

The Atomic Theory is Dead. Long Live the Atom

The God particle: Higs Boson

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Abstract

The discovery of the Higgs Boson or the (misnamed) God particle as the culmination of 40 year search has been well covered in the general press. It completes the latest model of matter and lends a sense of closure. We argue that the atomic theory of matter is dead. There are already three layers of the ultimate indivisible particles to explain matter

 chemical atoms and molecules

 the subatomic electrons and protons

 the nuclear quarks and leptons and bosons.

We explore the utility of these models and an alternate way of looking at models of matter covering infinite recursion, singularity and heterarchy.

at·om (ăt'əm)

n.

1.

a. A part or particle considered to be an **irreducible** constituent of a specified system.

b. The irreducible, indestructible material unit postulated by ancient atomism.

2. An extremely small part, quantity, or amount.

3. *Physics & Chemistry*

a. A unit of matter, the smallest unit of an element, having all the characteristics of that element and consisting of a dense, central, positively charged nucleus surrounded by a system of electrons. The entire structure has an approximate diameter of 10^{-8} centimeter and characteristically remains undivided in chemical reactions except for limited removal, transfer, or exchange of certain electrons.

b. This unit regarded as a source of nuclear energy. See Table at [subatomic particle](#).

[Middle English *attome*, from Latin *atomus*, from Greek *atomos*, *indivisible*, *atom*: *a-*, *not*; see *a-*¹ + *tomos*, *cutting* (from *temnein*, *to cut*; see *tem-* in Indo-European roots).]

The American Heritage® Dictionary of the English Language, Fourth Edition copyright ©2000 by

Motivation

Recently the general media has provided extensive coverage of a long running search of physicist on the Higgs Boson or “God Particle”. I majored in Physics at IITK and quantum physics and cosmology were my areas of interest but the mathematics exceeded my ability and I went on to run a software product company.

What got me to write this monograph¹ (and I will try to keep it simple and link to material on the web² for fuller exploration of those less initiated in this field) is the disconnect between the implied achievement of a Final explanation of the Universe and the irony that this proves that the atomic theory is dead and this is not the end of discovering particles. **Atomic theory is an oxymoron and that is being “lost” in the telling.**

Atomic Theory

Many people have speculated on the ultimate nature of matter. In the 6th Century BC [Kanada](#), founder of the [Vaisheshika](#) philosophy, held that the world was composed of atoms as many in kind as the various elements. Kanada believed [light](#) and [heat](#) to be varieties of the same substance; [Udayana](#) taught that all heat comes from the sun; and [Vachaspati](#), like Newton, interpreted light as composed of minute particles emitted by substances and striking the eye."

-Will Durant in “Our Oriental Heritage” quoted by Wikipedia:Atomism

In the 5th Century BC The Greek philosopher [Leucippus](#) and his pupil [Democritus](#) proposed that all matter was composed of small indivisible particles called atoms.

In the early 1800 the British chemist Dalton best established the atomic theory thru his experiments. This may be summarized as

1. Each element is composed of extremely small *indivisible* particles called atoms
2. All atoms of a given element are identical; the atoms of different elements are different and have different properties (including different masses)
3. Atoms of an element are not changed into different types of atoms by *chemical* reactions; atoms are neither created nor destroyed in chemical reactions

¹ I started as a blog but quickly had to expand and link to a large body of work to be accessible to those who are not keen followers of atomic physics.

² All colored texts and most graphics are hyperlinked to source.

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4. Compounds are formed when atoms of more than one element combine; a given compound always has the same relative number and kind of atoms.

Even within this short background we are already ahead of our story and dealing subtly with many advanced modeling concepts. A little diversion may help cast light on the core issue.

Models and Pathways to reality

We will never “see” atoms with our senses. We can not therefore have direct knowledge based on personal experience. We build a model of how things work and use experiments to prove or disprove our theory. No one model has proven to be able to explain all things all the time. We use different models for different purposes. . A sports coach can use a Bio-Mechanical model of the human body as a system of hinges and joints and train us. A doctor will use a model of the human body consisting of parts like kidney, lungs and blood and nerves to explain malfunction and cure. The economist recently proposed a micro-hume model as we have thousands of symbiotic microbes helping us ³.

Dalton’s chemical model of atoms works fine for chemist but is not very useful for nuclear physicist or cosmologist pondering the formation of stars and the development of the universe.

Model of Matter: First Cut the Chemical Model

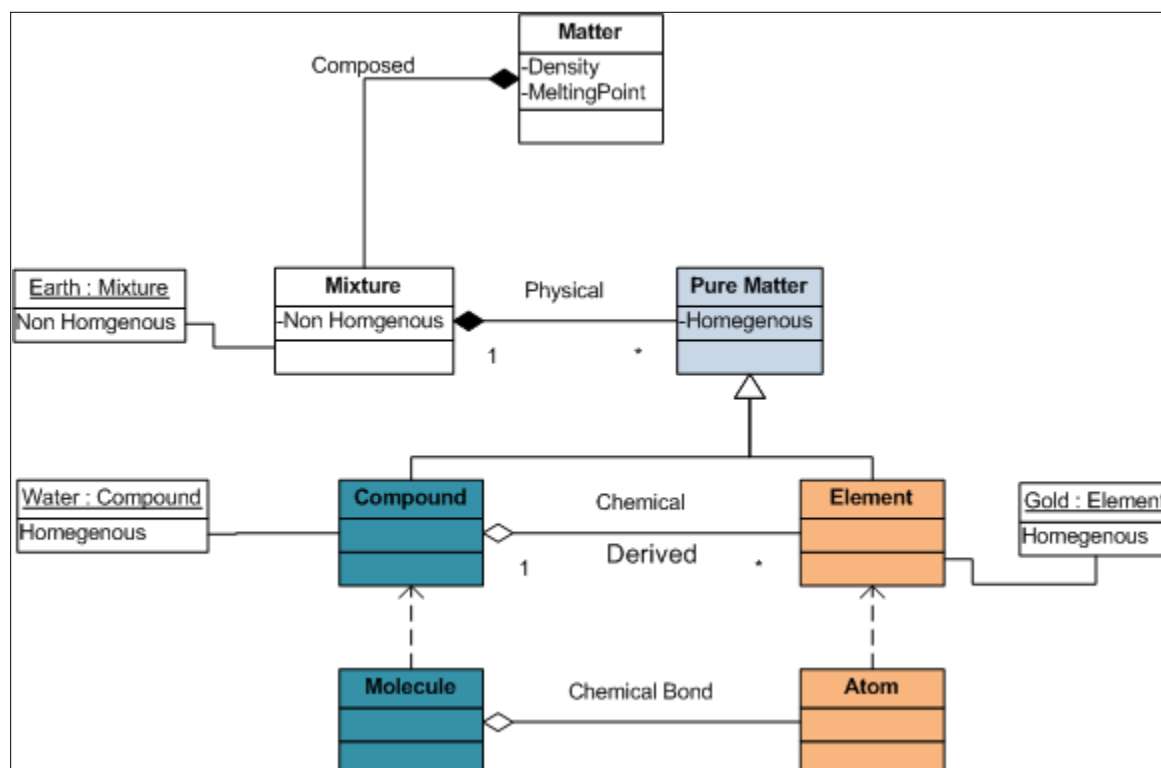
Even the chemical model of atoms has several complex concepts that will prove crucial. The following statements will cover concepts we all “understand:” intuitively but will prove very difficult to specify with rigor and precision. We are breaking all matter into three types. “Pure” elements which have definite properties like density, specific gravity, boiling and melting point and compounds which are composed from elements in fixed proportions. Compounds and elements have same properties in all places. They are homogenous and properties do not vary at the edges or inside a block of the compound. Mixtures are non-homogenous combination of elements or compounds and the properties vary by location. Mixtures can be separated by physical methods (Filtration, centrifuge ...) into those components compounds and elements. Compounds cannot be separated into its constituent elements by physical methods but by chemical reactions. *The smallest part of pure elements that have the same property as the larger block of the element is the Atom. The smallest part of a compound that has the same property as the compound is the Molecule.* Molecules are built from elements in a fixed proportion and held together by chemical bonds. A UML representation⁴ may look like this:

