

# Physics

The Standard Model.

Unification of forces

Electro-Weak and Strong }  
 Lepto-quarks  $\sim 10^{15}$  GeV.  
 Proton Decay }

Gauge Theories.  
 Higgs Particle.

Hadrons ?  
 Photons ? }

Neutrinos  
 from 1987c  
 Super Novae. }

Phase Transitions of  
 the early Universe.

Something out of Nothing ?  
 Vacuum Power Engineering ?

How do the Unifications  
 translate into the  
 Early Scenarios of  
 the Expanding Cooling  
 Universe ?

Higgs Connection. True Vacuum  
 False Vacuum.

Phase Transitions

# Astronomy

- Pulsars - Neutron Stars
- X-ray Stars - Black Holes
- Accreting Binary Systems
- TeV and PeV astronomy
- Neutrino Astronomy

Outstanding problems

- (i)  $\frac{\text{Photon}}{\text{Baryons}} \sim 10^9$  ?
- (ii)  $\frac{\text{Anti-Matter}}{\text{Matter}} < 10^{-4}$  ?
- (iii) No Magnetic Monopoles ?
- (iv) No Mini Black Hole Explosions ?



## Consequences of Quantum Mechanics.

- "Viewed through a microscope of sufficient power (this being far beyond anything attainable in practice), the ultimate particles of matter would seem to move not like railway train running smoothly on tracks, but like kangaroos hopping about in a field"

Niels Bohr.

- Uncertainty principle. (Heisenberg)

If you want to predict the motion of a particle, you should know its present position and velocity accurately. How accurately can you determine its present position and momentum? There is a limit to this accuracy - because of the 'interference of the observer' - in the process of observing you change the position and momentum.

$$\Delta p \cdot \Delta x \geq \hbar$$

$$\Delta E \cdot \Delta t \geq \hbar$$

This uncertainty principle has tremendous philosophical implications which we have discussed later.

- Probabilistic Interpretation.

In general Quantum Mechanics does not predict a single definite result for any observation. It gives the relative probability of different possible outcomes - Superposition of States - Causality, Determinism, Free Will suffer a setback.

Quantum Mechanics does not provide a picture of what is happening from instant to instant in any dynamical system. The mathematics of Q.M. enables the calculation of the final probabilities.

The penetration through potential barrier as is required in the explanation of radioactive emissions

"Provision of pictures is not the aim of physical science."  
Dirac

## • Dirac's Relativistic Quantum Theory -

prediction of the anti-particle of the electron -

the discovery of the positron in 1932 by Anderson.

Discovery of anti-particles - Anti Proton, Anti Neutron -  
at accelerators. - Anti-worlds?

Particle - Anti-Particle Annihilation.

Development of Quantum Electro-Dynamics.

## • The Nuclear Forces - the Yukawa Meson.

How are the Protons and Neutrons held together in the nucleus? What prevents the protons repelling each other due to Coulomb forces and breaking the nucleus apart? What binds Neutrons to other Neutrons?

Systematic investigation were carried out on nuclear disintegrations, nuclear transmutation, scattering of particles using accelerated beams. The extremely short range of the nuclear force, the saturation effects etc. became clear. Still the nature of the nuclear force was a big puzzle.

Yukawa postulated that the Nuclear forces were mediated by the exchange of massive particles

'the Mesons' - a new concept of force itself.

He calculated the rough mass of the particle  $\approx 200 m_e$ .

① The Confirmation of many aspects of quantum theory, Yukawa theory, Relativity theory came from an investigation of Cosmic Radiation that had been discovered in 1912 by Victor Hess.

# Cosmic Radiation

Cosmic rays are high energy particles that are incident on the top of the atmosphere and come from very distant parts of the universe. The dominant component of the radiation are protons with a small admixture of helium nuclei and other heavier nuclei.

These particles in passing through the atmosphere collide with the air nuclei and produce in these collisions a variety of new types of particles - mesons, nucleons, hyperons...

From the 30's to 50's of this century the nature of these particles in the lower atmosphere were investigated with a variety of particle detectors - at sea level,

mountain altitudes, balloon altitudes and also underwater and underground.

- In 1932, Cecil Anderson discovered in Cosmic Rays
  - (i) the positron - the anti-particle of electron
  - (ii) the  $\mu$ -meson - the most penetrating particle in Cosmic Rays (1935)  
which lived only for  $\approx 2$  microseconds in its own rest frame - which got dilated to milliseconds w.r.t. the observer on the ground - provided the first verification of relativistic time dilatation.
- In 1947, the  $\pi$ -meson, the particle that fitted the Yukawa meson, was discovered by Powell using photographic emulsions exposed to Cosmic Rays at Jungfraujoch.
- Cosmic Ray studies in the late 40's and early 50's led to the discovery of a host of new particles -  $K$ -mesons,  $\Lambda_0$ ,  $\Sigma^+$ ,  $\Xi^-$  - uncovered the micro world of extremely transient particles transforming into each other through spontaneous decay.

changing positions  
of stars and planets.

## The Beginnings of Science :

Naked  
Observations  
Naked Eye.

### Systematization of Planetary Motions :

- Day and Night.
- Seasons.
- Phases of the Moon
- Phases of planets.
- eclipses
- Comets, Meteors.
- Stars

Aristotle - Geo-Centric System  
- of Concentric Celestial Spheres.  
Fixed System of Stars and Constellations.

