History of Ideas

- History is essentially a reproduction of happenings of the past - especially of events that stood out as significant from the point of view of the development of society, nations and civilizations.
- According to Bertrand Shah, the lesson that we learn from history is that we cannot learn from it. Does this apply to history of ideas? particularly in the scientific field - there ideas are the bricks on which the edifice of science is built, cemented by facts established by observation and experimentation. ofcourse, i *→

- Progress of science has depended on:
  1. identification of problems.
  2. ideas on how to solve them
  3. observational, experimental and theoretical discoveries.
  4. Mathematical formulations.
  5. Development of new instrumentation. - (idea based)

'ideas' play a role in all these aspects.

Engagement towards solution of problems leads to generation of new ideas, flashes of genius.

- History of development of physical Sciences:

classification of Natural Phenomena

- Components - Matter, Radiation, Sound, Electricity, Magnetism.
- Principles - Motion, Laws
  - Motion: Space, time, velocity, acceleration, force
  - Laws: Conservation, Invariance

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*→ while ideas are the bricks with which the edifice of science is built facts based on observation and experimentation form the cement to bind ideas together.
Newton - universalization of the idea of gravity - falling stone, feeling moon →

Concepts : Space, Time, Matter, Radiation, Energy, ~~Field~~. Wave, particle.
~~Electric Charge, Magnetic Charge.~~ Aether.
Electric Field, Magnetic Field, EM, Laws., Aether.

Matter – "the atomic hypothesis" – Uncuttable / indivisible } final units.
- Kanāda to Bohr.
- The uncuttable final unit is NOT the modern Atom – Chemistry has established the atoms of so many elements – hydrogen to uranium. transuranic elements.
- While one can stop at the atom for certain purposes one has to go deeper.
- The chemical properties depend on the structure – particularly the electronic structure of the atom.
- Unstable matter. discovery of Radioactivity – Spontaneous disintegration of the atoms. the α, β, γ-ray emitted. Hidden energy in the atoms because of the nuclear structure – Solar and Stellar Energies – IS Radioactivity the source?
- Discovery of the Nucleus. 10^{-13} cms compared to 10^{-8} cms.

all the mass of the atom in the nucleus – much smaller than the atom

- Constituents of the atom –
  Electron, Proton and Neutron.
- Discovery of the electron – J.J. Thomson – Discharge of Electricity thro gases.
- The role of Crossed Electric and Magnetic fields in the discovery of the electron as a particle and determination of its charge.
- Electric and Magnetic Fields – Oersted's and Faraday's experiments. } EM field of Maxwell.
  The Concept of Fields.
- Gravitation Field introduced by Newton. – action at a distance.
- properties of the Aether – non-material medium.

~~Light as an EM wave – Maxwell.~~

- Velocity of EM wave same as that of light.
  ∴ Light is an EM wave.

Propagation of EM wave – medium aether? →
Is aether stationary? or ~~that is the velocity of~~
is it carried by the earth in its motion?

The Michelson-Morley Expt. – Velocity of light independent of the motion of the source and of the observer.

Agent clashed ideas of addition of velocities in dynamic systems.

- Einstein's Special Theory of Relativity.
- Einstein – If you are travelling with the velocity of light can you look at your face in the mirror in front of you?
- Special Theory of Relativity and its implications to Space, time, matter, energy
- How are the Protons and Neutrons held together in the Nucleus? Protons should repel protons and there is no force between Proton and Neutron

Yukawa's theory of nuclear forces – "Exchange Forces"

Wrong identification of the Mu-meson as the Yukawa.

Discovery of the Pi-Meson. — Anderson (Pennsylvania Campus of CR. Robertson)

Exchange Forces – virtual pairs – Particle / Anti-particle.

Dirac Vacuum.

Fundamental Particles – Seven hundred.

Quark Theory –

Creation of the Universe – Big Bang

Scientific Revolution

P4 idea of gravitational attraction. – idea of Mass, force → $= G \frac{m_1 m_2}{r^2}$

three Concepts – Mass, force, distance } Space → action

G = Universal

Tycho made observations, Kepler hypothesized, Newton explained

ideas + observations + (Experiment) theoretical formulation – generalization – Verification – Further Experiments

- Concepts
- Laws
- Mathematics
- Instrumentation
- Constants of Nature.

Matter { atoms. – action

Electricity, Magnetism { charge, Fields } – action — electron.

Sound { waves. – air, Lesion.

Motion – Inertial Frame (Uniform) motion – Acceleration – force

Energy –

{1 Bernard Shaw's Cryptic Comment on History.
{2. Does this apply to History of Ideas - especially in Science.

3. Commonsense ideas on Space, time, mass, motion, heat, light. (Causality ... gadgets') + (Machine) explanation of phenomena in nature. in classical Mechanics.

