Summary of popular lecture

on

'Parity in Nature'

By parity is meant the principle that all phenomena in nature could be explained on the basis of a few simple and fundamental laws. The whole progress of the physical and biological sciences is a striking confirmation of the fact that man has struggled for ages to percieve such parity in nature.

But one can immediately notice striking differences between biological and the physicists in their approach towards finding such fundamental laws of nature. While mighty revolutions are taking place in the concepts of the physical sciences, the biologist appears to be looking on these with detachment and exercising great restraint about stating new laws in his own subject. This attitude could perhaps be appreciated if we not e that Biology is still a young subject, and most complex one because of the hypothesis of evolution by natural selection, containing the laws of adaptation, competition and survival, and implying that there need be no theory of the origin of life at all. Another kind of complexity arises because of the validity in biology of the view that the design of an existing product is relative to its way of life. This is something like the principle of indeterminacy in physics, and leads to the result that the technique of recognising that not only general statements but their opposites also are meaningful appears valid in biology. A third complexity is the prevalence of the notion of a general type of complementarity which states that one understands the laws of nature only when considers all the three questions each independent of the others viz the questions of mechanism, the question of adaptation, and the twin questions of embryogeny and evolution. The most complex nature of biology, however, is that it is a science of life without defining life, but only

...2

recognising it. It is because of such complexities that biologists do not watn to theorise like physicists, but a time is certain to come when the biological sciences, having grown old enough, will indulge in abstract theories which will put into shade the extravagant theories of modern physics.

Coming to the physical sciences themselves, one could trace an interesting evolution in the attempts of physicists to perceive parity in nature. Based on Newton's law of motion, and generalised by deep and beautiful mathematical analysis developed by Euler, Legrange, Laplace, Jacobiand Hamilton, classical physics held sway for nearly two centuries until the discovery of electromagnetism by Faraday and Maxwell. It was then that Einstein formulated relativistic mechanics and quantum mechanics was created by Planck, Bohr, de Broglie, Schrodings, Dirac, Heisenberg and Pauli based on Rutherford's epoch making experiments. Further attempts at the search of uniform laws are illustrated by considering advances in the region of elementary particle physics. A fundamental development was the relativistic quantum theory of Dirac leading to discovery of new anti-particles and the processes of annihilation and creation of elemetary particles. Further experimental discovery of other elementary particles like the several types of mesons and hyperons, and a new process of spontaneous decay of several particles into other types greatly complicated the position. The interaction between several types of elementary particles holds the centre of interest in the subject today, and new theories have been developed to re-examine Dirac's work keeping the quantum principles in tact, but trying to consider the invariance of these interactions and discontinuous relativistic transformations like space reflexion denoted by by P, time-reversal denoted by T, and also under the new type of transformation of particles into antiparticles denoted by C. In this category falls the famous C P T- theorem of Pauli that if one of the operators is not conserved, at least one other also must not be conserved leading to five possibilities. Recent examination of this by Lee and Young for the particular interaction of β - decay viz (being the neutrions) showed that P and C are not conserved in this interaction, and this conclusion, was verified by the experiment of thus leading to the result that is a right handed screw, and (the anti-neutrino) is a left handed screw, and mirror images are nothing! A consequence of Pauli's theorem in this case is that T may or may not be conserved, and experiments have not yet decided this. If the latter be true, it leads to difficulties in statistical mechanics and thermodynamics about reactions and reversible reactions, and also to speculations, that at some previous history of the universe when conditions of extreme densities and extreme temperatures existed, ordinary thermodynamics did not hold. At least if C P invariance is valid, and hence also T invariance, then the world we see in a mirror would obey different physical laws, but would obey the same physical laws as in an anti-world and this difference may be due to an accident in history of our part of the Universe.

The rapid advance of experimental work in this field,

some of which by their very nature have to be classified as <u>strange</u> particles and have necessitated ascribing to them a new quantum number called the <u>strangeness</u> S. A further study of the large number of interactions between the several types of elementary particles, which number 32 at present, have led to the classification of these interactions as strong, electromagnetic and weak with relative strengths 1 : 10^{-2} : 10^{-14} with β decay mentioned above as a typical example of the last life, and besides a fourth type called a strange interaction ie decay of strength particles has also been added. Complex experiments are being performed to decide the question of conservation of C,P and T in the several types of interactions, and the physicist of today.appears to be back in the position of the Chemist in the pre-Rutherfordian era working with 92 particles and amssing vast information regarding interactions between them, but failing to perceive a parity in nature.