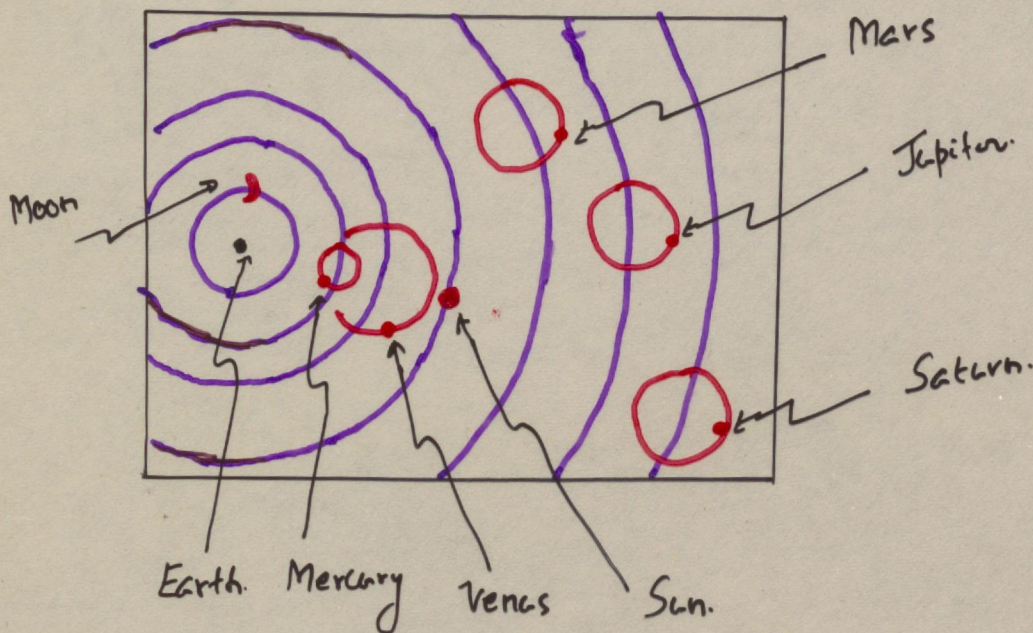
## Ptolemy (127-151 A.D) - The Almagest.

Alexandria period.

(13 books)

Book-1. Trigonometry.  
5 Books on optics.

Ptolemy replaced  
the Concentric Spheres  
of Aristotle by  
Moving Circles



Earth as the Centre  
of the Solar System

- Ptolemy's value of  $\pi = 3.14167$  (True value:  $3.1415927...$ )  
Explained the Retrograde motion of Mars that had been observed  
↳ Sometimes moving in the opposite direction to normal motion.

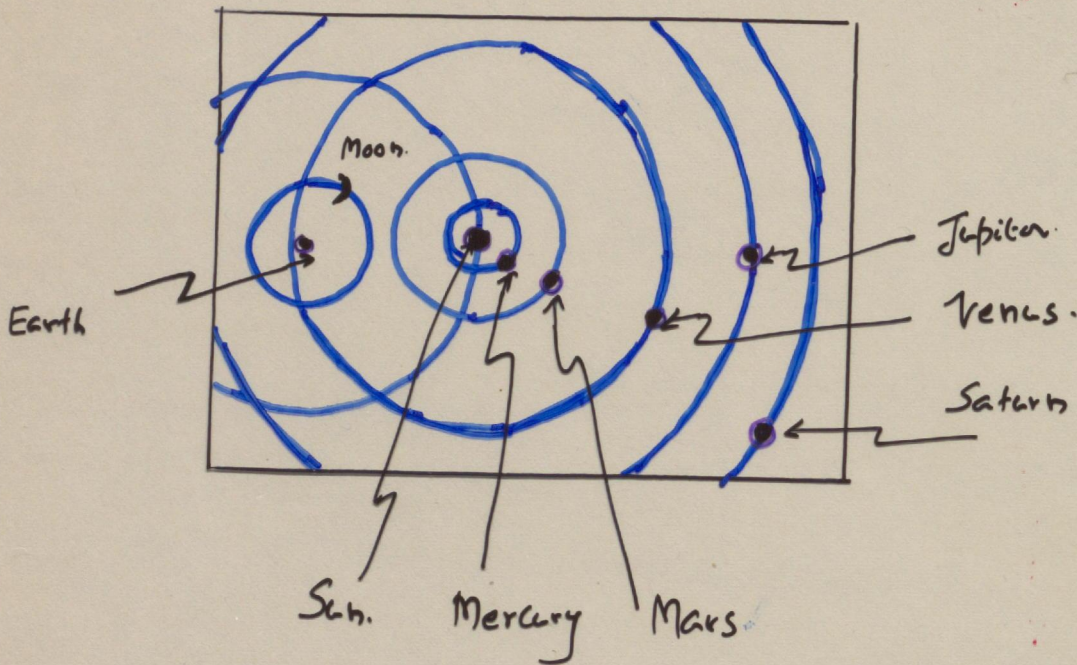
Two astronomical instruments were described by him

- (i) the Astrolabe
- (ii) the Mundus Circle.

Nicholas Copernicus: (1473-1543)

Helio Centric Theory

Revolutionibus  
Orbium Coelestium



- Copernicus knew that the planets did not move in perfect circles. He had to introduce Ptolemaic epicycles in his model also.
- Heliocentric theory of the Solar System - of the Universe Shook the Christian World in Europe.

Calvin (Protestant)

" Who will venture to place the authority of Copernicus above that of Holy Spirit ? "

Martin Luther

"

This fool wishes to reverse the science of astronomy; but Sacred Scriptures tell us that Joshua Commanded the Sun to stand still and not the earth."

- Even in the 18<sup>th</sup> Century, American Universities Yale, Harvard, taught both the Ptolemaic and Copernican Systems.

