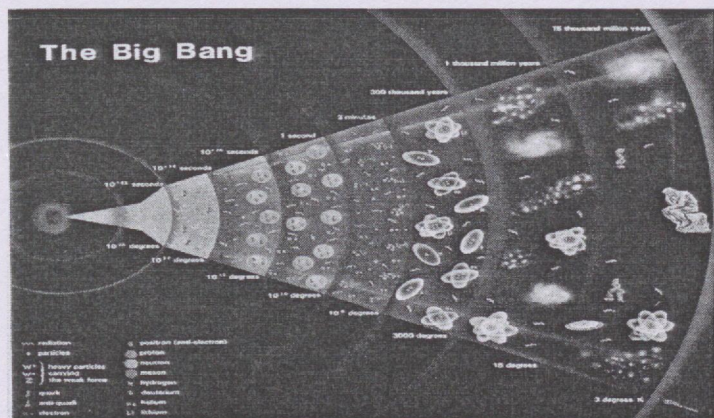
Micro Cosmos	Middle (our level)	Macro Cosmos
(10^{-33} cms- 10^{-8} cms) Molecules, Atoms, Particles, Radiations	10^{-6} – 8 Light minutes Earth and the solar system (Sun + Planets)	(4.3 Light years – 10^{10} Light years)
(High Energy Physics)	<ul style="list-style-type: none"> • Inanimate Matter Elements, Hydrogen to Uranium • Animate Amoeba to Man, DNA, etc. General Science	Stars, Galaxies, Clusters of Galaxies etc. Neutron Stars, Black Holes Expanding, Accelerating Universe, Dark Matter, Dark Energy (Astronomy and Astrophysics)

The Evolution of the Universe

(Big Bang Cosmology Physical – Chemical – Biological – Man)

Note that the entire universe has changed its constituents (capsule of energy) → High Temperature Plasma → Particles → Atoms → Animals. Physical Evolution – Chemical Evolution – Biological Evolution

REALITY OF THE UNIVERSE IS A FUNCTION OF TIME



Basis of Scientific Explanation

- For any Scientific Explanation at any level, especially at the fundamental level, we need to define first the following parameters:

Space, Time, Matter, Energy, Motion, Force, Medium, Fields, Waves, Electric Charge, Electromagnetic Waves

- The first few concepts are based on common sense, quantified and units defined for enabling measurement, concepts like Mass, Force, Energy are anthropomorphic. Waves are observational. Charge and field are inferential.

Newton's Definition of Space and Time

- Space is an empty (devoid of all matter) container in which objects are put. Space is Absolute and no motion. Same everywhere and does not change with time, Isotropic, homogeneous and three-dimensional.
- Time: The concept comes from succession of events; is continuous and moves in the forward direction (unidirectional). Rate of flow of time is constant and same everywhere, and at all times. Though the concept comes from succession of events, time exists independent of events.
- Without the concept of time we cannot come to any understanding of nature and its laws.
- Space and Time make a rigid frame work on which the world of objects displays its events.

- On the basis of these notions and Newton's laws of Motion and Gravitation, Classical physics developed and played a major role in explaining many physical phenomena including motion of planets.
- The Corpuscular theory of light proposed by Newton prevailed till the experimentally observed phenomena of interference and diffraction required the wave theory of light as proposed by Huygens and Fresnel. However, the particle aspect was brought back into the picture for the explanation of photoelectric effect by Einstein and later for explaining Compton effect too. This dual nature of light, particle/wave at the same time for the same entity became the starting point of the realization and confirmation of the dual nature of all particles.
- Einstein is reported to have stated toward the end of his life that even after fifty years of his association with it he has not been able to understand what the "photon" is!

The development of the Electromagnetic theory based on Faraday's magnetic induction experiments and Oersted's observation of magnetic deflection of a compass needle when an electric current was passed through a wire in the neighborhood was another major breakthrough in connecting three distinct phenomena: electricity, magnetism and light. In fact this was the first grand unification that was achieved in understanding the intricate realities of nature.