³ Microbes maketh Man <http://www.economist.com/node/21560559?frsc=dg%7Cd>

⁴ The UML diagram are used for illustration and are not intended to specify the models being discussed. For lucidity of presentation some liberties have been taken in the notation and visual presentation. See [Annexure : A quick introduction to the UML](#)

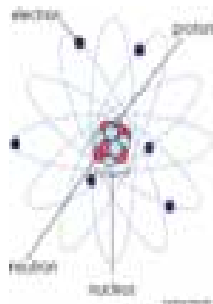
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Figure 1 Chemical Model



I am glossing over the distinction between physical and chemical transformations. Originally Atoms were considered indivisible. This is the core philosophical requirement of all models and philosophy. However the chemical Atom has proven to be divisible with consists of sub atomic particles like Electrons and protons. The smallest piece of interest for the chemist however is the Atom and they are not interested in smaller subdivisions.

Model of Matter: Second Cut the Bohr Model of the Atom



In 1911 Rutherford showed that the chemical Atoms may lend to a finer model where they are composed or created from sub atomic particles. The Bohr Model⁵ introduced in 1913 by Danish physicist Niles Bohr served a foundation for many years. Atoms consist of negatively charged Electrons circling positively charged Nuclei consisting of Protons and Neutrons. The Bohr Model or Quantum Electro Dynamics (QED) has an elaborate scheme of shells at different energy levels (distance from nuclei) where electrons buzz around and what are stable configurations. It predicts the energy level of emitted LASER beams as electrons jump from a higher level to lower level. The

⁵ See http://en.wikipedia.org/wiki/Bohr_model

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predicted frequencies are very precise and have been tested to be accurate to 12 or more digits of accuracy⁶!!

The Bohr Model had a remarkable convergence with the Periodic Table⁷ of chemists and added even more explanatory power to the Periodic Table. The periodic Table groups elements by certain similarities like atomic mass, Metal/Non-metal, Crystal Structure, Alkali, Gas. The Bohr Model of Atom allowed chemist to correlate this with the atomic number (Number of Protons) and the number of electrons in the outermost shell of the atom.

The current table is generally credited to [Dmitri Mendeleev](#), who developed it in 1869 to illustrate periodic trends in the properties of the then-known elements; the layout has been refined and extended as [new elements](#) have been discovered and new theoretical models developed to explain chemical behavior. Mendeleev's presentation also predicted some properties of [then-unknown elements](#) expected to fill gaps in his arrangement; most of these predictions were proved correct when those elements were discovered and found to have properties close to the predictions.

V · T · E [hide]

Periodic table (standard form)

Group →	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
↓ Period																		
1	1 H																	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	*	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	**	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Uut	114 Fl	115 Uup	116 Lv	117 Uus	118 Uuo
			* Lanthanides	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
			** Actinides	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

This is an 18-column periodic table layout, which has come to be referred to as the **common** or **standard form**, on account of its popularity. It is also sometimes referred to as the *long form*, in comparison to the *short form* or *Mendeleev-style*, which omits groups 3–12. The *wide periodic table* incorporates the lanthanides and the actinides, rather than separating them from the main body of the table. The *extended periodic table* adds the 8th and 9th periods, including the superactinides.

Some element categories in the periodic table									
Metals					Metalloids	Nonmetals			Unknown chemical properties
Alkali metals	Alkaline earth metals	Inner transition metals	Transition metals	Post-transition metals		Other nonmetals	Halogens	Noble gases	
		Lanthanides	Actinides						
Color of the atomic number shows state of matter (at standard conditions: 0 °C and 1 atm):					Border shows natural occurrence:				
black=Solid	green=Liquid	red=Gas	grey=Unknown		Primordial	From decay	Synthetic		

84 of the 114 elements recognized till 2012 occur in nature and 14 (especially the heavier ones) occur in decay reactions and are transient. We will see the same pattern in the sub atomic particles where atomic physicist are trying to produce their version of the periodic table. The heavier sub atomic particles are transient and decay quickly into smaller particles.

⁶ http://en.wikipedia.org/wiki/Precision_tests_of_QED

⁷ http://en.wikipedia.org/wiki/Periodic_table

God plays Dice

This ability to predict new features or properties which are subsequently verified by experiments are the hallmark of the scientific method and all models (Theory) are subject to challenge if the empirical facts do not fit. The march of Science consists of major paradigm shift⁸ as gradual accumulation of anomalies in theory lead to a radical change to a new theory which better explains the facts. The adoption of QED was very controversial.

In the late 1920's quantum mechanics was producing a paradigm shift in the way we think of measurement and causality. Einstein won the Nobel prize for showing that Light which is normally considered a wave behaves (sometimes) like a particle (photo electric effect) . Bohr and his colleagues were busy trying to make particles behave like waves. See <http://hyperphysics.phy-astr.gsu.edu/hbase/mod1.html> . This wave particle duality⁹ was a radical shift in our way of thinking.

Unlike classical physics QED assumes a fundamental uncertainty about a particle (Heisenberg Uncertainty Principle).¹⁰ So electrons are fuzzy and zooming around the nuclei as a cloud or wave with non zero probability of being anywhere specific. Only when they interact or are measured does their positions get resolved. Also it is not an error of experimental tools or techniques but a fundamental nature of the world that we cannot precisely know both the position and the momentum of a particle. Determinism implies our ability to predict outcomes based on laws and initial (starting) conditions. QED introduces probabilistic approach and removes strict determinism. More radically it removes "objective" external observer. In quantum physics, the observer is no longer external and neutral, but through the act of measurement he becomes himself a part of observed reality. This marks the end of the neutrality of the experimenter.

The paradigm shift led to an epic clash at the Fifth Solvay Conference¹¹ in 1927. This probably was the most intense debate by the greatest minds of that generation (17 of 29 participant were or became Nobel prize winners) . The realists led by Einstein would pose a puzzle and the instrumentalists led by Bohr would work overnight and propose a resolution next day. This went on for many days. Einstein famously said "God does not play Dice". To which Bohr replied "Stop telling God..."¹²

This statistical interpretation is now universally accepted as the best possible interpretation for quantum mechanics, even though many people are unhappy with it. People had got used to the determinism of the last century, where the present determines the future completely, and they now have to get used to a different situation in which the present only gives one information of a statistical nature about the future. A good many people find this unpleasant; Einstein has always objected to it. The way he expressed it was: "The good God does not play with dice". Schroedinger also did not like the statistical interpretation and tried for many years to find an interpretation involving determinism for his waves. But it was not successful as a general method. I must say that I also do not like indeterminism. I have to accept it because it is certainly the best that we can do with our present knowledge. One can always hope that there will be future developments which will lead to a drastically different theory from the present quantum mechanics and for which there may be a partial return of determinism. However, so long as one keeps to the present formalism, one has to have this indeterminism.

(P.A.M. Dirac, "The Development Of Quantum Mechanics" Conferenza Tenuta il 14 Aprile 1972, in Roma, Accademia Nazionale dei Lincei, 1974)

⁸ Thomas Kuhn who wrote [The Structure of Scientific Revolutions](#). This is an elegant theory of the complex social process by which scientist switch from one grand theory(Newtonian Physics) to another(Quantum).