- In 1822, the Roman Church gave permission for Copernican System to be taught as truth and not just hypothesis.

Tycho Brahe (1546-1601) - Aristocrat. Son of a Danish Nobleman.

- The most renowned observer who kept very accurate record of his observations.
- Solar eclipse of Aug 21, 1560, when he was in school made deep impressions on him
- Tycho was opposed to the Heliocentric theory of Copernicus. (∴ contrary to sound physics; against Scriptures; Stars did not move w.r.t. the earth.)
- Tycho observed the explosion of a star - Tycho Supernova (1572)

Johannes Kepler (1571-1630)

• Son of a protestant officer  
Active brain. enfeebled body  
(Small boy as a child) -  
Crippled hand and damaged eye.

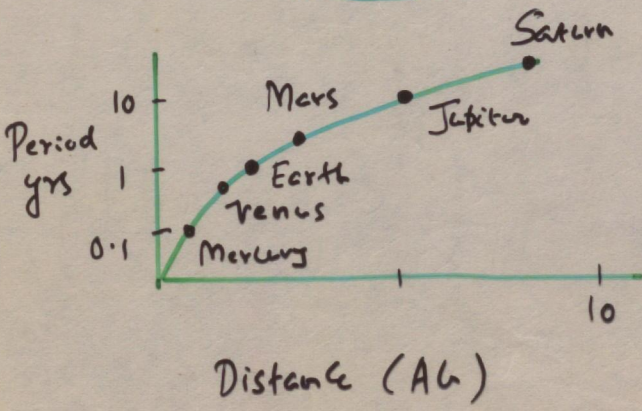
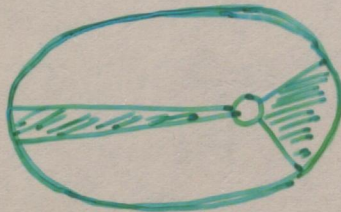
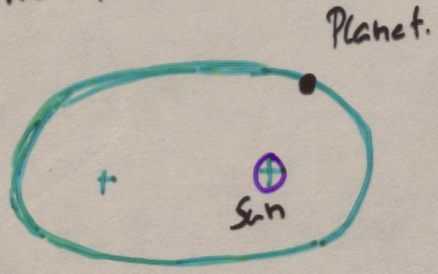
• Tycho invited Kepler to Prague first as a guest and then as assistant in his observatory. Kepler's Laws were deduced on the basis of Tycho's systematic observations and records.

Kant said of Kepler  
"The most acute thinker ever born"

The most used laws in astronomy even today.

Kepler's Laws.

- ① The orbits of planets are ellipses with the Sun at one focus
- ② The areal velocity is constant - Sweeps equal areas in equal times.
- ③ The period of revolution  $T$   
 $T^2 \propto R^3$   
Where  $R$  is the mean distance.



These are probably the first scientific laws to be enunciated by accurate observations and use of mathematical equations.

• His own epitaph: "I measured the skies, now I measure the shadows  
Sky bound was the mind, the body rests in the earth"

Galileo (1564-1642) Pisa.

\* " Pure logical thinking cannot yield us any knowledge of the empirical world; all knowledge of reality starts from experience and ends in it ... Because Galileo saw this, and particularly because he drummed it into the scientific world, he is the father of modern physics - indeed of modern science altogether "

- Einstein -

• Falling Bodies: Mechanics

• Aristotle had maintained that heavier bodies fall at a faster rate than lighter ones. No one had verified this experimentally for 2000 years.

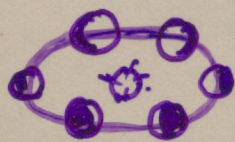
• Galileo's experiments (from the Leaning Tower of Pisa?) showed that Aristotle was wrong. He found a Cannon ball and a musket ball to fall at the same time from a given height.

• Led to the famous "principle of equivalence".

He also established through his experiments that the speed of fall increases uniformly with time. - the law of "uniform acceleration" - this led Newton to say that the effect of force is not motion, but acceleration.

• The Telescopes - observation of the Skies

Galileo was not the inventor of telescope, but the first to use the telescope at the Moon, at the Jupiter, the other planets, ...



Venus

• Moon: Saw the Craters

• Jupiter: Saw four moons orbiting round the planet

• Venus: He saw the phases of Venus.

• Milky Way: Innumerable Stars  
Three dimensionality of Stars - Depths of Space.

↑ Earth

# ISSAC NEWTON (1642-1727)

Born on Christmas Day - in the year Galileo died.

- **Universal Gravitation:**  $F = G \cdot \frac{m_1 m_2}{r^2}$

The Same Force that is responsible for falling bodies, for the moon to go round the earth, the planets around the Sun . . . .

- Deduced the Kepler's laws of motion. **Invented Calculus.**

- Newton's Laws of motion **Newtonian Dynamics.**

1. Every body perseveres in its state of rest or uniform motion in a straight line, unless acted upon by an external force.

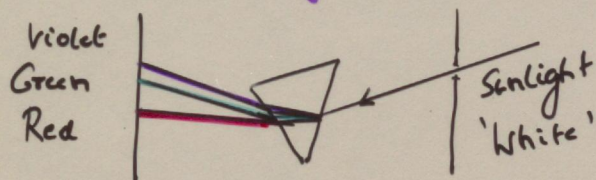
2. Rate of change of momentum is proportional to the impressed force and takes place in the direction in which the force is impressed.

3. Action and Reaction are equal and opposite.

- Concepts of absolute Space, absolute time were inherent in Newtonian Mechanics. - as atleast working hypotheses.