- The Phenomenon of light posed two further problems:

- (i) If light is an electromagnetic wave, then what is it that is waving? (What is the ontology?)

Maxwell tried hard to provide a mechanical explanation by assuming it is the 'ether' that is waving though there was no idea what constituted ether itself!

- (ii) If the ether is there, is it stationary while the earth is moving or is it carried by the earth?

- (iii) The experimental observation of Michelson and Morley showed that the velocity of light is independent of the direction of motion of the earth with respect to the source of light. Light does not obey the theorem of addition of velocities as in dynamics.

Relativity which was proposed by Einstein in 1905 to solve these problems changed the concepts of space, time, mass and energy as follows (>1905)

- No Absolute Space
- No Absolute Time
- Space contracts and time elongates at higher and higher velocities
- Reality is in four-dimensional space-time
- What we observe because of our mental limitations is the projection of the four dimensional activity on to 3-dimensional space and one-dimensional time.
- Velocity of light is a constant of Nature and does not change with the motion of the observer or source.

- Energy and Mass are identical with the relation $E=M_0c^2$ where c is the velocity of light and M_0 is the rest mass.
- Relativistic mass has to be added to the rest mass when the particle is moving with velocity $v = \frac{m_0}{\sqrt{1-v^2/c^2}}$

Further, according to General Relativity which Einstein proposed in 1915:

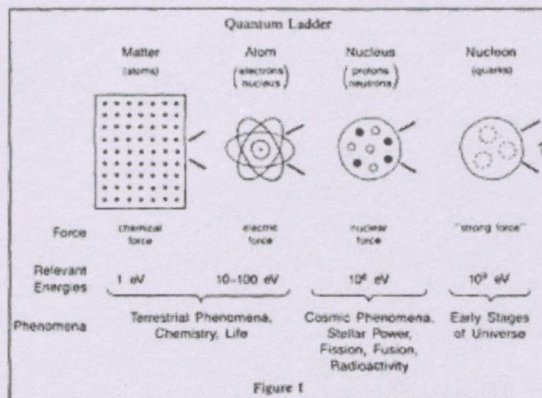
- Gravitational Force is due to curvature of space in higher dimensional space-time.
- Rate of flow of time slows down when space is curved.

- We thus see all the concepts space, time, mass and energy have undergone drastic changes.
- However, these effects are generally very small at low velocities and do not affect our normal observations directly. But, as we shall see, they are important from the point of "reality".

- The Micro-world – Advent of Quantum Mechanics
- Towards the end of the 19th century, the other problems that the electromagnetic radiation (light) from hot bodies had created were
 - (i) the experimentally observed energy distribution as a function of wavelength of emission showed a peak at low wave lengths while the classical theory predicted an increase right upto smallest wave length – UV catastrophe as it was known.
 - (ii) In addition there were discrete spectral lines in the emission characteristic of the chemical nature of the hot body.

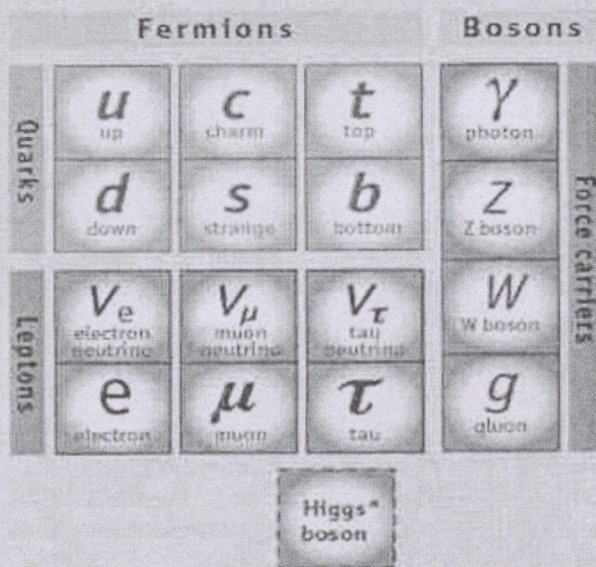
- To explain the first feature, Max Planck introduced in 1900, “the quantum hypothesis” according to which energy was emitted in discrete chunks – in multiples of $h\nu$ where ν is the frequency of radiation and h is the Planck constant ($\hbar=h/2\pi$). On the basis of this assumption Planck explained the spectral distribution of the radiation.
- To explain the second feature, Niels Bohr introduced the Bohr Model of the atom according to which the atom existed in discrete energy states only due to the orbital motion of the electrons in quantized orbits and emission of light took place when an electron jumped from an orbit of higher energy to a lower one.