4. Adaptation of these to Scientific Explanation with the intervention of (i) Logic, (ii) Measurements (systematization)

5. Additional Concepts - velocity, acceleration, force, energy, charge, field aether, mathematical formulations. Laws of Nature. Constants of Nature.

6. Matter and its Constituents - Chemistry → physics - Nuclear physics
Compounds - elements - atoms - nuclei .. protons, neutrons, electrons. -

- ideas
- { Specific planned experiments. observations
- { Serendipity
Enlightening touch of prof Kumar
- The atomic hypothesis was an 'idea' - from Kanāda to Rutherford.
- Atom has a structure. - }

Particles created in [the] nucleus of the atom and fly over a big barrier.

- Discovery of Radioactivity. - totally unexpected.
- Discovery of the Electron - Systematic study of discharge of electricity through gases.

- Electric and Magnetic Fields - crucial for investigating Radioactivity, as well as Cathode Rays.

(α, β, γ)

e/m ratio.

Millikan's oil drop.

Charge on the Electron
Mass of the electron

Discovery of Electricity }
" of Magnetism }

Faraday's Expts. }
Oersted's Expt } Induction Connection between Electricity and Magnetism

EM Laws.

(Fields, Aether)

Connection between EM waves and light.
Velocity of light - experiments. - Michelson-Morley.
↓ problems with the concept of ether.

Einstein's theory of Special Relativity - and General Relativity.
Changes in the concepts of space, time, mass, energy, simultaneity.
Space-time. $E = mc^2$

Relativistic Equations } heavily depended..
Spatial Contraction }
Dispensation of ether concept - replaced by four dimensional Space-time.

Einstein's way of dealing with Natural Motion

Gedanken Exp.
- Travel at the speed of light and try to look at yourself in a mirror
- Twin in a train travels with large speeds
- falling lift.

Concept of force gravity }

Force

- Fundamental and Primordial Notion in Physical Theory
- Central Element of Physical Reality in Classical Mechanics.
- demise under modern theories -

Kepler - initiated the Conceptualization of the idea of force.
Newton - attempted definition of force.
Einstein - Elimination of the Concept of force. (?)

—

Classical notion of force:

- "metaphysical, a priori, intuitive, and anthropomorphic"
  (Hesse) → Mary B. Hesse)
  ↓
  M.B. Hesse, Review of Concept of Force, British Journal for Philosophy of Science 10, 69-73, (1960)

No exponent of descriptive mechanics ever denied that historically the concept of force was formed in analogy to the sensation of strain or effort experienced by man.

Strains are indicators of force.

- Newton: Force is that which produces acceleration. (absolute Cause of acceleration)

—

A. Stinner (The Story of Force from Aristotle to Einstein) Physics Education 29, (77-83) 1996.

- General Theory of Relativity eliminates gravitational force.

"What ever aspect of ~~gravitation one~~ gravity one measures and however one measures it, one is studying the geometry of Space-Time."

"In Newton's theory the symbol F in F = ma refers to the cause of acceleration of the body. Force then is an external agent that acts on matter with an inertial mass, causing it to accelerate at the rate 'a'. In the General theory of Relativity, however, there is no external force. Indeed Einstein was able to derive Newton's Equation F = ma from purely geometrical considerations. He saw

PTO

the possibility that all "external" forces may be apparent - that the "effect" of other matter may be represented by geometrization of the geometry of ~~matt~~ Space-time that describes the motions"

- What about forces other than Gravitation?

Forces should not be eliminated but differently constituted. Effect of elimination leaves us without any adequate account of the causal relationship.

—

Developments in Modern Physics:

Quantum-Electro Dynamics
Gauge Theories
Standard Model

} Force treated as exchange phenomenon.
= Exchange of Momentum
Concept of Interaction —
Exchange of additional particles
(photons, gluons, $W^{\pm}$, Z^0, gravitons)

Exchange Interaction —
Comparison with two ice-skaters:
Sudden Exchange of balls between the two who are moving
Will produce transfer of momentum — a repulsive interaction
Exchange of boomerangs (hitting each other from outside)
equal to negative momenta — Will produce
an attractive force

These four forces are not so in the traditional sense.

NUCLEAR FORCES

- Wigner Force: Short Range non-exchange force
- Heisenberg Force: Exchange of both position and Spin Co-ordinates of the two interacting nucleons
- Majorana Force: Exchange of position Coordinates
- Bartlett Force: Exchange of Spin Coordinates only.

Different methods of introducing the dependence of forces
Of the particle. - different parameters of ϕ
the "State" of

Cause of Gravity
Action at a distance problem }

Coates in the Introduction to PRINCIPIA

[Sir Issac Newton's mathematical principles of natural philosophy : Trans. Andrew Motte, rev Florian Cajori : University of California Press, Berkeley 1934 P XXVII.