Among the elemetary particles, the photon and neutrino ( ) appear the most romatic, and the mupterious , apart from having helped in proving the violation of P in weak interactions, appears destined to play an important role in future developments attempting to absorb Einsteins general relativistic theory of gravitation into the main stream of quantum mechanics. Gravitational attraction as compared with other interactions is weakest being of the order of 10^{-34} and if gravitational theory be quantised, and we can talk of 'gravitons' as elmentary particles, it would be most interesting to find how they are related to the neutrinos, For this the great open question of cosmology dealing with the 'boundary conditions' satisfied by the universe at its beginning have to be answered by observation. Important innovations in this direction may arise in the next few decades out of astronomical observations relating to cosmological questions made possible by elaborate equipment assembled in sputniks in interplanetary space. But a clear understanding of the problems of elementary particles physics appears possible only when a still deeper mathematical anaylysis is made of existing quantum field theories of the nature that Hamilton's theory did to classical physics.

--

Summary of popular lecture

on

"Parity in Nature".

~~The perception of parity in nature & what is meant by parity in nature is the~~ By parity is meant the principle that all phenomena in nature could be explained on the basis of a few simple and fundamental laws. The whole progress of the physical and biological sciences is a striking confirmation of the fact that man has struggled for ages to perceive such parity in nature.

But one can immediately notice striking differences ~~in the approach~~ ~~betwe~~ between biologists and the physicists in their approach towards finding such fundamental laws of nature. While mighty revolutions are taking place in the concepts of the physical sciences, the biologist appears to ~~look~~ be looking on these with detachment and exercising great ~~constraint~~ restraint about stating new laws in his own subject. This ~~could perhaps be understood underst explained~~ attitude could perhaps be appreciated if we note that Biology is still a young subject, and a most complex one because of the hypothesis of evolution by natural selection, containing the laws of adaptation, competition and survival, and implying that there need be no theory of the origin of life at all. Another kind of complexity arises because of the validity in biology of the view that the design of an existing product is relative to its way of life. This is something like the principle of indeterminacy in physics, and leads to the result that the technique of recognising that not only general statements but ~~also~~ their opposites also are meaningful appears valid in biology. A third complexity is the ~~notion of "complementarity" proposed by Niels Bohr~~ prevalence of the notion of a general type of complementarity which ~~consists of the st~~ states that one understands the laws of nature only when considers all the three questions each independent of the others ~~relating~~ viz. the question of mechanism, the question of adaptation, and the twin questions of embryogeny and evolution. ~~But Above~~ The most complex nature of biology however, is that it is a science of life without defining life, but only recognising it. It is because of such complexities that biologists do not want to theorise like physicists, but a time is certain to come when the biological sciences, ~~will have~~ having grown old enough, ~~and~~ will indulge in ~~extravagant~~ abstract theories which will put into shade the extravagant theories of modern physics.