Era of Fundamental Particles (20th Century)



- Discovery of Cosmic Rays
- Elementary Particles – Positron, mu-meson, pi-meson, k-meson, Hypheron
- Strange, charm: new quantum numbers
- Relativity
- Quark Theory
- Relativistic Quantum Mechanics
- Quantum Field Theory

The Standard Model



Source: AAAS

*Yet to be confirmed

The Standard Model of Particle Physics

KNOWN FORCES (Bosons)

FORCE	PARTICLE /QUANTUM	RELATIVE STRENGTH	MASS (GeV)	RANGE (meters)
Strong nuclear	gluon	1	0.14 (?)	10^{-15}
Electromagnetic	photon	7×10^{-3}	none	infinite
Weak nuclear	W^+, W^- & Z bosons	10^{-5}	80-90	10^{-17}
Gravitation	graviton (tentative)	6×10^{-39}	none	infinite

QUARKS (Fermions)

FLAVOR	GENERATION	MASS (GeV)	ELECTRIC CHARGE
Up	First	0.003	+ 2/3
Down	First	0.006	- 1/3
Charm	Second	1.3	+ 2/3
Strange	Second	0.1	- 1/3
Top	Third	175	+ 2/3
Bottom	Third	4.3	- 1/3

LEPTONS (Fermions)

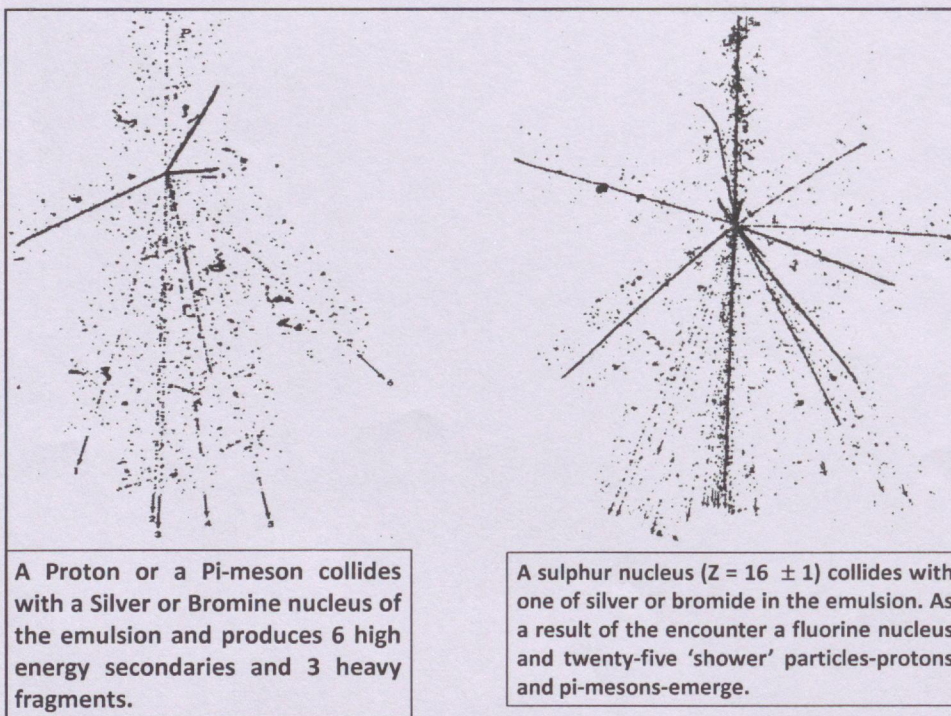
FLAVOR	GENERATION	MASS (GeV)	ELECTRIC CHARGE
Electron (e^-)	First	5.11×10^{-4}	- 1
Electron neutrino	First	$< 10^{-8}$	0
Muon (μ^-)	Second	0.106	- 1
Muon neutrino	Second	$< 3 \times 10^{-4}$	0
Tauon	Third	1.78	- 1
Tauon neutrino	Third	$< 3.3 \times 10^{-2}$	0