"But shall gravity be therefore called an occult cause and thrown out of philosophy, because the cause of gravity is occult and not yet discovered? Those who affirm this, should be careful not to fall into an absurdity that may overturn the foundations of all philosophy. For causes usually proceed in a continuous chain from those that are more compounded to those that are simple; when we arrived at the most simple cause we can go no further. Therefore no mechanical account of explanation of the most simple cause is to be expected or given; for if it could be given, the causes were not the most simple. These most simple causes will you then call occult? and reject them? Then you must reject those that immediately depend on them, and those that depend on these last, till philosophy is quite cleared and disencumbered of all causes,"

Deanthropomorphic, positivistic or operational doctrine — elimination of the concepts of Cause and Force:

Mach: Mass and Force reduced to mathematical expressions relating to measurements of Space and time.

—

Karl Pearson: Grammar of Science (1892)
Dent, London (1949)

"The notion of force as that which necessitates certain changes or sequence of motion, is a ghost of the old Spiritualism"

Henri Poincare (Science and Hypothesis — (French)
The Foundations of Science Trns. G.B. Halsted.
Science Press, Lancaster, Pa (1946) p104

"On the anthropomorphic Concept of force"

Anthropomorphism, he declares, has played an important role in the genesis of mechanics; it may, perhaps, even have a heuristic value also in the future by supplying symbolic notions that seem to be convenient to some minds. But it can never serve as the foundation of truly scientific reasoning"

Poincare admitted Kirchoff's definition of "force" as the product of mass and acceleration.

Radioactivity

Chance discovery by Henri Becquerel in 1896.

~~Anton~~ Antoine Henri Becquerel (1852 - 1908)
Prof. Ecole Polytechnique —

Motivation → Sun light falling on some crystals might emit x-rays discovered by Rontgen (1895)
(Uv of sun to light)
crystal studied - Salt of Uranium, Uranium - Potassium
photographic plate covered with Black Paper

"On 26th and 27th. Feb (1896) — the Sun appeared only intermittently. So I stopped all experiments and left them in readiness by placing the wrapped plates in the drawer of a cabinet, leaving in place the Uranium salts. The Sun did not appear on the following days and I developed the plates on March 3, expecting to find faint images. The silhouettes appeared, on the contrary with great intensity."
(Uranium ore - Pitchblende from Bohemia)

(1) Emission unaffected by physical conditions - Temperature, Pressure etc.
(2) Radiation intensity proportional to amount of Uranium.

Rayons Uraniques —
1898 — Marie Curie (1867-1934) discovered similar emissions from Thorium and found that Radium has millions of time more powerful. She gave the name Radioactivity

Rutherford — two different kinds of Radiation
α-particles — Helium Nuclei
β- " — Electrons.
γ-Rays — undeflected by Magnetic Field.

- Radioactivity is actually a change of one chemical element to another — Rutherford and Soddy.
- Disintegration of the Nucleus
- Life Times.

Radiation delay.
Probability of emission

^{232}Th 1.41×10^{10} yrs.
Thorium Emanation — 54.5 Seconds.
Radium " — 3823 days.
^{238}U 4.51×10^{9} years.

Velocity of α-particles 1/10 Speed of light.

$\frac{\text{kinetic Energy}}{\text{mass}} = 3 \times 10^{14}$ joules/kilogram

Each α-particle of Radium 5×10^{12} j/kg.
Normal Burning of Natural gas 5×10^{7} j/kg

" Energy latent in the atom / electrons compared to that demanded of fire in ordinary Chemical Change"

Rutherford never expressed any doubt on Conservation of Energy in Radioactive processes. — It is energy that is stored in the atom.

Among those who speculated on that radioactive substance might give energy for extraneous source are Curies, Lord Kelvin, Jean Perrin

How did the energy get stored?
How is this released?

Existence of bodies smaller than the atom.
+ how can they be real?

The Electron:

30. April 1897 J.J. Thomson.

"Electric matter consists of fine particles"

[1750: Franklin (reasonable speculation) ↗

For these particles the name 'electron' had been given 1882 by Thomson's compatriot "Stoney".

- Roentgen refuted the discovery of bodies smaller than the atoms. He did not allow his students to mention the name 'electron'.
- Pyotr Lebedev, a student at Strassburg had noted in his diary in Jan 22, 1887 (24 years earlier than the Planetary Model of Rutherford)

"Each atom.. is a complete Solar System that is consists of different atom-planets which revolve at different speeds around the central planet, or move periodically in any other way"

[Pavlov and Stoney also had similar ideas]
Jean Perrin..

- When Eddington said that the electron is a speculative concept and did not exist, Rutherford sprang to his feet

Not exist? not exist? Why I can see the 'little beggars' as plainly as I can see that spoon in front of me.

(α-particles)

[The only lesson of history is that nobody learns from it — Bernard Shaw]

• Electron as an elementary particle

Pieter Zeeman (1865-1943) — Dutch Spectroscopist.