Coming to the physical sciences themselves, one could trace an interesting evolution in the attempts of physicists to perceive parity in nature. Based on Newton's laws of motion, and generalised by deep and beautiful mathematical analysis developed by Euler, Lagrange, Laplace, Jacobi & Hamilton, classical physics held sway for nearly two centuries until the discovery of electromagnetism by Faraday and Maxwell. It was then that Einstein formulated relativistic mechanics, and quantum mechanics was created by Bohr, de Broglie, Schrödinger, Dirac, Heisenberg and Pauli based on Rutherford's epoch-making experiments. ~~To understand~~ Further attempts at the search of uniform laws ~~it is~~ are best ~~to consider~~ illustrated by considering advances in the region of elementary particle physics. A fundamental development was the ~~work of Dirac, using strictly the principles of quantum mechanics and special relativity~~, relativistic quantum theory of Dirac leading to the discovery of new anti-particles ~~like positrons~~ and ~~anti-protons, and anti~~ the processes of annihilation and creation of elementary particles. Further experimental discovery of other new elementary particles like the several types of mesons and hyperons, and a new process of spontaneous decay of ~~a new type~~ several particles into other types greatly complicated the position; ~~and necessitated a re-examination of the~~ The interaction between several types of elementary particles holds the centre of interest in the subject today, and new theories have been developed to re-examine Dirac's work keeping the quantum principles intact, but trying to ~~modify relativistic~~ consider the invariance of these interactions under discontinuous relativistic transformations like space reflexions denoted by P, time-reversal denoted by T, and also under the new type of transformation of particles into anti-particles denoted by C. In this category falls the famous CPT-theorem of Pauli that if one of the operators is not conserved, at least one other also must not be conserved, ~~and~~ leading to five possibilities. Recent examination of this by Lee and Yang for the particular interaction of β-decay viz. $n^0 \rightarrow p^+ + e^- + \nu^0$ (ν^0 being the neutrino) showed that P and C are not ~~conservation~~ conserved in this ~~act~~ interaction, and this conclusion was verified by the experiment of Wu on Co^{60}, ~~which lead~~ thus leading to the result that ν^0 is a right-handed screw, and $\bar{\nu}^0$ (the anti-neutrino) is a left-handed screw, and mirror images are nothing! ~~It is strange that nature should know the difference between such screws. This experiment does not decide~~ A consequence of Pauli's theorem in this case is that T ~~is~~ may or may not be conserved, and experiments have not yet decided this. If the latter be true, it leads to difficulties in statistical mechanics and thermodynamics ~~also~~ about reactions and reversible reactions, and also to speculations that, at some previous history of the ~~host~~ Universe when conditions of extreme densities and extreme temperatures ~~ruled~~ existed, ordinary thermodynamics did not hold. At least if CP invariance is valid, and hence also T invariance, then the world we see in a mirror would obey different physical laws, but would obey the same physical laws as in an anti-world, and this difference may be due to an accident in the history of our part of the Universe.

The ~~great~~ rapid advance of experimental work in this field, which has left theory far behind, has yielded many more new types of particles some of which, by their very nature, have to be classified as <u>strange</u> particles, and have necessitated ~~the~~ ascribing to them a new quantum number called the <u>strangeness</u> S. ~~Also the classification~~ A further study of the large number of interactions between the several types of elementary particles, which number 32 at present, have led to the classification of these interactions as strong ~~(πN)~~, electromagnetic ~~(γe)~~ and weak ~~(β-decay)~~ with ~~interactions of~~ relative strengths $1 : 10^{-2} : 10^{-14}$, and besides a fourth type ~~was~~ called a strange interaction ~~resulting in the decay~~ from i.e decay of strange particles, has also been added. Complex experiments are being performed ~~today~~ to ~~find~~ decide the question of ~~interaction~~ conservation of C, P and T in the several types of interactions, and the physicist of today

with β-decay mentioned above as a typical example of the last type appears to be back in the position of the Chemist in the pre-Rutherfordian era working with 92 particles and amassing vast information regarding interactions between them, but failing to perceive a parity in nature.

~~Excepting~~ Among the elementary particles, the photon and the neutrino (ν^0) appear the most romantic, and the mysterious ν^0, apart from having helped in proving the violation of P in weak interactions, appears destined to play an important role in future developments attempting to absorb ~~the general~~ Einstein's general relativistic theory of gravitation into the main stream of quantum mechanics. ~~Gravitational attraction which is important on a cosmological scale~~ Gravitational attraction as compared with other interactions is weakest being of the order of 10^{-34} & if gravitational theory be quantised, and we can talk of "gravitons" as elementary particles, it would be most interesting to find how they are related to the neutrinos. For this the great open questions of cosmology dealing with the "boundary conditions" satisfied by the Universe at its beginning have to be answered by observation. Important innovations in this direction may arise in the next few decades out of astronomical observations relating to cosmological questions made possible by elaborate equipment assembled in sputniks in interplanetary space. But a clear understanding of the problems of elementary particle physics appears ~~only~~ possible only when a still deeper mathematical analysis is made of existing quantum field theories of the nature that Hamilton's theory did to classical physics.

Popular Lecture on "Parity in Nature".