Revelations of the Micro-world

In contrast to the Middle world, where we have more or less first hand knowledge of the details of happenings, in the microworld variety of phenomena happen in extremely short intervals of space ($10^{-12} - 10^{-43}$ cms) and time ($10^{-6} - 10^{-33}$ sc) as a consequence, only the results of whatever happened we can see indirectly with the most powerful instruments and as specified by theoretical predictions.

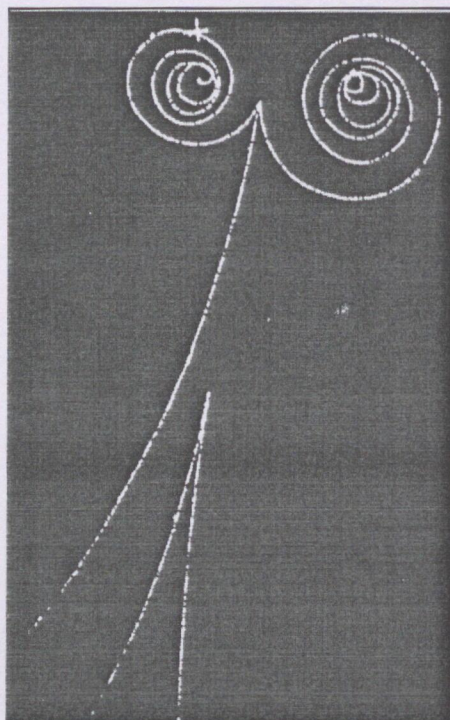
Most consequential happenings are

- Production of high energy radiation by accelerating charged particles
- Production of electron-positron pairs by gamma-rays
- Cascade process – single electron developing into billion electrons and photons – Extensive Air Showers
- production of mesons, hyperons, nucleons, anti-nucleons in high energy collisions
- Spontaneous Decay of Particles
- Production of Resonances which last only for $\sim 10^{-23}$ s
- Production of the Higgs Boson (125 Gev)

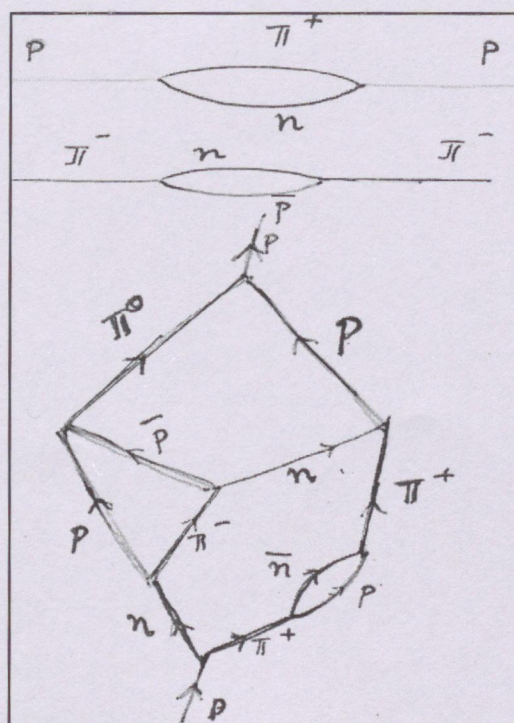


A Proton or a Pi-meson collides with a Silver or Bromine nucleus of the emulsion and produces 6 high energy secondaries and 3 heavy fragments.