↓

- Observed that the D-lines of Sodium, which are normally quite sharp, widen in a strong magnetic field and the widening in frequency is proportional to the magnetic field.
- It was the Dutch theorist H.A. Lorentz (1853-1928) who in 1896 used the numerical factor in the above relation of proportionality to deduce a value for the (mass/charge) ratio of the carriers of electric charge in atoms.

[This was one year before Thomson's Discovery, and 15 years before Rutherford discovery of the nucleus and his theory of the atom., 17 years before Bohr's theory.]

Lorentz used the idea of Larmor frequency —

- Zeeman's measurements had provided a rough estimate of the mass to charge ratio of whatever it is that carries electric currents in atoms.
- Thomson's work on cathode rays showed that these carriers are not just part of the architecture of atoms but have separate existence of their own outside as well as inside of atoms.
- The universality of these particles verified when emission of β-rays were observed from radioactive substances.
- Thomson found that the particles emitted in photoelectric effect have the same mass/charge ratio and therefore are electrons.

The Nucleus:

1907- Geiger joined Rutherford as a postdoc.
Marsden " Student

Geiger began his programme on Scattering of α-particles by ~~gases~~.
through thin metal foils,
with a Zinc Sulphide Screen.
In the forward direction - no surprises.
In 1909 — Rutherford for some reason had the idea of
checking whether some α's might be
scattered much larger than the original
direction.

From Rutherford's last lecture:

" One day Geiger came to me and said " Don't you think young Marsden, whom I am training in radioactive methods ~~should~~ ought to begin a small research? Now, I had thought of that too, so I said " Why not let him see if any alpha particles can be scattered through a large angle". I may tell you in confidence that I did not believe that there would be, since we knew that the alpha particle was a very massive fast particle with great deal of energy and you could show that if the scattering was due to the accumulated effect of a number of small scatterings, the chance of an alpha particle being scattered backwards was very small. Then I remember two or three days later, Geiger coming to me in great excitement and saying " We have been able to get some of the alpha particles coming backwards". It was quite the most incredible event that ever happened to me in ~~my~~ life. It was almost as incredible as if you fired a 15-inch shell at a piece of tissue paper and it came back and hit you"

Rutherford concluded that the large angle scattering could only be explained if there is an appreciable probability that an α-particle is deflected by a large angle in a <u>single encounter</u> with an atom.

By 1911, Rutherford had focussed on the idea that the atom consists of small, massive positively charged nucleus surrounded by orbiting electrons. Geiger recalled that early in 1911, "One day Rutherford obviously in the best of spirits, came into my room and told me that he now knew what the atom looked like and how to explain the large angle deflection of ~~part~~ α-particles"

(He gave not only the idea, but also tested it)

- Problems with the Rutherford model
- Bohr's Atomic Theory - based on Quantum Hypothesis.

  Discrete Energy States
  Discrete orbits -
  No emission by electrons moving in the quantized orbits
  emission only when electrons jump from one discrete state to another $E=h\nu$ - energy of the emitted photon.

Time: • In the great drama of nature, space and time were originally regarded as the stage or arena in which the play of matter goes on.
• matter was the cast and space and time the stage. Space and Time - God given.
The Scientist's job was to work out the plot.

All this was changed with the advent of Relativity

Einstein's major Contribution:
- Space and time are not just "there" as unchanging background to nature;
- they are physical things - mutable, malleable and no less than matter, subject to physical laws.

* Conceptual Foundations of Newtonian physics questioned.

" He liberated time and space from the severe structures of Newtonian thinking, but was unable to stitch the newly freed concepts of a flexible space and time into a properly unified theory." Paul Davies.

—

Early ideas: Time is known intuitively.
Time is cyclic, Rhythmic dance.
Is time eternal. ?

• Clock - an emblem of Scientific Culture - but intellectual straight jacket.
• Before Galileo and Newton - time was subjective - not parameter to be measured with precision

- Newton gave time an abstract independent existence. – to keep track of motion mathematically It did not do anything.
- Einstein – made time an integral part of nature.

Einstein's Space-time is in many ways just another "field" – to be set alongside the EM field, Nuclear field

Personal aspect of time – we know, we cannot explain.

Einstein's time has no arrow. It does not make a distinction between past and present and future. It does not flow.
This revolution is UNFINISHED (TOE?)

There can be a beginning and end of time.
Origin

Big Bang – Orthodox Cosmology

There is much about Quantum Time, we do not understand.

—

Clockwork Universe
Newton's Time – (commonsensical)

- Absolute time true and mathematical time (Within) of itself and from its own nature flows equably without relation to anything external
- The universal, absolute and completely dependable time entered into laws of mechanics (God as the watchmaker)
- The whole universe shared a common time and a common NOW.

Einstein's Time it is Relative.