⁹ See http://www.youtube.com/watch?v=4Z7yIfrx4xU&feature=player_detailpage for a basic introduction

¹⁰ <http://www.thebigview.com/spacetime/uncertainty.html>

¹¹ http://en.wikipedia.org/wiki/Solvay_Conference

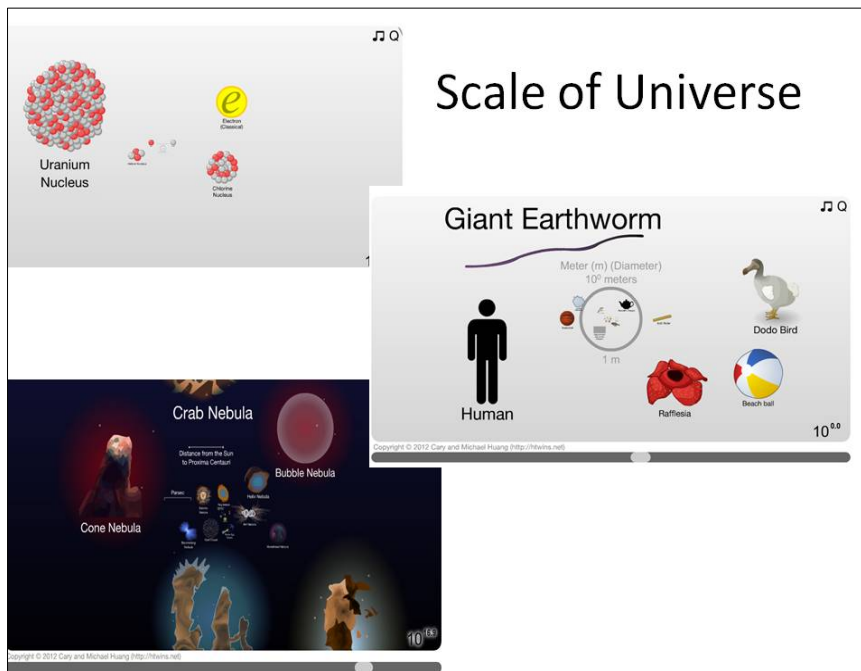
¹² A technical description of Einstein Bohr debate can be found at http://en.wikipedia.org/wiki/Bohr%E2%80%93Einstein_debates.

Energy Fields and Matter from Microcosm to Macrocosm.

QED model is far too complex for everyday use. Fortunately at large scale that we work every day they conform to more classical deterministic rules. Thus a copper wire may consist of 10^{24} Atoms oscillating in a Brownian or random motion but produce a well defined and constant resistance to electric charge as per Ohm's Law. This also was an original Einstein work.¹³ As aside this holds the promise of reconciling "Free Will" of individuals with sociological determinism of market researchers and Gallup forecasters for a large enough (Trillions) group of people....!!!

Thus at macro scale we may think of a lake filled with water as a field and see waves on its surface toss a basketball around. As we move closer to the size of the water molecules which constitute water ie 10^{-8} meters we begin to experience random molecules whizzing around in (vacuum !) with space between them.

Figure 2 Scale of Universe



As we go deeper at 10^{-10} meters we can experience the sub atomic world of the QED with electrons circling nuclei of the water molecules. Going inside the nuclei (10^{-14} m) is the stuff of the next model *The Standard Model* of subatomic physics.

Do take a quick virtual tour from the macrocosm (10^{26} Meters of the observable universe) to Microcosm(10^{-20} Meters) in the [The Scale of the Universe](#).

Physics is trying to find one unified grand theory.

Yotta to Yocto : The golden braid

The great surprise is that the nuclear physics of the sub atomic particles esp the components of proton , neutron etc are more important to cosmological explanations of the formation of the Universe, BIG BANG¹⁴ and "Dark matter"¹⁵ than to the civil or electronic engineer plying his/her trade.

¹³ <http://www.aip.org/history/einstein/brownian.htm>

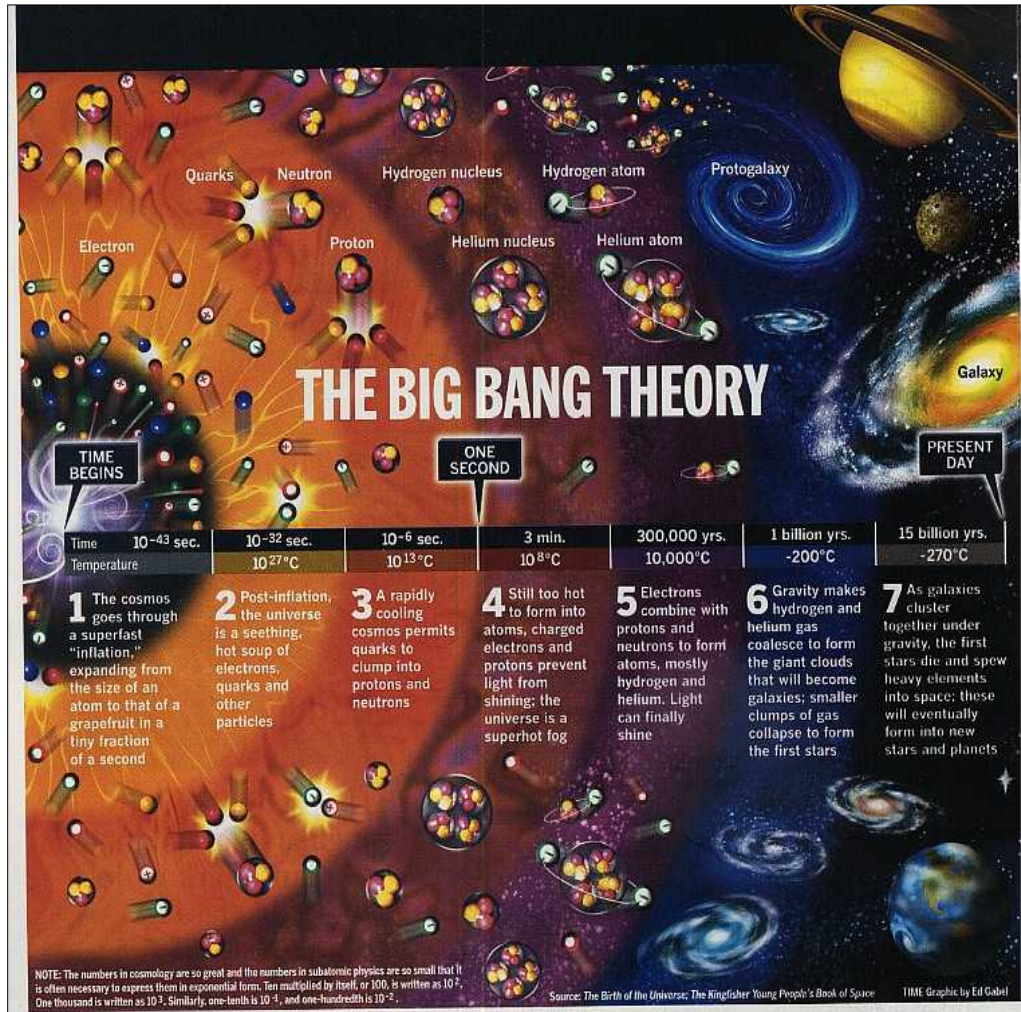
¹⁴ BIG Bang is concerned with the events around 10^{-45} Second of the formation of universe and the evolution of the universe to the current 17 billion years (10^{17} Seconds) of expansion of the universe. See <http://www.big-bang-theory.com/>

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Is this a hint of cyclical nature of reality (the furthest point from the north pole is actually very close to the north pole after we have circumnavigated back from the south pole on the other side !!!) Far into the future (17 billion years after BIG BANG) and at great scale (millions of light years) we are close to the BIGBANG and within the nuclear particles

See [Creation of a Cosmology](#) .

Figure 3 Creation of Cosmos



**William Blake -
Auguries of
Innocence**

To see a world in
a grain of sand,

And a heaven in
a wild flower,

Hold infinity in
the palm of your
hand,

And eternity in an
hour.