A sulphur nucleus ($Z = 16 \pm 1$) collides with one of silver or bromide in the emulsion. As a result of the encounter a fluorine nucleus and twenty-five 'shower' particles-protons and pi-mesons-emerge.



Electron-positron pair production. A high-energy gamma-ray coming in from above scatters off an atomic electron, losing some of its energy and producing an energetic recoil electron and an electron-positron pair. The electron and positron paths curve because the chamber is placed in a strong magnetic field. The direction of the curves reveals the signs of the particles' charges.



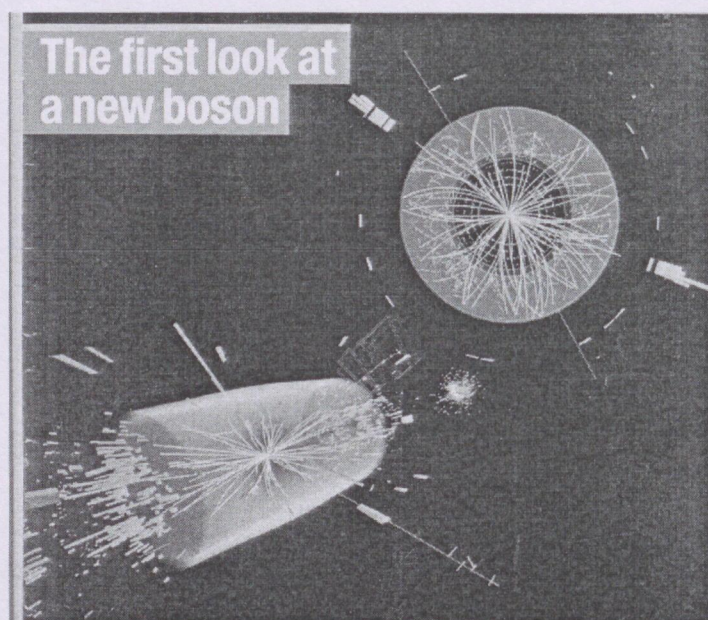
Virtual State

What is Vacuum?

Repository of all fundamental particles (discovered and yet to be discovered) in negative energy states.

Higgs Field – Higgs Boson

- In the Standard Particle Physics Model, it is seen that while the gravitational force and the electromagnetic force are mediated by zero mass particles, the other two forces, the strong and the weak are mediated by particles with a mass.
- The weak force is mediated by W^\pm , Z^0 , Bosons which have mass in the region of 90-100 GeV
- Accelerator experiments showed that the strength of these two forces come closer at higher energies ~ 200 GeV and distance to 10^{-15} cms.
- This led to the possibility that all the four forces could be manifestation of a single unified force at very short distances.
- Higgs and several others proposed a theoretical mechanism in which this single field interaction with another, namely the Higgs Field gave rises to the mass of the particle.
- Higgs Field was to be a universal and present all over the universe with the same intensity.
- The Higgs Field may be the Dark Energy Field which we will consider later.



Source: CERN Courier (Intl. Journal of Higher Energy Physics), Volume 52, No. 7, Sept. 2012

Two important question are

(i) Where were these particles before they became manifest? Did they exist as such or were they created?

(ii) How do they get their specific properties?