- The English Chemist William Prout (1785-1850) had in 1815 proposed that all chemical elements are made of hydrogen atoms. Thomson thought that the fundamental atom was the 'electron'

- Walter Kaufmann in Berlin had made more accurate measurements of mass/charge ratio than Thomson. But he did not claim to have discovered a new particle. Why? - Like Hertz and other physicists in Germany, Kaufmann was strongly influenced by Ernst Mach's (1836-1916) philosophy — It was unscientific to concern oneself with hypothetical entities like atoms that could not be directly observed.

- Anglo-Irish physicist and astronomer George Johnstone Stoney (1826-1911) gave the name 'Electron' to the particle

- Experiment of J.J. Thomson on the determination of e/m ratio. (Page from Cambridge book)
- Determination of the charge 'e' by Millikan's oil drop experiment.

Linear time vs Cyclic - (Jewish)

↓

implies Arrow of Time.

Law of Thermodynamics. Entropy (mid 19th. Century)

Universe moving towards total degeneration?

II Law of Thermodynamics introduced Arrow of Time.

Biological Evolution

Darwin: There is an innate drive in nature towards improvement. - Ladder of progress.
(Microbe → Man)

Unfortunately, progress is nature does not mesh well with blind thermodynamic Chaos or purposeless chaos that supposedly underlie Darwin's evolution.

progress of biosphere as opposed to Universal Death

Biologists don't believe in elan vital - life force. driving evolution.

- Prigogine's Self-organizing process - A UNIVERSAL LAW LIKE TENDENCY.

Rutherford : In a War Research Committee Meeting (1917)

"I have been engaged in experiments which suggest that the atom can be artificially disintegrated. If it is true, it is ~~far~~ of far greater importance than Trafalgar"

To find out that the Nucleus consists of it was necessary to break it up.

—

- Nuclear Disintegration by Cosmic Rays.
- ~~Creation of Mesons~~ -
- The μ-Meson -
- The π-Meson
- The production of Mesons in Nuclear disintegration
- The production of electron - positron pairs - Cathodes.

Slides

- pair creation.
  Cascade development
- Meson production
- $\pi^- \to \mu^+ \bar{\nu}$ and $\mu^- \to e^+ \nu \bar{\nu}$
- positron
- virtual particles transporting.
- Big Bang.

- The parting gifts of the 19th Century were the three major discoveries – X-rays, Radioactivity and the electron.
- The 20th Century began with the Quantum Hypothesis

In the very first lecture of this series on 'history of ideas' Prof. Kumar gave a fascinating account of the journey of the 'atomic hypothesis' through the brilliant beginning with Kanāda on Leucippus earlier than 5th. Century BCE & Niels Bohr of the 20th. Century AD. In this talk I propose to take this journey further into the subatomic domain of nuclear, elementary particles and fields which began only a Century ago.

Till the time of Proust and Lavoisier, the atomic hypothesis" was essentially conjectural in nature. - not supported by experiments or quantitative theories. Newton (1642-1727) attempted to account for the expansion of gases in terms of actions of atoms and Dalton (1766-1844) explained the ratios of weights of chemical elements in terms of the relative weights of atoms of their elements. These two were British scientists and their atomic hypothesis were accepted in England, but in other countries, especially Germany.

Mach (1836-1916) of Vienna objected to the atomic theory, because atoms could not be observed directly!

The 'atomic hypothesis" accepted in the first ~~part~~ decade of 20th. Century - Discovery of Electron and Discovery of the Nucleus.

Field: Space in which bodies manifest interaction.
Field exists everywhere and at all times
Not only between bodies, but within them also.
Fields are as Real as matter.
Matter is tangible. Field is not. but we can
perceive the effect of a field - an apple
falling from a tree. Mag. field etc

Light — Electro-Magnetic Rad - is quantized (photon)
photons are the field quanta. - photoelectric effect,
pressure of light.
Field quanta can have the ~~properties of~~ characteristics
of particles of matter.
Electrons could have wave properties - de Broglie
Material properties of the field are
obvious only at large ensembles of quanta.
At low energies field is field, matter is
matter.

—

Vacuum or void or emptiness is generally
non-existent. Only matter and fields fill all
Space. The vacuum that Dirac had in mind
was simply a pictorial image to facilitate
depicting the processes of the interconversion
of particles of matter and field quanta.

The term vacuum signifies the possibility of
mutual transformation of material particles
into field quanta and field quanta into
particles.

To summarize, vacuum has given way to field.

Vacuum (Contd)

Bohm

What we call empty space contains an

Spontaneous decay of fundamental particles

$N \rightarrow P + e + \nu$
$N \rightarrow P + \pi^-$
$\pi^- \rightarrow \mu + \nu$
$\mu \rightarrow e + \nu + \bar{\nu}$

$\Big\}$ $N \rightarrow P + e + \nu + \nu + \bar{\nu}$ (?)