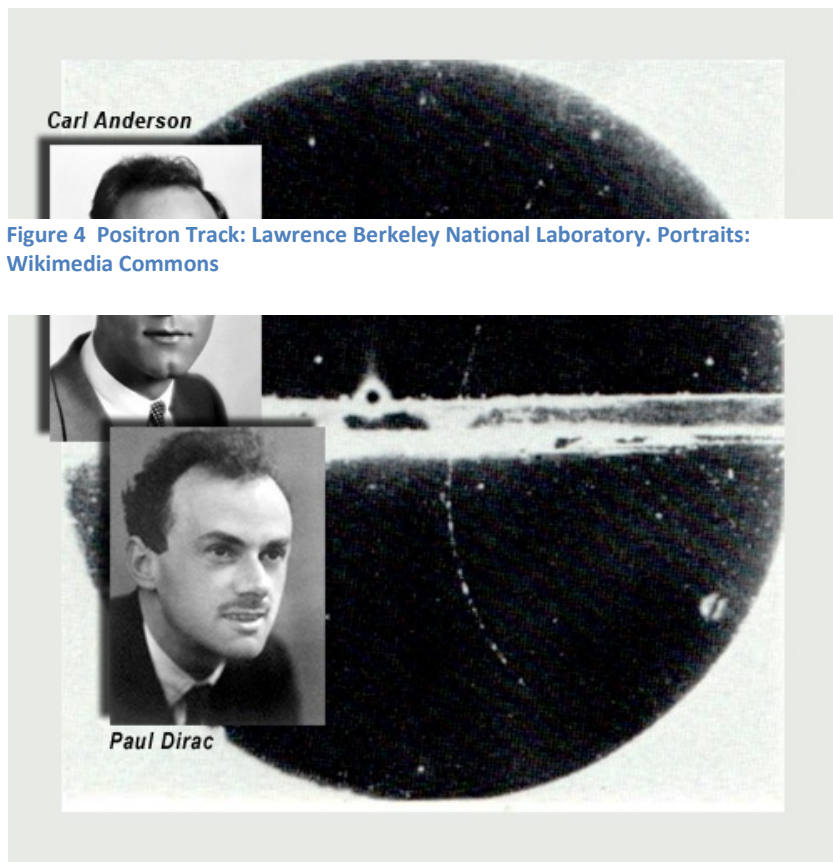
¹⁵ <http://science.nasa.gov/astrophysics/focus-areas/what-is-dark-energy/>

Radioactivity and Antimatter: The Sub Atomic Particle Zoo

Nuclear physicist discovered a new world of particles as they researched radiation and radioactivity¹⁶. [Radioactivity](#) was discovered by A. H. Becquerel in 1896. The radiation was classified by E. Rutherford as alpha, beta, and gamma rays¹⁷ according to their ability to penetrate matter and ionize air.

Cosmic rays (solar flare) are rich sources of particles that hit earth. The decay of large atoms leads to a more particles. These were originally tracked in cloud chambers¹⁸. A nuclear physicist had to cut his teeth studying the tracks created in cloud chambers. It is here that much of the original work around the sub atomic particle zoo was done and the discovery of the anti electron the positron which

gave a massive confirmation to emerging new model of the nucleus. The positron as the antiparticle of the electron was predicted by Dirac ("[On the quantum theory of electron](#)":1928). First experimental indications of an unknown particle were found in cloud-chamber photographs of cosmic rays (Anderson 1932). This particle was identified later as the positron¹⁹, which was thus the first antiparticle in physics. This established Quantum Field Theory (QFT). Dirac was trying to incorporate relativistic effects in Quantum mechanics (QED) to better predict results for particles moving close to the speed of light. His major contribution was to quantize fields (Electromagnetic) by converting the continuous field (Einstein) using discrete states of harmonic oscillators. QFT is the foundation of the Standard model and gauge theories of



¹⁶ <http://hyperphysics.phy-astr.gsu.edu/hbase/nuclear/radact.html#c5>

¹⁷ Alpha - these are fast moving helium atoms. They have high energy, typically in the MeV range, but due to their large mass, they are stopped by just a few inches of air, or a piece of paper. Beta - these are fast moving electrons. They typically have energies in the range of a few hundred keV to several MeV. Since electrons are much lighter than helium atoms, they are able to penetrate further, through several feet of air, or several millimeters of plastic or less of very light metals. Gamma - these are photons, just like light, except of much higher energy, typically from several keV to several MeV. X-Rays and gamma rays are really the same thing, the difference is how they were produced. Depending on their energy, they can be stopped by a thin piece of aluminum foil, or they can penetrate several inches of lead.

¹⁸ <http://www.s-cool.co.uk/a-level/physics/radioactivity/revise-it/cloud-and-bubble-chambers>

¹⁹ Positron Emission Tomography (PET) is a application of particle imaging for investigation of biological functions See <http://www.cc.nih.gov/pet/index.html>

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matter and in hindsight a monumental solitary achievement for a young physicist. Study of cosmic rays and radioactive decay lead to the finding many particles like the mu meson (muon 1936), pi meson (pion 1947) etc. Fermi predicted a “neutral electron” or neutrino which was discovered in 1956²⁰. As nuclear physicist have been able to study interactions at higher energy levels thru colliders they have seen an explosion of particles like psi/J (1974, Stanford & Brookhaven), Upsilon (Fermilab 1977) etc.²¹

Figure 5 The sub atomic particle zoo

ELEMENTARY PARTICLES				
The elementary particles are those subatomic particles that are not made up of smaller units. They include the quarks, the leptons, and the gauge bosons. The antiparticles of the quarks and leptons are also elementary particles. Each of these elementary particles interacts with other elementary particles through one or more forces. These forces are mediated (carried) by the gauge bosons. The photon mediates the electromagnetic force, the gluon mediates the strong nuclear force, the intermediate vector bosons mediate the weak nuclear force, and the graviton (if it exists) mediates gravity.				
Family Name	Particle Name	Approximate Mass*	Electric Charge	
Quarks	up (symbol u ^{**})	10	$+\frac{2}{3}$	
	down (symbol d)	20	$-\frac{1}{3}$	
	charm (symbol c)	2,935	$+\frac{2}{3}$	
	strange (symbol s)	391	$-\frac{1}{3}$	
	top (symbol t)	352,000	$+\frac{2}{3}$	
	bottom (symbol b)	9,200	$-\frac{1}{3}$	
Leptons	electron	1	-1	
	electron neutrino	$<3 \times 10^{-9}$	0	
	muon	207	-1	
	muon neutrino	<0.33	0	
	tau	3,480	-1	
	tau neutrino	<59	0	
Gauge Bosons	photon	0	0	
	graviton	0	0	
	gluon	0	0	
	W boson	160,000	-1 or +1	
	Z boson	182,000	0	
*Masses are expressed as multiples of an electron's mass, 9.1066×10^{-31} g, and are approximate.		**The antiparticles of the quarks are denoted by the same symbols as the quarks but with a bar over the symbols, as in \bar{u} .		
SUBATOMIC PARTICLES THAT ARE NOT ELEMENTARY PARTICLES				
Family Name	Particle Name	Composition	Approximate Mass*	Electric Charge
Baryons	proton	uud	1,836	+1
	neutron	udd	1,839	0
	lambda	uds	2,183	0
	lambda-b	udb	11,000	0
	lambda-c	udc	4,471	+1
	sigma	$uus \text{ or } (u\bar{u} \pm d\bar{u})s/\sqrt{2}$ or dds	2,328 or 2,334 or 2,343	+1 or 0 or -1
	xi	uss or dss	2,572 or 2,585	0 or -1
	xi-c	dsc or usc	4,834 or 4,826	0 or +1
	omega	sss	3,272	-1
	omega-c	ssc	5,292	0
Mesons	pion	$u\bar{d} \text{ or } (u\bar{u}-d\bar{d})/\sqrt{2}$	273 or 264	+1 or 0
	kaon	us or ds	966 or 974	+1 or 0
	J/psi	c \bar{c}	6,060	0
	omega	$(u\bar{u}+d\bar{d})/\sqrt{2}$	1,532	0
	eta	$(u\bar{u}+d\bar{d})/\sqrt{2}$	1,071	0
	eta-c	c \bar{c}	5,832	0
	B	d \bar{b} or u \bar{b}	10,331 or 10,331	0 or +1
	B-s	s \bar{b}	10,507	0
	D	c \bar{u} or c \bar{d}	3,649 or 3,658	0 or +1
	D-s	c \bar{s}	3,852	+1
	chi	c \bar{c}	6,687	0
	psi'	c \bar{c}	7,213	0
	upsilon	b \bar{b}	18,513	0