3-d Euclidean Spce. He thought the remote parts of the universe contained stars at rest. - with reference to which the motions of other objects could be measured.

- **Optics** : Analysis of Sunlight with a Prism.



- True meaning of 'Colour'
- Corpuscular

Spectrum

## Newton's Beliefs:

- God Created in the beginning material particles, the forces between them and the fundamental laws of motion.
- All that happened had a definite cause and gave rise to a definite effect.
- The cause of Gravity is what I do not know; I frame no hypothesis - "Hypotheses Non fingo"

## Other developments in physics during 17, 18 and 19th Centuries.

- Nature of Light: While Newton was a Champion of the Corpuscular theory of light, Huygens (1629-95) who was his contemporary constructed the Undulatory or Wave theory of light - a luminous object set up disturbances in the medium at perfectly regular intervals - which spread out as Spherical Waves - from each point of disturbance. Huygens theory explained the phenomenon of Double Refraction observed in Calcite crystals and of Polarization. (Huygens waves were longitudinal. Hooke suggested transverse waves which neatly explained Polarization.)
- The later experiments of Young (1773-1829) and Fresnel (1788-1827) - the phenomena of interference and Diffraction of light supported the Wave theory.
- The Structure of Matter - the phenomenon of Heat.
  - Leucippus, Democritus and Epicurus had Speculated in the 5th. Century B.C. on the 'atomic' Structure of matter.
  - These ideas were revived in the 16th and 17th Centuries by German botanist Joachim Jung (1587-1657), the French philosopher Pierre Gassendi (1592-1655) and the "Father of Chemistry" Robert Boyle (1627-1691)
  - Boyle introduced the modern concept of "Elements"
  - In 1766, Cavendish (1731-1810) discovered the inflammable gas - 'hydrogen'. Priestley (1733-1804) discovered many other gases, oxygen in 1744, nitric and nitrous oxides...
  - Lavoisier studied the Chemical Composition of various substances.
  - Proust (1754-1826) - real breakthrough - "In all chemical compounds the different constituents always enter in unvarying proportions"

- **Proust's Hypothesis:** "All matter might consist of hydrogen atoms"  
(Weights of most atoms were exact multiples of the weight of hydrogen atom)

- Dalton (1766-1844) Atomic Hypothesis.

- Gases must exist in the form of minute particles - atoms
- (The heavier and lighter gases in the atmosphere did not separate out like oil and water)

- Avogadro's Law

In 1811, Avogadro formulated the famous law:

"Under identical conditions of temperature and pressure all gases contain the same number of molecules in a given volume"

$$N = 2.685 \times 10^{19} / \text{cc at NTP.}$$

Avogadro defined the molecule as the smallest unit into which atoms combine.

## Heat, Thermodynamics, Kinetic Theory: Major developments of the 19th Century.

Energy, Entropy, Conservation Laws.

Carnot (1796-1832), Joule (1818-89), Kelvin (1824-1907)

- ⊙ Connection between atoms and molecules and the properties of matter - temperature, pressure, specific heat, ...

Hooke - "Pressure of air resulted from hard rapidly moving particles impinging on the walls of the enclosed vessel"

Joule calculated how fast the molecules of a gas must move in order to produce the observed pressure of air - 500 meters/second. (the speed of a rifle bullet)

- Maxwell calculated the velocity distribution in gases

- Kelvin The temperature at which all motion ceases  
Absolute Zero  $[-273^{\circ}\text{C}]$  Carnot: Same for all substances.

- The application of Newtonian Mechanics to the study of thermal phenomena - gases, liquids, solids - led to the formulation of Thermodynamics - led to the Law of Conservation of Energy. - "The total energy involved in any process is always conserved" **First Law of Thermodynamics** **CONSERVATION**

It was realised by Sadi Carnot, that while the total energy is conserved, the amount of useful energy diminishes. This led to the famous

- **Second Law of Thermodynamics** "Any isolated physical system will proceed spontaneously in the direction of increasing disorder." This has helped to **ENTROPY** define the direction of Arrow of Time.

Clausius introduced the term "Entropy" - measure of the extent of disorder.

- Boltzmann showed that the **Second Law of Thermodynamics is a Statistical Law** - one has to talk in terms of Probabilities - in a microscopic system consisting of small number of molecules - the Second Law may be violated - but not so in **STATISTICS** systems with large numbers

- According to the Second Law, the universe as a whole is moving towards a state of maximum entropy -

# • Electricity, Magnetism and Electromagnetic Theory.

The 18<sup>th</sup> and 19<sup>th</sup> Centuries - inauguration of "Electrical Age"

(The Chinese had invented the Mariner's Compass in 11<sup>th</sup> Century)

Gilbert in 1600 published his book "De Magnete" -  
Magnetic Power of Loadstones - Magic powers to cure diseases -  
Gilbert ignored these aspects.

Electricity - A piece of amber rubbed in a proper way  
produced electrical charges.

In 1749 - Benjamin Franklin suggested that lightning  
could be due to electric conduction

Coulomb (1736-1806) built up theory of electrical forces -  
(inverse square law)

Galvani (1773): Shocks produced by electric fishes  
Effect of electricity on 'frogs'

Volta (1745-1827) - "Volta pile" - Zinc, paper, Copper, Zinc }  
paper, Copper }  
proto type of batteries.

Nicholson }  
Carlisle } → put in Salt Water - Electro-Chemistry

- Michael Faraday (1791-1867) :
  - } Electrolytes
  - } Magnetic Lines of Force
  - } Magnetic Induction.
- Oersted: Magnetic needles could be  
affected by electric currents.
- Ampere: Two currents attracted or  
repelled each other.