π - Limit of Duality Particle and Wave.

field quanta - Bosons. $\mu = 1/2$ (Spin.) Spin(0)

We can get a departure from the vacuum state in two ways: One way is to bring an electron into a positive energy state; the other way is to have a "hole" in the distribution of the negative energy states. That focusses attention on the holes.... as I said before the negative energy particle according to the classical Lorentz equation behave as though it had a positive energy and a positive charge.. the "holes" appear as new kind of a particle having a positive charge.

PAM DIRAC in his lecture in Australia in August 1975.

Directions in Physics PAM DIRAC (1978)
John Wiley & Sons NY, Lond...

Heisenberg:

Energy is in fact the substance from which all elementary particles, all atoms and therefore all things else made... Energy is a substance since its total amount does not change and the elementary particles can be made from this substance... the experiments have shown the complete interchangeability of matter. All elementary particles can if sufficiently high energies be transformed into other particles or they can be simply be created from the kinetic energy and can be annihilated into energy, for instance into radiation... the elementary particles are made of the same substance - they are just different forms in which matter can appear.

W. Heisenberg. Physics and Philosophy Penguin Books Ltd p 25 107

Energy According to Newton's theory

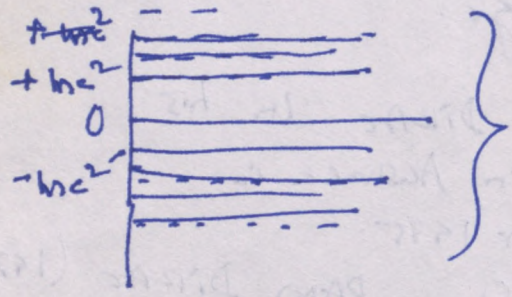
$$E = \tfrac{1}{2} m v^2 = \frac{1}{2m} p^2$$

Where p = particle momentum

According to Einstein $E = c\sqrt{m^2c^2 + p^2}$

When the particle is not moving $p = 0$ $\therefore E = mc^2$ (rest energy)

Since there is a square root in Einstein's equation, mathematically you can positive and negative values



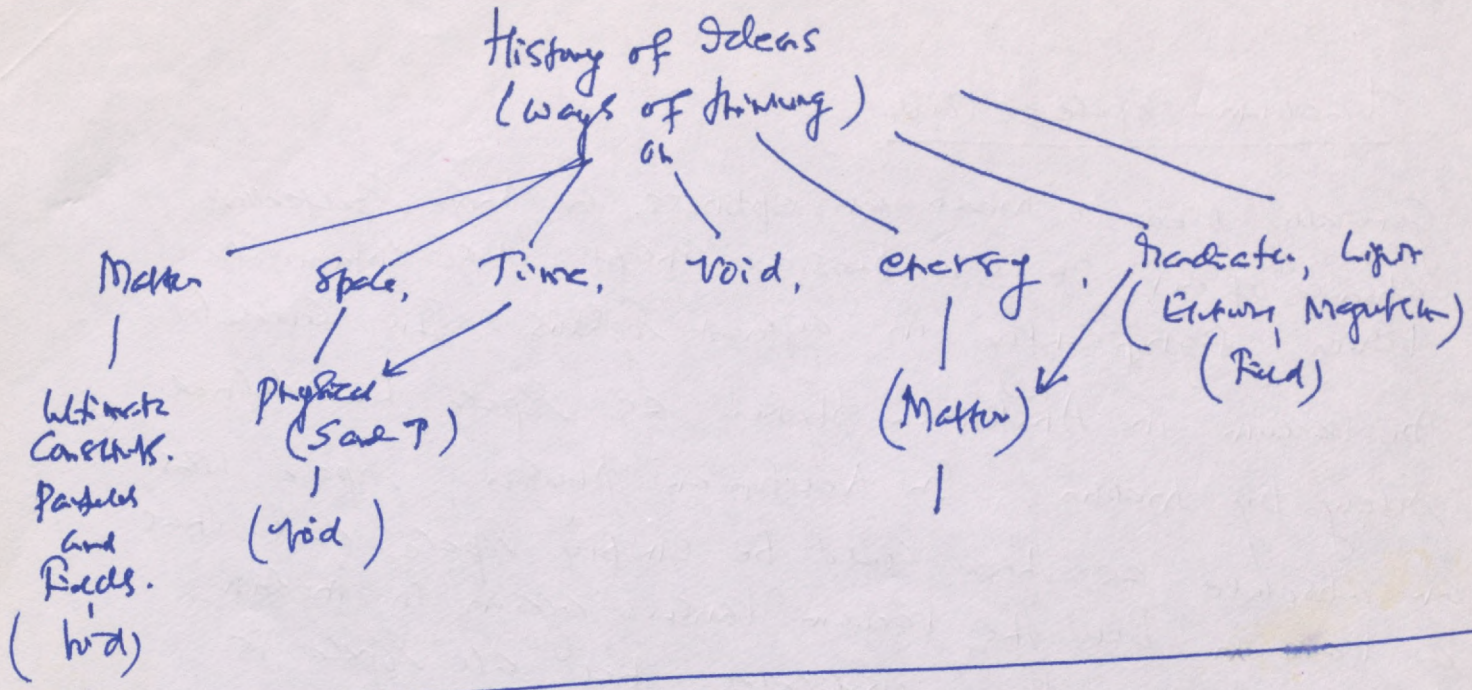
+ve values observed in practice.
-ve values not observed

Lorentz equations can be applied to electrons with negative energy.