Catherine Hawkes, Cat & Mouse

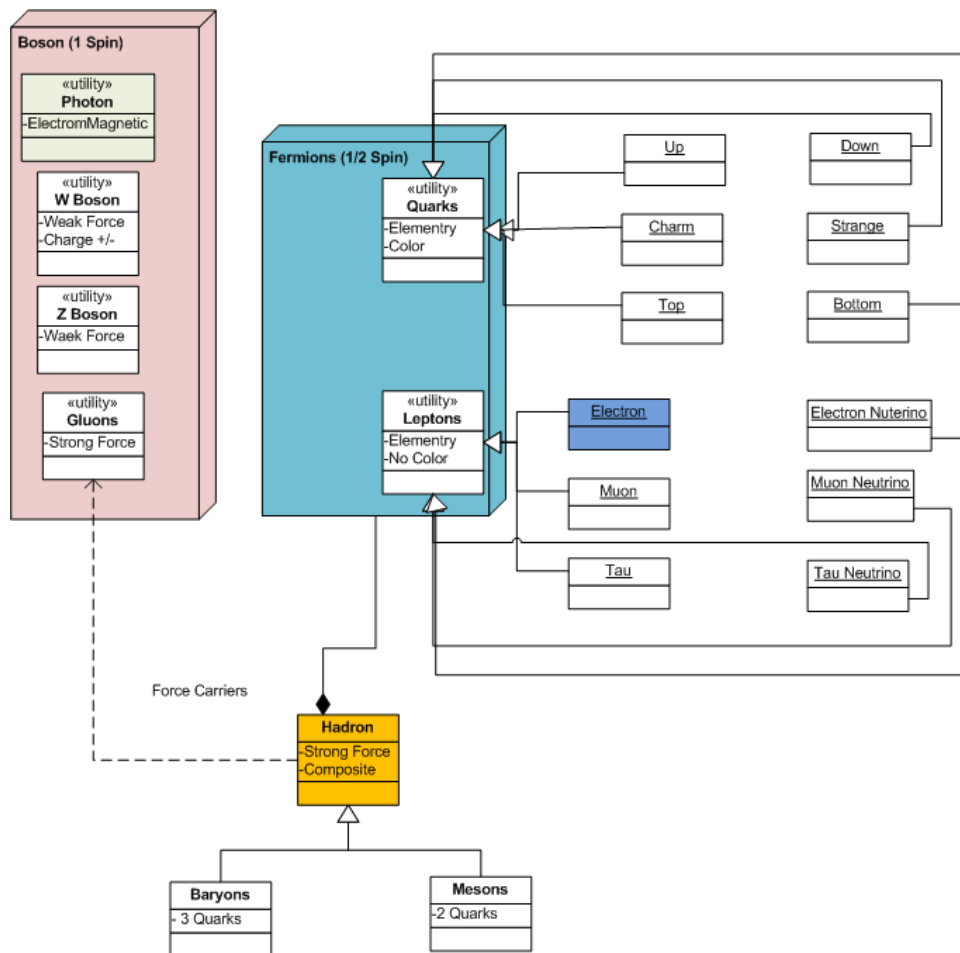
²⁰ <http://icecube.wisc.edu/info/neutrinos/>

²¹ <http://hyperphysics.phy-astr.gsu.edu/hbase/particles/hadron.html>

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They soon needed a periodic table of sub atomic particles a “Atomic” theory of what constitutes these particles. This is the Standard Model which posits 47 more elementary particles like quarks and leptons which combine to create composite particles (Hadrons) like electrons, protons , neutrons and all other. See Figure 4 The sub atomic particle zoo. Quantum Chromo dynamics (QCD) is the attempt to develop a model to explain the Strong Force and the structure of Nucleus (Neutrons, Protons etc) and uses quarks and their properties²² (C harm, Strangeness ...). This is distinct from Quantum Electro Dynamics QED and Quantum Field Theory QFT which are more focused on electromagnetic interactions outside the nucleus.

Figure 6 Quantum Chrono Dynamics (QCD)



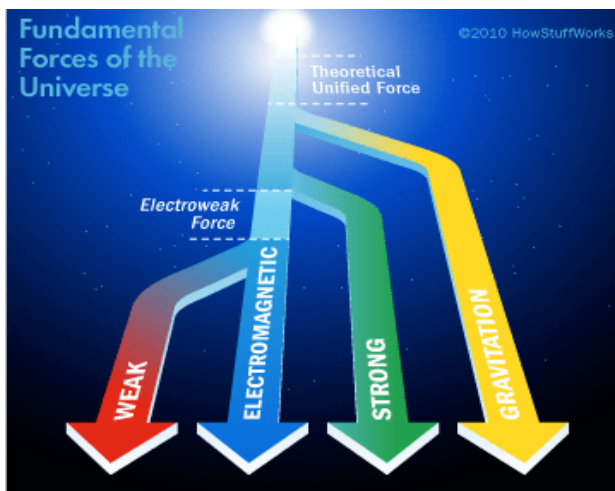
²² In building their sub atomic periodic table nuclear physicist had to give names to properties of these particles. These names like charm, color are “Alice in Wonderland type names. *It is wise not to read too much into the meaning of the property from the name.*

Energy of Fields and their mediating particles

QFT considers fields as exerting force on particles thru exchange of virtual particles or carriers of the field. QFT also considers the following as fundamental forces

- **Strong** - holds the nucleus of the atom together. Proposed by [Yukawa Hideki](#) in 1935 as binding protons within the nucleus else positively charged protons would be repelled by electromagnetic field. These were supposed to be mediated by mesons. The standard Model assigns this role to Gluons. Active within the nucleus (10^{-14} M)
- **Weak** - involved in radioactive decay. Mediated by vector bosons (Z, W)
- **Electromagnetism** - interactions between charged particles (electricity and magnetism) mediated by photons.
- **Gravity** - attractive force based on mass and distance. Not integrated into QED/QFD but some proposals to quantize gravity predict gravitons as carriers.

Figure 7 Fundamental Forces of Nature



Currently weak and electromagnetic forces are considered different facets of a more basic field (Electroweak theory). This theory was proposed in 1970 and postulates a Higgs field permeating the universe²³. They suggested that all particles had no mass just after the Big Bang. As the Universe cooled and the temperature fell below a critical value, an invisible force field called the 'Higgs field' was formed together with the associated 'Higgs boson'. The field prevails throughout the cosmos: any particles that interact with it are given a mass via the Higgs boson. The more they interact, the heavier they become, whereas

particles that never interact are left with no mass at all²⁴. More formally, in the standard model of particle physics, the existence of the Higgs boson explains how spontaneous breaking of electroweak symmetry takes place in nature.

Since Electromagnetic and Gravity are felt at our human scale they are expected to be mediated by (Virtual) zero mass photon or gravitons. Since weak and strong force work at much smaller scale their carriers are expected to be heavy and the Z,W and now the Higgs Boson are indeed very heavy particles. It is a big relief that it may have been found²⁵.