Did not realise what I was in for – original intention – looking at several dictionaries meaning being equality, parallelism, analogy, symmetry or order; sp. meaning of equality in status among ~~ministers~~ members or ministers of a Church, and as the condition or fact having borne children (in medicine) – not dealing with last two – Considering creations of the human mind as part of nature, vital role played by these notions in the several branches of humanities, Religion, phil, logic, literature, fine arts, psychology, economics, sociology etc, ~~but this would~~ & in interrelating them, ~~but this would be too wide a field~~ – notions purely mathematical & could be sharpened using math. logic & applied in the above branches, ~~but this would be too abstract – Hence consider only the physical & natural sciences~~; and this would not be unnatural – first part of Bronowski's creative process ~~– such a search~~ and thus creativeness is the finding a new kind of parity in the variety of nature – And thus such an approach linking sciences with humanities on basis of these notions would however be very abstract – Hence confining to physical & biological sciences –

Leaving aside notions of analogy, parallelism & symmetry as secondary meanings of parity, the most fundamental meaning is that of equality, but what does one mean by equality in nature. Apparently equalities in nature are not apparent at first sight, but I think what is is really meant by parity or equality in nature is the principle, or shall I say faith, that all phenomena in nature could be explained on the basis of a few simple & fundamental laws (or that nature has a unity & this unity makes the laws seem beautiful in simplicity). Infact, the whole progress of the physical & biological sciences is a striking confirmation of the fact that man has struggled for ages to find such laws or to perceive ~~equality~~ parity in nature.

As a step in this direction, the biologist seeks to explain life in terms of the physical ~~concepts of~~ sciences in view of the fact that in the latter the possibility of finding such universal laws does not appear hopeless at least in principle. But the remarkable fact is that the biologists themselves do not appear to be keen in hastening the advent of such an explanation by enunciating laws of their own; on the other hand they have just preferred to wait, and looked with detachment on the mighty revolutions that are taking place in the concepts of the physical sciences, and exercised great constraint about stating new laws. At least one would have thought that the present universal position that biologists hold about the origin of life would have prompted them to undertake such a task – supernatural creation & spontaneous creation from non-living matter, – present view that there ~~be~~ need be no theory of origin of life at all. Present concept of origin of life is . . . . (Wald)

— concept of order of Nature. Although this is a simplification in one respect, Biology is still a most ~~complicated~~ complex subject because ~~of~~ the hypothesis of evolution by natural selection containing the laws of adaptation, competition & survival only formulates past history, but has little to say about the future. In a mathematical terms one could say that biology deals with nature from $t = -\infty$ to $t = 0$ but not ~~from~~ with $t = 0$ to $t = +\infty$. Another kind of complexity ~~permeating~~ permeating biology is the kind of essential opposition of ideas that arises from the present concept of life held by most biologist viz while Darwinian theory of evolution is ~~firmly held~~ true, Goethe's view of archetypes that the design of an existing product is relative to its way of life is also true. This is something like the principle of indeterminacy in physics on which ~~Bohr~~ Einstein & Bohr held opposite views, and in defending which Bohr classified two kinds of truth .. (Wald) - - - - abound. Examples of the so-called "deep truths" are statements like "War is peace, Freedom is slavery", Hegel's dictum that "Freedom is the recognition of necessity", and again statements from the teachings of great religions like "Blessed are the poor in spirit, & Blessed are they that mourn" ~~The further one departs from the rigorous sciences~~ this technique of recognising that not only several statements but their opposites are also good ~~in biology~~ appears valid in biology. A third complexity that prevails in biology is the notion of "complementarity" proposed by Niels Bohr. Confronting ... (Wald) - - in the physical sciences. But the most complex nature of biology is that it is a science of life without defining life, but only by recognising it. This cannot be pronounced unsatisfactory, for, taking a particular example suppose one were ask to define one's wife. There is no trouble in recognising her accurately & unequivocally but one cannot define her — Put in here imaginary conversation on this with Sonya & her reaction to it about defining a husband. ~~This~~ It is because of such complexities that biologists don't want to theorise like physicists. Look at the present state of the two sciences; The physical sciences have most eccentric theories ~~and~~ & are alive & kicking with unexpected things happening everyday, while the biological sciences are dead so far as theorising goes. This appears a strange inversion - - (Bronowski) ... - - - physical sciences. In fact, one could say confidently that if biology is ever "reduced" to physics ie if we ~~now~~ find new parities in nature it will be because the physical sciences will have grown up to biologists and then the biologist will not wait, and at that point it will be hard to say which is which.