Maxwell: (1831-1879) Related Electric and Magnetic  
actions to pressures and tensions  
in the 'ether' and showed that any disturbance  
created in the ether by electric and magnetic charges  
propagated through it in the form of waves -  
the Electro-Magnetic waves.

# The Theory of Relativity

- Maxwell's theory of Electro-Magnetism, which had identified light as an electromagnetic wave required that the EM wave travelled with a 'fixed speed'. This speed was obviously with respect to 'ether' the medium <sup>which</sup> through the waves propagated.
- The 'ether' had been imagined as stationary and all pervasive throughout the universe. The earth travelled round the sun with a velocity of 20 miles/second. The question arose 'What is the velocity of the earth w.r.t. ether.'
- Also since the velocity of light was fixed with respect to ether, different observers moving w.r.t. the ether should measure different velocities of light.
- Michelson and Morley devised in 1880's a very sensitive experiment using light beams to measure the velocity of earth w.r.t. ether. Their experiment showed that there was no relative motion between the earth and the ether. Earlier experiments had ruled out the possibility of the earth dragging the ether.
- The Michelson-Morley experiment also meant that the velocity of light was independent of the direction of the earth's motion. Whether the earth was moving towards the light source or away from it the velocity was the same. This contradicted the normal laws of addition of velocities.
- While many leading physicists were grappling with this surprising result, Einstein, a clerk in the Patent's office came on the scene with revolutionary ideas.

- In the Electro-Magnetic Waves, the Electric and Magnetic Forces would be at right angles to each other and to the direction of propagation.
- The most surprising feature was that when the velocity of propagation of the wave was calculated, it turned out to be identical to the value of the velocity of light.
- This led to Maxwell's theory that light is an Electro-Magnetic phenomenon.

Hertz (1857-1894) - Student of Helmholtz.

Produced Electro-Magnetic Waves in the laboratory through electrical discharges. - Hertzian waves.

# The Universe is the Best Laboratory for

1. Gravitational Physics - Gravitational Force  
Gravity waves, Gravitons  
Spacetime Gravitation  
Gravitational Lensing
2. Plasma Physics - Sun, Stars, H II regions, SN explosions  
AGN's... Low density plasma.
3. High Temperature Physics  $10^5 - 10^{28}$  ok.
4. High Pressure Physics - White Dwarfs, Neutron Stars
5. High Magnetic Fields  $10^{12}$  gauss.  
High Electric Fields  $10^{15}$  V/cm.
6. Synthesis of elements Hydrogen - Transuranic
7. Nuclear Physics, Neutron Physics
8. Particle Physics
9. Variation of fundamental constants  $g, c, e, m_e, \dots$
10. New Exotic phenomena
11. Grand Unified theories.

# Binary Systems - Possible Scenarios.



Eclipsing Binary - orbital plane makes  $\angle$  small angle with viewing direction.

↑  
observer

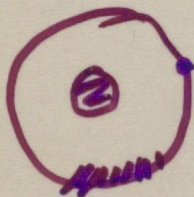


Roche lobe of the Companion fills up and mass transfer takes place through the Lagrangean Point.



Roche not filled. Accretion disk formed around the Compact object

Matter trails behind the Compact object with a phase difference.



Spin axis and Magnetic field axis different.

Precession of the Spin axis - accretion disk precesses . . . etc.

# Ultimate Constituents of Matter -

- Matter (Stable) → Compounds Elements 92 — Molecules Atoms — Protons Neutrons Electrons.

Protons - Quarks - ?  
Neutrons - Quarks - ?

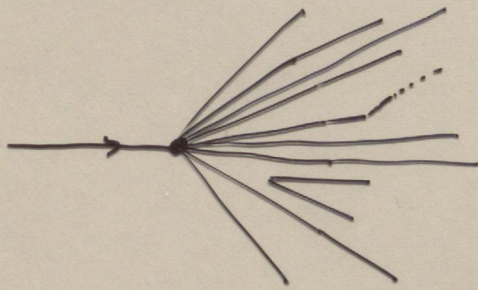
Leptons  
 $e^{\pm}, \mu^{\pm}, \tau, \bar{\nu}$

$\nu_{\mu}, \nu_e, \nu_{\tau}$

- The Short lived Unstable Particles produced in High Energy Collisions

Mesons  $\pi, K,$   
Hyperons  $\Lambda, \Xi, \Omega,$

Life Times  $< 10^{-8}$  Sec.