²³ <http://www.youtube.com/watch?v=9Uh5mTxRQcg>

²⁴ http://www.youtube.com/watch?v=ASRpIym_jFM&feature=relmfu

²⁵ <http://scienceblogs.com/startswithabang/2012/07/03/the-biggest-firework-of-them-all-the-higgs/>

The Atomic Theory of matter is dead. Long live Atomic Theory

It will take another five years and many more experiments to confirm the Higgs Boson but scientists are 90% sure they have their man.

The search is on for unifying all the fields into one Unified Field...

The mass of a particle is felt as a drag/inertia in a field. The drag is created by interactions with virtual particles that carry the field and fill space. Fields have energy. Particles have energy. The Particles can behave as waves and waves as fields. .

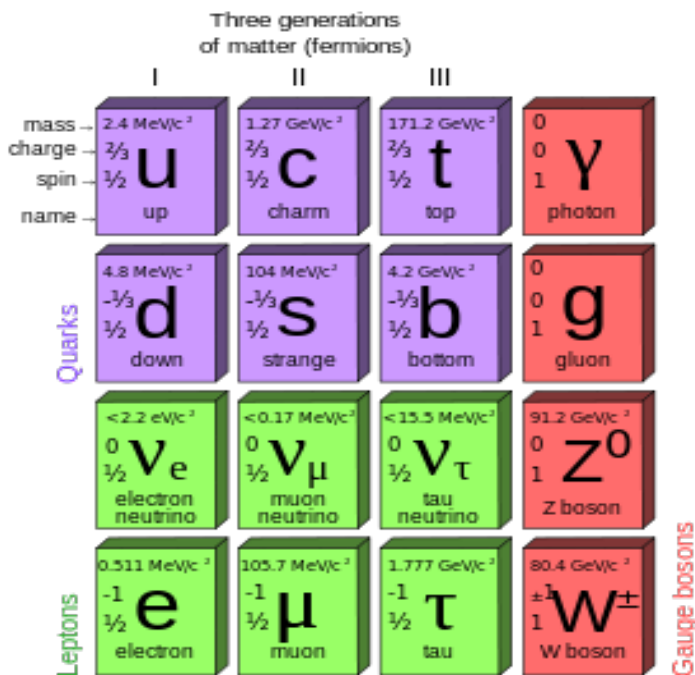
Model of Matter : Third Cut The Standard Model

In building their sub atomic periodic table nuclear physicist had to give names to properties of these particles. These names like charm, color are “Alice in Wonderland type names. *It is wise not to read too much into the meaning of the property from the name.*

We do not intend to dwell on the standard model and encourage the reader to read the slightly lengthy and technical article in the [Encyclopedia Britannica](http://www.britannica.com/EBchecked/topic/570533/subatomic-particle).²⁶

The Standard Model covers 61 particles (47 elementary particles with 14 force carriers) . These are arranged in three columns (generations) and two rows (types) much like the chemical periodic table. For simplicity the antiparticle and color variations are not shown.

Figure 8 Standard Model (Wikipedia)



²⁶ <http://www.britannica.com/EBchecked/topic/570533/subatomic-particle>

Highlights of the Standard Model extracted from Wikipedia ²⁷

“ The Standard Model includes 12 [elementary particles](#) of [spin](#) $\frac{1}{2}$ known as [fermions](#). According to the [spin-statistics theorem](#), fermions respect the [Pauli exclusion principle](#). Each fermion has a corresponding [antiparticle](#).

The fermions of the Standard Model are classified according to how they interact (or equivalently, by what [charges](#) they carry). There are six [quarks](#) ([up](#), [down](#), [charm](#), [strange](#), [top](#), [bottom](#)), and six [leptons](#) ([electron](#), [electron neutrino](#), [muon](#), [muon neutrino](#), [tau](#), [tau neutrino](#)). Pairs from each classification are grouped together to form a [generation](#), with corresponding particles exhibiting similar physical behavior (see table).

The defining property of the quarks is that they carry [color charge](#), and hence, interact via the [strong interaction](#). A phenomenon called [color confinement](#) results in quarks being perpetually (or at least since very soon after the start of the [Big Bang](#)) bound to one another, forming color-neutral composite particles ([hadrons](#)) containing either a quark and an antiquark ([mesons](#)) or three quarks ([baryons](#)). The familiar [proton](#) and the [neutron](#) are the two baryons having the smallest mass. Quarks also carry [electric charge](#) and [weak isospin](#). Hence they interact with other fermions both [electromagnetically](#) and via the [weak interaction](#).

The remaining six fermions do not carry colour charge and are called leptons. The three [neutrinos](#) do not carry electric charge either, so their motion is directly influenced only by the [weak nuclear force](#), which makes them notoriously difficult to detect. However, by virtue of carrying an electric charge, the electron, muon, and tau all interact electromagnetically.

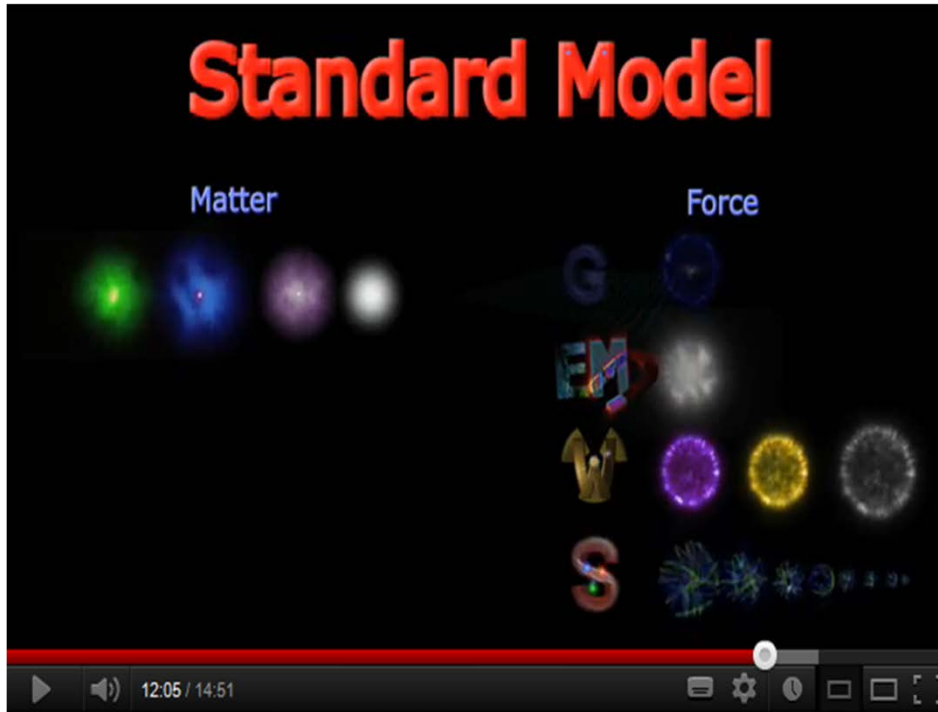
Each member of a generation has greater mass than the corresponding particles of lower generations. The first generation charged particles do not decay; hence all ordinary (baryonic) matter is made of such particles. Specifically, all atoms consist of electrons orbiting [atomic nuclei](#) ultimately constituted of up and down quarks. Second and third generations charged particles, on the other hand, decay with very short half lives, and are observed only in very high-energy environments. Neutrinos of all generations also do not decay, and pervade the universe, but rarely interact with baryonic matter. “

Hadrons or all non elementary particles like protons, mesons etc are made from Fermions as shown in Figure 5 The sub atomic particle zoo. Thus Proton is made up of two up quarks and a down quark (uud) while a Neutron is composed of one up quark and two down quarks (udd).