In QM an electron can jump into a negative energy.
In classical theory we can close our eyes to negative energy states we cannot do that in QM.

Interpretation of negative energy states in Dirac's equation required reinterpretation of vacuum. (founder of)

// Vacuum was thought previously as a region of space that does not contain anything at all. Now we must adopt a new picture. We must say that vacuum is a region of space where we have the lowest possible energy. ~~The more electrons we can put into the~~ Now to get to the lower energy we must fill up all the states of negative energy. The more electrons we can put into the negative energy states, the lower the total energy becomes. Thus we must set up a new picture of vacuum in which all the negative energy states are occupied and all the positive energy states are unoccupied.



- Bernard Shah:
  - The lesson that we learn from history is that we cannot learn from it.
- Bryan Appleyard (Understanding the present)
  History is a dusty archive of doubtful value
  Truths of Science do not require the wisdom of the past.
  Scientific progress is so radical that, at every stage, it is able to throw away almost all the baggage of its own history.

→ going with the flow - my life an episode in the flow?

A Computer Scientist need not know anything about Newton.

—

This irrational, inexplicable, non-computable ability of ours to 'see' things lies at the heart of that is to be human.

Vacuum - Space - Void.

Generally used to mean an emptiness or more specifically absence of air. It is a physical concept whose interpretation varies significantly in different systems. There could be no vacuum in Aristotlean physics as space was defined solely by matter. In Newtonian physics, space was an absolute as there could be empty space and thus a vacuum. But the vacuum vanishes again in modern physics. Quantum theory indicates that all space is replete with fields and is occupied by virtual particles which can become fully-fledged apparently out of nothing. So currently there is no such thing as nothing (30. March 2020 Scientists for the entire universe)

Quantum theory establishes that a vacuum cannot happen in nature (Quantum Aristotle: Nature abhors vacuum)
A field cannot be given a precise value and a precise rate of change; Quantum fluctuations lead to the formation of pairs of "virtual particles" like protons and anti-protons. We have to say space is full of virtual particles that can spring into existence any moment.
Far from being empty, space is plenitude of potential — Indeed that is the only meaningful way of defining space. A vacuum cannot exist because existence exists.

Mendeleev : (1834-1907) {Progress of Science} ✓

" At first the Sciences, as bridges, could be built only with strong supports and long beams. I would like to show ... that for a long time the Sciences could be built as suspension bridges supported by network of cables which could hardly be broken, ~~though~~ though individually each of the cables could easily snap; in this way ravines could be spanned which had seemed impassable. Thus the Sciences learned how to span the ravines of the unknown without touching the bottom, to reach firm ground of reality and cover the entire visible world.

Dimitri
[Mendeleev in "Fundamentals of Chemistry
Preface to 8th. edition, p XXIII]

"Having descended to the very bottom, he heard a knock from below"

Pole Lezh.

" Clearly the depths of nature are bottomless. The time has come, perhaps soon, when Quantum Mechanics reaches the bounds of applicability as happened with classical mechanics in this (20th.) Century. For this to happen the

Studies of the submicroscopic world have to reach and penetrate a yet unknown level of reality. It seems that physicists have already heard a 'knock from below'. At any rate they keep listening .... For instance, there are hints that on a smaller-than-the submicroscopic scale the inevitable changes in the geometric properties of space-time will play the decisive role. And this may have revolutionary consequences for the description of nature!

One thing is clear: the future development and deeper probing of physics will not revive old ~~physics~~ and familiar classical concepts, but will lead to new astonishing surprises, and new great ordeals, out of which will spring joys of new, yet unforeseen knowledge"

DANIEL DANIN in
Probabilities of the Quantum
World. (1983)
Mir Publications, Moscow

The Nucleus: journey inside the atom.—

(1) Atom is Neutral.
Electron is -ve charge.
There is the +ve charge

(2) There is the mass of the atom.
e/m found 2000. Are there 2000 electrons? There is the +ve charge.

(3) What is the structure of the atom?