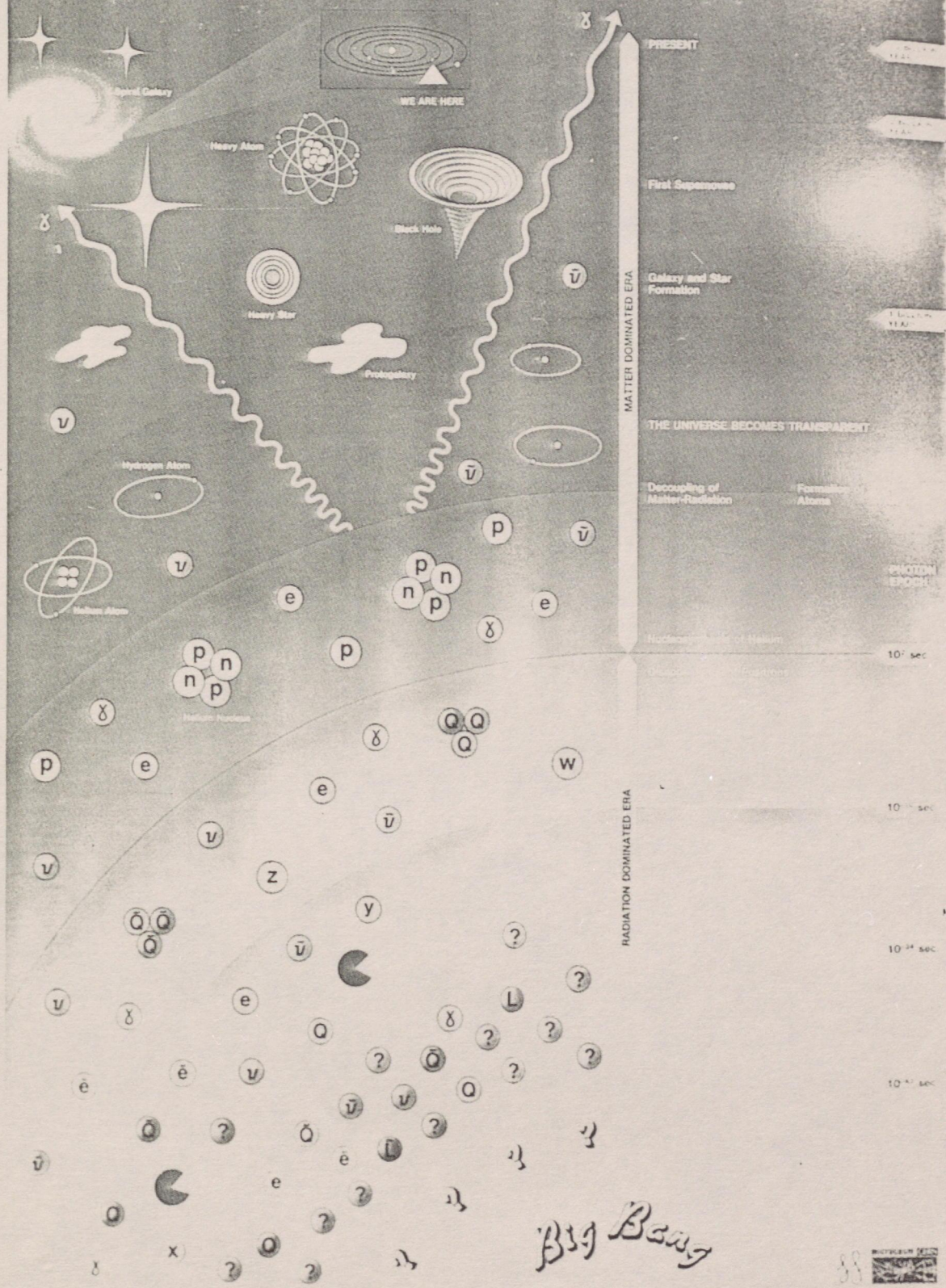


The pions are made of quarks and antiquarks

The K-mesons are made of quarks and Strange quarks.

- There was a time about 50 years ago, when we thought that the ultimate constituents were protons, neutrons and electrons.
- Today we think that the world is made of quarks and leptons.

# History of the Universe



Time scale and important constituents in the history of the universe.

is how  
spend  
one s  
final  
ment

South  
tina,  
was,  
had  
aircra  
and C  
tor a  
fortu  
the t  
ideal  
less  
and

the s  
Vior  
keep  
almo  
light  
City  
glist  
of th  
fishi  
had  
pack

to ch  
near  
whe  
take  
tells  
guy  
wok

*Big Bang*



# Outstanding Problems in Cosmic Ray Research (1988)

- ① Primary Spectrum and Composition at  $E > 10^{15}$  eV  
(only method is EAS)
- ② Composition  $10^{12}$  eV -  $10^{15}$  eV (Satellite Balloon experiments.)  
Isotopic Composition  
Very Heavy Primaries
- ③ Sources of Cosmic Rays - TeV, PeV, Astronomics  
Accreting Binary Scenarios (Cygnus-3, Her X-1, ...)  
Possibilities of Exotic Astronomics.
- ④ Very High Energy Interaction Characteristics  
Nucleus-Nucleus  
Emulsion Chamber Anomalies - Centauro, Gemination, Chiron  
Calorimeter Anomalies Long Flying Component.  
Suggestion of new Quantum Numbers?  
  
Like the Collider and Nucleus-Nucleus Collision results in the TeV-PeV region, better simulations of EAS - discerning of any special features beyond  $10^{16}$  eV.
- ⑤ High Energy Interactions of Neutrinos - Kolar Events.
- ⑥ High Energy Neutrino Astronomy  
**DUMAND**  
**GRANDE**
- ⑦ Exotic Experiments - Antarctic Ice } as targets  
Moon
- ⑧ Cosmic Rays high SPACE PLATFORMS

## Gravitation and Gravitational Collapse.

- \* According to Newtonian Theory, the Gravitational Acceleration of a freely falling body - Gravitational Force  $F$

$$F = \frac{G \cdot M}{r^2}$$

Where  $G$  = Gravitational Constant

$M$  = Mass of the body responsible for the acceleration

$r$  = distance of the falling body

- \* According to General Theory of Relativity the Schwarzschild Solution of the Einstein equation gives

$$F = \frac{G \cdot M / r^2}{\left\{ 1 - \frac{2G \cdot M}{c^2 \cdot r} \right\}^{1/2}}$$

Where  $c$  = velocity of light in vacuum.