²⁷ http://en.wikipedia.org/wiki/Standard_Model

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Figure 9 Video The Standard Model

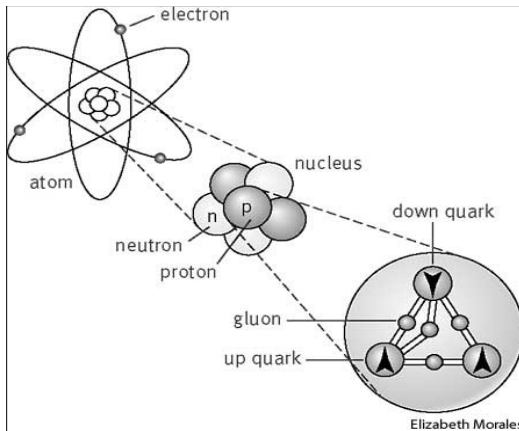


A good flavor of

how the model attempts to explain the BIG bang and cosmology can be viewed in this video [“ You Tube Standard Model “](#). It is a simplified and sometimes inaccurate presentation but gets the big ideas across well.

Matryoshka Principle: Particles within particles within Particles...

Figure 10 Peeling the Layers of "indivisible" particles



The Russian Matryoshka dolls are popular examples of recursion where a large doll contains a similar smaller doll which may again contain a similar smaller doll. As of now the search for that indivisible smallest part of matter is like peeling onions. We start with the Chemical Atom as the smallest “indivisible” part and this is peeled by atomic physics to reveal another smaller “indivisible” part of Electrons and Neutron and Proton. This layer of the onion is also peeled by Nuclear physics and reveals quarks and leptons.

Are we done with the layers of the onion? Is this the end?

We do not know for sure.

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Nuclear physicists are comfortable that for their enquiry they do not need to peer at another layer underneath the Quark and Bosons. However there are a number of anomalies (Dark matter and Dark Energy ...) that the Standard Model does not address. There are competing theories like String Theory²⁸ in the wings. Their time may yet come.

String theory considers particles to be fluctuations in energy levels of a omnipresent field. *Thus we change from looking at the figure (particle) of the painting (World) and see the background (field) as the main actor.*

The first Yuri Milner Fundamental Physics Prize²⁹ (richer then the Nobel) were awarded among others to Dr Ashok Sen for his work in string theory.

The death of Atomic Theory

Is atomic theory dead? There is no indivisible particle. We can always peer deeper and see more “elementary “particles as long as we want....

This would be quiet a sea change. The Nobel Laureate and great teacher Richard Feynman held the Atomic Theory as the “ultimate learning “of Science

If, in some cataclysm, all of scientific knowledge were to be destroyed, and only one sentence passed on to the next generation of creatures, what statement would contain the most information in the fewest words? I believe it is the atomic hypothesis that

All things are made of atoms-little particles that that move around in perpetual motion, attracting each other when they are a little distance apart, but repelling upon being squeezed into one another.

In that one sentence, you will see, there is an enormous amount of information about the world, if just a little imagination and thinking are applied.

<http://www-scf.usc.edu/~kallos/feynman.htm>

Each layer of the “indivisible” matter covers smaller size of space and shorter duration of time just like the onion becomes smaller as we peel it!!!

Is it possible that there is no end to the layers of onion that we have to peel off? Is there infinite recursion?

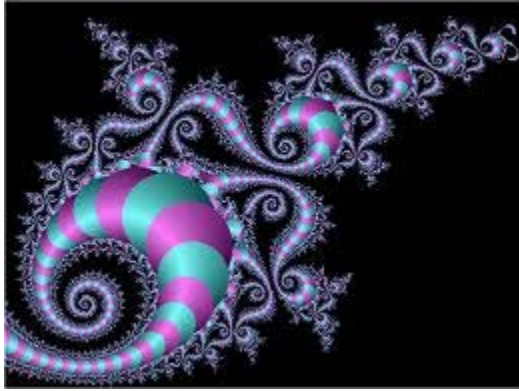
²⁸ <http://www.superstringtheory.com/>

²⁹ See <http://www.siliconindia.com/news/general/Indian-Scientist-Ashoke-Sen-Wins-Worlds-Richest-Academic-Prize--nid-125118-cid-1.html%20>

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Fractal mathematics provides a hint of self similarity occurring in a recursive manner.

Figure 11 Infinite recursive Self Similarity Fractals



See <http://en.wikipedia.org/wiki/Fractal>

We find many patterns in nature such as the coastline, leaves, beating heart, stock prices that display fractal nature but on a finite (not necessarily small) scale. Does layers of atomic and elementary particles actually stop at some level?

Singularity and Heterarchy

Infinite recursion is a problem that already occurs in QED. Richard Feynman introduced renormalization to escape infinite recursion in deriving the mass of the electron. Extracts from Wikipedia:Renormalization Group³⁰

In [theoretical physics](#), the **renormalization group (RG)** refers to a mathematical apparatus that allows systematic investigation of the changes of a physical system as viewed at different *distance scales*. In particle physics, it reflects the changes in the underlying force laws (codified in a [quantum field theory](#)) as the *energy scale* at which physical processes occur varies, energy/momentum and resolution distance scales being effectively conjugate under the [uncertainty principle](#) (cf. [Compton wavelength](#)).

A change in scale is called a "[scale transformation](#)". The renormalization group is intimately related to "scale invariance" and "conformal invariance", symmetries in which a system appears the same at all scales (so-called [self-similarity](#)). (However, note that [scale transformations](#) are included in [conformal transformations](#), in general: the latter including additional symmetry generators associated with [special conformal transformations](#).)

As the scale varies, it is as if one is changing the magnifying power of a notional microscope viewing the system. In so-called renormalizable theories, the system at one scale will generally be seen to consist of self-similar copies of itself when viewed at a smaller scale, with different parameters describing the components of the system. The components, or fundamental variables, may relate to atoms, elementary particles, atomic spins, etc. The parameters of the theory typically describe the interactions of the components. These may be variable "[couplings](#)" which measure the strength of various forces, or mass parameters themselves. The components themselves may appear to be composed of more of the self-same components as one goes to shorter distances.

For example, in [quantum electrodynamics](#) (QED), an electron appears to be composed of electrons, positrons (anti-electrons) and photons, as one views it at higher resolution, at very short distances. The electron at such short distances has a slightly different electric charge than does the "[dressed electron](#)" seen at large distances, and this change, or "running," in the value of the electric charge is determined by the renormalization group equation.

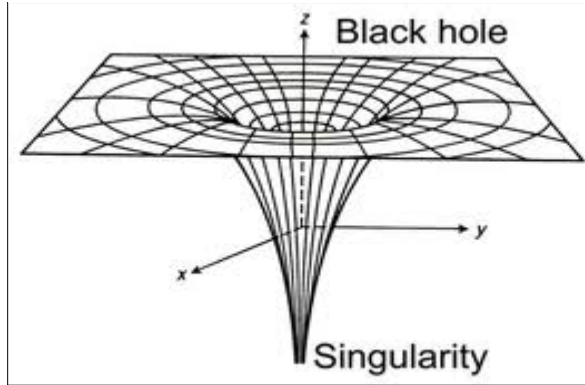
Conceptually the mathematics allows us to treat the infinite recursions as a "singularity" where the current mathematical laws break down like dividing zero by zero an undefined operation and then allows

³⁰ http://en.wikipedia.org/wiki/Renormalization_group

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us to substitute the actually observed values as the answer. (*And you thought only students cheat in exams...*)

Figure 12 Hawking Penrose Singularity aka Black Hole



In Cosmology a singularity³¹ like a Black Hole may lead to a departure from laws of a larger scale and lead to a newer dimension and alternate laws to dominate³². *Can we have a singularity in the microcosm rivaling the one in the macrocosm? At what scale do matter collapse into a singularity in the microcosm?*

Another way of breaking out from infinite self similar recursion is a heterarchical model . This is a more sophisticated version of “Which came first? chicken or the egg “. Answer neither³³, a new dimension has to be introduced to resolve the issue .