Nagaoka (1865-1950) } proposed the "Saturnian" model around 1903

J. J. Thomson
Electrons are stuck in a continuous matrix of positively charged matter
Like Raisins in a plum pudding

1895 X-rays (Roentgen)
1896 Radioactivity (Becquerel)
1897 electron (Thomson)

Rutherford:
b. 1871 at Brightwater, New Zealand.
1895 → Cambridge - Cavendish.
(1895-1898) - (α, β)
1898 - McGill University Chemistry Fredrick Soddy radioactivity
trained on different kinds of
1900 - got married. 1903 - Balfour Lecture at Royal Society.
1906 - Professor at Manchester - Scattering of α-particles
Discovery of Nucleus -
positive charge concentrated in a tiny volume.

- Why orbiting electrons collapse into nucleus by radiating energy.
- Why nuclear constituents don't fly apart
- What is the distribution of mass in the atom?

Basis for Bohr's theory of the atom

Rutherford: You know Bohr your conclusions seem as certain as I do as the premises on which they are based.

1919 - Rutherford succeeded Thomson at Cavendish
His students Chadwick discovered the Neutron
Cockroft and Walton - Split the Nucleus

Distribution of Mass in the Atom:

Dalton's work in the early 19th. Century -
ratio of masses determined by Chemical methods

The Manchester Experiments showed not only the Concentration
of Charge, but also of mass in the Nucleus "Protons"
Particles in the Nucleus - Rutherford named them

the anomaly Nuclear charge and Nuclear mass -
Solved by the discovery of the Neutron.

Moseley Calcium atomic weight 240
Atomic Charge = 20
Nuclei
α-particle 4 and 2

Elementary Particles:

Till 1932 only 3 elementary particles –
Electron, Proton and photon.

In 1932 – { Neutron – Chadwick
~~Meson~~ – Carl Anderson.
positron. }

By 1965 > 100 elementary particles., 1978 ~ 350.
2002 >

[6 neutrinos, 2 μ's, 3 $\bar{\pi}$'s, 4 k's
Δ resonances, hyperons – $\Sigma^{\pm}$, Ξ, ψ/J

Quarks

1905 Special Theory of Relativity.

- Einstein abandoned the fetters of Newtonian Absolute Space and Time
Space and time formed a Continuum that Curved and enfolded about itself.
Gravity was a distortion of this Continuum caused by the presence of Mass.
Mass and Energy were Correlated by $E = mc^2$
c was absolute.
Our perception of the Universe was wrong at large Scale-objects & that of Quantum Systems.

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(6) Quantum Theory Refracted Spiralling electrons both discrete energy States. Planck's Constant put a Lock on the System.

=

CHAOS Theory Butterfly effect.

- Point of view of Maths than Physics.
- Chaos eliminates the Laplacean Fantasy of deterministic predictability.
- Henri Poincaré — (early 20th Century)
- 1961 - using Computer for Met purposes - Convection of heated patterns — Bizarre Results. — Why
On the feed back equation Some numbers were calculated to 3 instead of 6 decimal places.
One expected Small Variation of the final outcome - but the result Showed wide fluctuations
- Statistics - acknowledgement of ignorance.

LORENZ

- Atoms to Void - Exotic Ideas and facts of the Land of Elementary Particles.
- Atoms to Void - A historical journey through the domain of particles, fields and forces.
- A journey into the Void - through the domains of particles, fields and forces.
- ~~In thy "Nothing" may I see "all"~~
- In this thy Nothing may I find thy all" Goethe. So said Goethe. Is this what modern Science telling us?
- "We are like the musk-deer which hunts for the fragrance which exudes from its own body"
- The Physicist and his Void
- Particles, Fields ~~and~~ Forces and the Void. and discoveries
- ~~Some~~ Scientific Ideas) of the 20th. Century: Nuclei, particles, Fields and ~~void~~. the Void.

× Revolutionary Ideas and Discoveries of the Twentieth Century.

(2) 1780 Lavoisier — Matter can be changed from one form to another — yet it can not burst in and out of existence. (Conservation of Mass)

By 1800 - Energy and Mass two separate domed cities

fire, crackling battery lim — trees, stone, people

or

Energy and Mass - different topics - having to do with each other

1900 -

1905 - Einstein $E = mc^2$.

1900 - All matter made of "atoms" — that atoms are made of? No one knows.

Rutherford and the Nuclear. — Atom an "entity"

Chadwick and the Neutron (1932)

1938 - Lise Meitner - Austrian scientist - Madame Curie of Germany.

Leading German

Otto Hahn - grabbed all the credit and disdain of

Fission

1934 - Fermi - Neutron as tool for studying Nuclear structure.

Meitner (Jewish)

↓ thrown out by Hahn. (1938)

Hahn and Meitner star work at least without

From stockroom the diamond the bomb

How could the entry of one small particle break the entire dam?

One Neutron enters and Fissions the Uranium Nucleus.

(Meitner and Frisch)

Radioactive Barium Detector has the first clue

Fermi and Slow Neutrons.