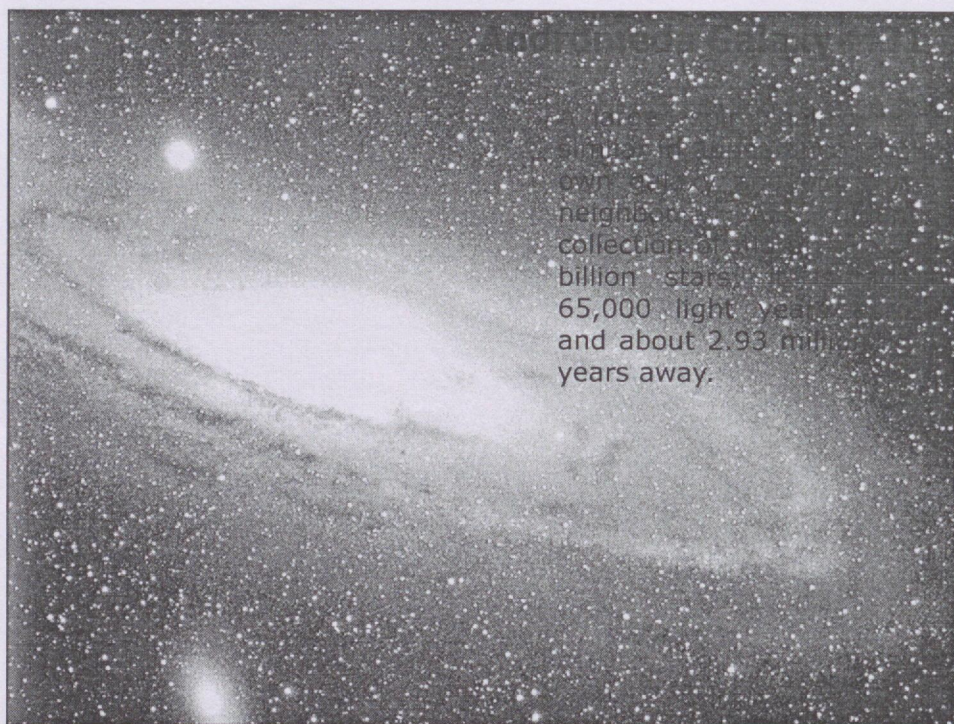
Mass, charge, spin, interaction character etc. and make atoms, molecules etc.

Quantum Field Theories

These fundamental issues could not be solved within the framework of classical theories. It became necessary to extend the quantum mechanical theories developed by Schrödinger , Heisenberg, Dirac, Max Born and others into two further theories known as Quantum Electrodynamics (QED) and Quantum Chromodynamics (QCD) which are essentially field theories.

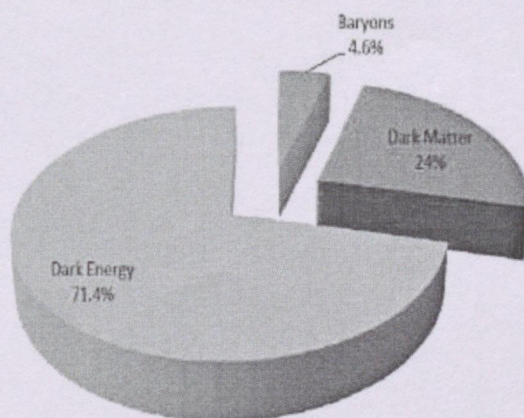
Just to illustrate how this works:

Every particle is associated with a quantum field that is present all over space. The amplitude of the wave function at any point gives the probability of finding the particle at that place. The properties of the particle like mass is a function of the interaction of the wave function with that of another universal field like the Higgs Field. The mass is not given in just one interaction. The electron wave for example has to interact with the Higgs field continually. This calls for the same strength of Higgs field everywhere for interaction, to be constant and give the same mass – be it on the earth or in the Andromeda nebula.