“You can’t solve a problem on the same level that it was created. You have to rise above it to the next level.” – **Albert Einstein**

Formally a Heterarchy is a tree where there is no root or top and the graph of nodes seems to invert as what is top becomes a child of another node. . The Artist M.C Escher is famous for using self similarity and inversion (a hallmark of heterarchy) and challenging all our established notions.

In the drawing below which hand is the creator and drawing the other?

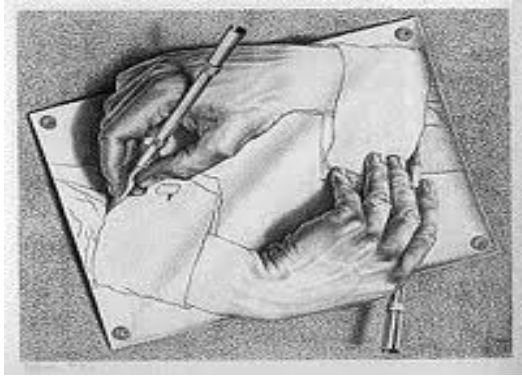
³¹ <http://en.wikipedia.org/wiki/Singularity> Penrose hawking singularity deal with black holes

³² On a personal note in 1980 while studying for M.Sc(Physics) at IITK the author speculated that a black hole and a white hole were the obverse of each other funneling energy from one universe to another in the multiworld interpretation of Quantum mechanics. The math’s to express this notion were far beyond the authors capabilities

³³ : God or Darwinian mutation driven by randomness evolved new forms (take your pick)

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Figure 13 Heterarchy or inversion in Escher's works



Inversion is the central “surprise” in a Heterarchy as the “master” become a “slave”.

Douglas R. Hofstadter covered a lot of ground in his seminal book **Gödel, Escher, Bach: an Eternal Golden Braid**³⁴.

An extract from the website <http://tal.forum2.org/geb> will give a flavor of the work.

It is a book that attempts to discover what “self” really means. Introducing the reader to cognitive science, *Gödel, Escher, Bach* draws heavily from art to illustrate fine points in mathematics. The works of M.C. Escher and J.S. Bach are discussed, in addition to other works of art and music. The topics presented range from mathematics and meta-mathematics to programming, recursion (in math as well as in computing), formal systems, multilevel systems, self reference, self representation, and others.

.....

Self-representation (self-rep), on the other hand, is the more complex notion of an object that includes, within itself, a complete representation of itself. This is more complicated to achieve, but one easy to grasp example would be a mirror facing another mirror. Each of these mirrors contains a complete representation of itself (in fact, it contains an infinite number of such complete self-representations, each smaller than the other).

³⁴ On a personal note eternal thanks to Sudip Nandy for introducing me to this tour-de-force.

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In Vedic Philosophy the world is composed of atoms (parmanu) but is sustained by Consciousness and ruled by Thought.

Feynman thought the atomic hypothesis was the single most important learning in Science. Maybe we should restate to

The central learning or most important thing we need to preserve and pass on to any future generation is the amazing ability of pure thought (mathematical formulations of physics are pure thought) to govern the material world. And the recurrence of magic numbers (Pi) etc or universal constants which determine process at all scale from sub atomic (10^{-23} m) to cosmic(10^{+26} m)

Thought does explain or rule the world!!! We are yet to decide if it creates and sustains also?

The quest of the ultimate atom leads to surprising place. That is as we peel the layers of the onion of the “indivisible “ particles we end up finding ourselves!!!

"*Tat Tvam Asi,*
Thou art That."

The theory of maya³⁵ is mis-translated as illusion but for a computer scientist like your author is more of a simulation being played out in a cosmic computer . Tipplers Omega point theory³⁶ and is also explored by Frank J. Tipler in “**The Physics of Immortality**: Modern Cosmology, God and the Resurrection of the Dead “.It builds on the computational capacity needed to simulate humans, the earth and the cosmos. Maya and Simulation are different ways of describing the playful nature of realty....

We are the creators of the simulation that we are experiencing...

The Matrix

“Matrix Reloaded” a 2003 film by [the Wachowskis](#) covers this well. Do read this telling and note the recursion of and inversion across time (Future to Past) and levels of simulation (Dreaming to Waking)

³⁵ http://www.ramakrishnavivekananda.info/vivekananda/volume_2/jnana-yoga/maya_and_illusion.htm

³⁶ http://www.conservapedia.com/Omega_Point_Theory

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Figure 14 Meaning of the Matrix Reloaded



<http://thematrix101.com/reloaded/meaning.php>

To end we quote Shakespeare

There are more things in heaven and earth, Horatio,
Than are dreamt of in your philosophy.

Hamlet Act 1, scene 5, 159–167

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Annexure : A quick introduction to the UML

Figures (1, 6) are based on the Unified Modeling Language (UML) used in Software design. Here is a working introduction ³⁷barely sufficient for the drawings used in this monograph.

The building blocks of UML can be defined as:

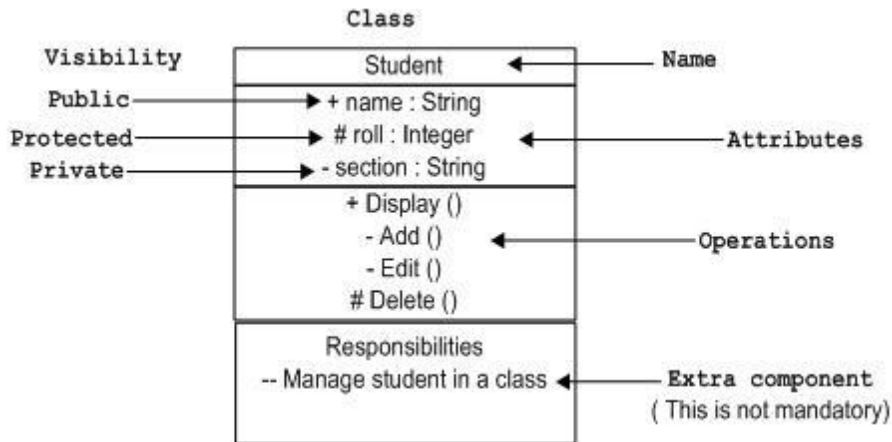
- Things
- Relationships
- Diagrams

We have used mostly structural diagrams and the following things and relationships

The **Structural things** define the static part of the model. They represent physical and conceptual elements. Following are the brief descriptions of the structural things.

Class:

Class represents set of objects having similar responsibilities.



Object

As object is the instance or implementation of a class. So it has the same usage as the class. The *object* is represented in the same way as the class. The only difference is the *name* which is underlined as shown below.

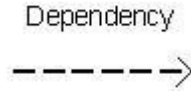
Relationship :

Relationship is another most important building block of UML. It shows how elements are associated with each other and this association describes the functionality of an application. There are four kinds of relationships available.

³⁷ Extracted from Tutorialspoint. See <http://www.tutorialspoint.com/uml/>

Dependency:

Dependency is a relationship between two things in which change in one element also affects the other one.



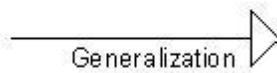
Association:

Association is basically a set of links that connects elements of an UML model. It also describes how many objects are taking part in that relationship.



Generalization:

Generalization can be defined as a relationship which connects a specialized element with a generalized element. It basically describes inheritance relationship in the world of objects.



Aggregation and Containment

It is an association that represents a part-whole or part-of relationship. *Aggregation* can occur when a class is a collection or container of other classes, but where the contained classes do not have a strong *life cycle dependency* on the container—essentially, if the container is destroyed, its contents are not. In [UML](#), it is graphically represented as a *hollow diamond shape* on the containing class end of the line with lines that connect contained classes to the containing class. If the contained classes are dependent on the container and do not exist independently then the diamond is shaded to show this.