It is seen that when

$r = \frac{2GM}{c^2}$  , the Gravitational Force becomes infinite

$r_g = \frac{2G \cdot M}{c^2}$  is called the gravitational radius of the Schwarzschild Sphere

- \*  $\therefore$  A static body of mass  $M$  cannot have radius  $< r_g$ .

# Black Holes

Mass	Object	Radius	Mean Density	Black Hole Radius	Black Hole Density
$6 \times 10^{27}$ gms	Earth	6400 kms	$5.5 \text{ gms/cc}$	0.44 cm	$10^{28}$ gms/cc
$2 \times 10^{33}$ gms	Sun	$7 \times 10^5$ kms	$1.4 \text{ gms/cc}$	3 kms	$2 \times 10^{16}$ gms/cc
$2 \times 10^{34}$ gms 10 $M_{\odot}$	Star	$7 \times 10^5$ kms	$14 \text{ gms/cc}$	30 kms	$2 \times 10^{14}$ gms/cc
$2 \times 10^{44}$ gms 10 <sup>11</sup> $M_{\odot}$	Galaxy	$7.5 \times 10^{17}$ kms	$7 \times 10^{-24}$ gms/cc	$3 \times 10^{11}$ kms	$2 \times 10^{-6}$ gms/cc
$10^{15}$ gms	Mini Black hole			$1.5 \times 10^{-13}$ cms	$6 \times 10^{52}$ gms/cc

## Topics to be Covered in the Four Lectures + Audio Visuals + Slides.

- Perspectives of Science and Philosophy
- Beginnings of Man, Civilization, Development of Crafts
- Early insights on Science and Philosophy
- Early Astronomy - Mathematics.
- Dawn of Modern Science - Development of Scientific Methodology.
- Triumph of Classical Physics 1687-1887.
- New discoveries - Downfall of Classical Physics
- Emergence of Modern Physics, Modern Technology  
the Science-Technology Spiral → "Micro-Cosmos"
- New Astronomies and the Current ideas  
on what the Universe is - "Macro-Cosmos".
- The Unification of Micro and Macrocosmos -  
the Big Bang Cosmology - the early moments of  
the Universe. Nature's highest energy accelerative  
Laboratory.
- Are we alone in the Universe? Search for other planets.  
Artificial Intelligence
- Current trends in the Philosophy of Science

### Popular Books

- |                                  |                  |
|----------------------------------|------------------|
| • The Growth of Physical Science | Sir James Jeans  |
| • Physics and Philosophy         | Sir James Jeans. |
| • Brief History of Time          | Stephen Hawking  |
| • The Emperor's New Mind         | Roger Penrose.   |
| • Shape of Modern Mind           | Crane Brinton.   |
| • Coming of Age in the Milky Way | Timothy Ferris.  |
| • Something Called Nothing       | Podolsky         |

# Physics

Symbiosis

# Astronomy

- Matter, Radiation
- Space, Time, Forces.
- Temperature.
- Blackbody Radiation.
- Molecules, Atoms
- Excitation Levels

Gravitation.  
NEWTON

SAHA'S  
THEORY OF  
IONIZATION

Quantum  
Mechanics

Bohr's Atomic  
Theory

- Radioactivity -  $\alpha, \beta, \gamma$ .

- Nuclear Structure } Proton, Electron
- Neutron Discovery. } Neutron
- Nuclear Forces } Decay.

Meson  
Theory

Positron  
Meson  
Pion  
Kaon  
 $\Lambda^0, \Sigma^{\pm}$   
 $\Xi^{-}$

Conservation  
Laws and  
Symmetry.

Strongness.

- Elementary Particles  
(Mass, Spin, Mag Moment)  
Charge

- High Energy Physics  
High Energy Accelerators  
(Lawrence Cyclotron  $\rightarrow$  SSC)

- Hadrons and Leptons  
Hundreds (Strong) (e,  $\mu, \tau, \nu$ ) (Weak.)

- Quark Theory } Charm.
- $\psi/\bar{\psi}$  discovery }

- Variation of Coupling  
Strength with energy  
of interaction.

- Electro-Weak  
Unification. } Discovery of  
Neutral Currents  
and  
 $W^+, W^-, Z^0$

Top Quark ??  
 $T_{Neutrino}$  ?

- Planets, Stars
- Distance, Mass,  
Temperature, Pressure  
Chemical Constitution.
- Energy of Sun, Stars.  
(Nuclear Energy  
Fusion)

- Nucleo Synthesis
- Discovery of Cosmic Rays  
Primary - Protons &  
Heavy Nuclei  
Secondary
- Doppler Shift of  
Spectral Lines
- The Expanding Universe.
- The Solar Neutrino Problem
- Missing Mass

- Radio Astronomy
- Quasars
- 30-Microwave Radiation.