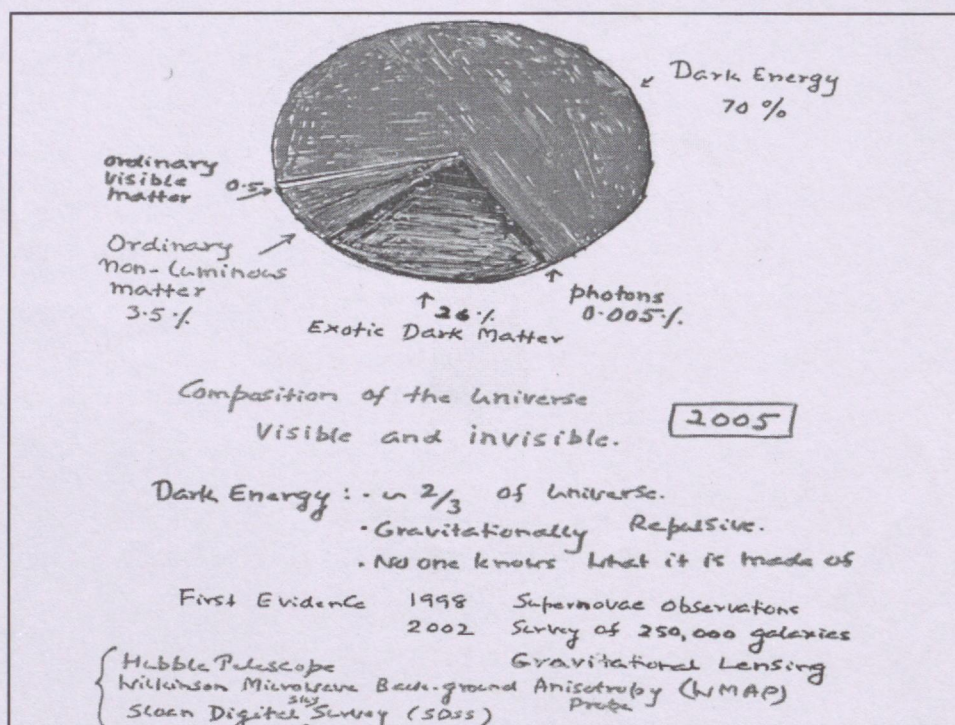
Highlights of 20th century Astronomy and Astrophysics – Cosmology

- Installation of 100" and 200" telescopes
- Hubble's Discovery of External Galaxies Increasing separation of galaxies – Expanding universe
- The Big Bang theory of creation – Inflation
- Advent of Radio Astronomy
- Quasars
- Discovery of 3^o Microwave Radiation
- Structure of Microwave Radiation
- Discovery of x-ray Sources
- Discovery of Pulsars – Neutron Stars
- Compact x-ray binaries – Black Holes
- Giant Black Holes – Cosmic Ray Sources
- Dark Matter
- Dark Energy



Dark Matter

(Ref. Dark matter in our Universe by Chandan Hati & Raghavan Rangarajan, Planex Newsletter, Vol. 4(3), July 2014, Physical Research Laboratory, Ahmedabad)



John Wheeler

"Physical Reality has thus moved from Matter \rightarrow Molecules \rightarrow Atoms \rightarrow protons, Neutrons and Electrons \rightarrow quarks and leptons \rightarrow Space or Vacuum and Geometry of Space \rightarrow Matter. We have seen that matter and radiation are equivalent and transform to each other. So, ultimately, the physical substratum of everything is just one entity – quantum mechanical vacuum. The question arises – does it help to reduce life, consciousness, mind etc., to the motions of subatomic particles similar to matter? It looks that such a step even if realized is not likely to give any different insight into reality. All that again will be reduced to "empty space".

The last remarks of Wheeler is very significant, "All that again will be reduced to empty space. It now behooves the life scientists to figure out how the aspects of life and consciousness arise from "empty space" or rather "the quantum mechanical vacuum". To establish that all matter and all physical phenomena arise from vacuum the physicists had to carry out a whole sequence of reductionist experiments and resort to the insights from unconventional theories, particularly in the 20th century. The challenge now is for the life scientists of the 21st century to carry out something similar in the field of the emerging Quantum Biology. New non-invasive technologies have to be developed to go deeper into the happenings during the life processes – far far deeper than molecular structures and keep their options open to higher dimensional effects in the **Planckian** domain as it has happened in the case of matter. There could be an entire range of fields undetected so far!

Thank you