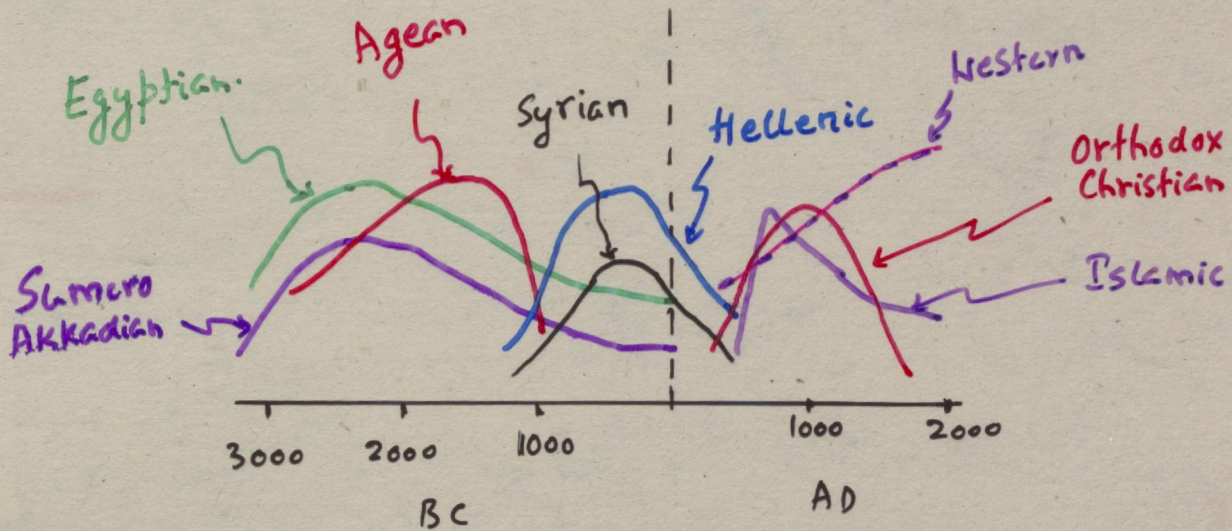
- The Early Universe.  
(How hot the  
Universe could have  
been?)

Backward  
Extrapolation  
of Size, Density  
Temp of the  
Universe.

Hagedorn  
Limit of  
 $10^{12} \text{ K}$   
Crossed because  
of Quarks  
(Point Particles)

# The early Civilizations

- Egypt ~ 3000 BC
- Pyramids 2900 - 2750 BC.
- Aegean - Crete 3000 BC.
- Babylon - Assyrian - Sumerian 2750 BC
- Israel 1010 BC (David, Solomon)

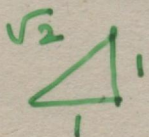


## Rise and Fall of Mediterranean Civilizations.

- The opinions held by some of the early intellectuals before the dawn of modern science

- Thales of Miletus : (first scientist?)  
640 - 546 BC.
  - Urged the importance of gaining substratum of facts independent of the judgement of individuals.
  - 'Maintained all things were full of God'

Pythagoras  
540 BC



- Mystic, Mathematician, investigator of nature. introduced the concept of "Proof" in mathematics. Believed that "Everything is interpretable in terms of numbers" (1, 2, 3, ...). Changed his view when he realized  $\sqrt{2}$  is irrational.

Democritus  
(470 - 400 BC)

- Only atoms and voids are real.

Epicurus  
(341 - BC)

- Materialist. All existence is Corporeal. Supported the philosophy of Democritus and added 'atoms' must be infinite in number and void must be infinite.

Zeno of Citium, Cyprus  
(311 BC)

- Stoic philosophy  
The world must be moving towards a perfection - (designed by God.) which could in part be achieved by Man.

The Greek Philosophers :

- Socrates (469 - 399 BC)
- Plato (429 - 347 BC)
- Aristotle ( - 322 BC)

- Holistic, Comprehensive approach. They did not appreciate scraps of isolated knowledge of different corners of the universe.
- There was an aversion to experimental knowledge. Mental activity was placed at a much higher pedestal than physical which they thought was the work of slaves. In fact of mechanical trades, medical treatment of diseases were considered as leading to degeneration of soul.
- Mathematics was given the highest place and it was firmly believed that mathematics furnished the key to Nature.
- The approach was teleological - each fragment of the universe had a specific function - purpose.

# Plato (429-347 BC)

Plato distinguishes between what the mind perceives through the senses - the World of Sense, and what the mind apprehends by thinking - approaches through sheer intellect - the Ideal World - Forms.

## World of Sense

The outer world is the raw material for the impress of Forms - becomes a sort of meeting place of different forms -

A Red Square Brick is a lump of raw material stamped with the impress of Forms of redness, squareness, brickness etc.

Seen in a different light the brick may appear different. ∴ We have sure knowledge of form and not object.

In Neo-Platonic version God himself is Supreme Good and the Forms are his eternal thoughts.

## Ideal World.

- The human mind is equipped from birth with set of forms or 'ideas' which exist independently of the external world.
- These Forms are not just abstractions of the mind. They exist in a spiritual world.
- Hierarchy of Forms:  
The Supreme form is the Form of Good - the source of both knowledge and Being. Just as there is the source of light and life to all created beings, the Forms derive their rationality and being from the Form of Good.
- The Form of Good is not God.
- God is not a Form, but a living active soul - the self-moving source of the motion of heavens

• Einstein said that the whole idea of the ether was an unnecessary complication. He can do away with the ether and the velocity of light may be considered as constant of nature independent of the motion of the source or the receiver provided he give up the idea of absolute time.

• Einstein formulated his Special Theory of Relativity "Laws of science should be the same for all freely moving observers, no matter what their speed". This was also the law of Newton (only for mechanical motions); Einstein extended it to Maxwell's theory and the speed of light.

Einstein's theory led to many startling results

(i) There is No Absolute Space; No Absolute Time. Time and Space have to be fused into a four dimensional continuum.

(ii) Space contracts and time dilates in a moving medium and the extent depends on the velocity

(iii) The idea of 'Simultaneity' has no longer any meaning. What is simultaneous in one frame of reference may not be so in another moving frame

(iv) Mass and Energy are equivalent and related by the famous equation  $E = mc^2$  Atom Bomb Equation!

1 kg of Coal (if fully converted to Energy) = 25 Billion kilo Watt hrs of Electricity

lightning at A and B simultaneous for observer on the ground. Not so for the moving in the train.