Now coming to the physical sciences themselves, do we perceive parity in nature in the general sense that I have mentioned earlier viz basing phenomena on a few fundamental laws? Physicists thought so at the time when the great & immortal Newton enunciated his three laws of motion; and ~~this~~ these laws held the field for nearly a 150 years & during this period Newtonian dynamics or classical physics had been ~~developed~~ generalised by deep & ~~beautiful~~ mathematical ~~and~~ & deep analysis developed by Euler, Lagrange, Laplace, Jacobi & Hamilton. They held sway for still another ~~p~~ 50 years until the discovery of electromagnetism by Faraday & Maxwell, a new science being as fundamental as Newtonian Dynamics. It was then that Einstein formulated his relativistic mechanics, and ~~the~~ quantum mechanics was created by Bohr, de Broglie, Schrodinger, Dirac, Heisenberg & Pauli based on Rutherfords epoch making experiments. Newtonian classical mechanics could no longer be treated as giving universal laws, but only as giving approximate ones, and the search for such universal laws has been going on ~~still~~ since 1925. This is best illustrated by the work of physicists in the region of "elementary particle physics". It does not mean that work of creative chemists in the regions of physical ~~chemistry~~ & organic chemistry, and of creative technologists in the fields of superconducting materials and semi-conducting materials or transistors has not helped in the search for fundamental laws; but that elementary particle physics has held a predominant role in this. I remarked earlier that ~~the~~ this subject is alive with ~~eccentric~~ numerous & eccentric theories, but the fact ~~it~~ is that, in spite of this, experimental knowledge in this field is far ahead of theory & this is perhaps a very healthy sign since more & more and new kinds of expts. are bound to throw ~~light~~ more light on the phenomena concerned. The situation was the same at the time of Rutherford's expts & his discovery did not --- ~~Charlatans~~ -- (Dyson) -- Charlatans & philosophers. Excuse me this grouping is accidental & I mean no offence to philosophers present in the audience. It is only when Bohr built up a theory that R's expts. could be properly explained.

As long as the old elementary particles like e^- & p & n (Chadwick) were in the centre of interest, a consistent theory, what ~~is know~~ was then known as relativistic quantum mechanics was built up & it looked as if one ~~again~~ had universal laws, one famous such being the connection between spin & statistics of elementary particles (Bose & Pauli). But further development of the theory by Dirac, starth using strictly the principles of quantum mechanics & of special relativity, gave rise to the ~~concept of anti-particles as holes in negative energy states leading to positrons, anti-protons & antineutrons,~~ and ~~were this was the first serious blow to~~ radically new concepts. He gave a ~~logical~~ derivation of quantum mechanics on the basis of a logical concept of the states of a system and a discontinuous transition from one state to another. He further based these quantum-mechanical laws on the postulates of special relativity viz that the laws should be invariant for continuous translations & rotations in space-time (Give 3 dimensional analogy of physical laws being independent of choice of coordinate system)- Such a rigorous treatment led to the discovery of the existence of negative energy states & he removed the difficulty by postulating new anti-particles as holes in -ve energy states thus leading to positrons, anti-protons & antineutrons. Discovery of other new elementary ~~new~~ particles like the several types of mesons, and the hyperons and processes of annihilation & creation & spont of such particles greatly complicated the position. The present knowledge of about these particles is that they are 32 in number (diagram - emphasise) characterised by their masses, charges & spins as the three parameters, and they interact with each other & show a new process of spontaneous decay into other particles. ~~This interaction~~ The interactions between several types of particles holds the centre of interest in elementary particle physics of the present day, and new theories have been developed to re-examine Dirac's work keeping however the quantum ~~mechanical~~ principles intact ie without disturbing Bohr's principle of complementary, but trying to modify the relativistic principles. As I mentioned above quantum mech. ~~considered~~ is discontinuous by its very nature, while relativistic transformations were taken as continuous. ~~The position~~ The new theories want to take into consideration ~~bring the~~ discontinuities in ~~these~~ rel. transformations also. Thus one considerations nowadays transformations like space reflexions (mirror images), time-reversals; and also the transformations of particle → antiparticle states also called charge conjugation (since this is true of charged particles). P, T & C (P called parity which I originally wanted to discuss in today's lecture) denote these transformations. Invariance of interactions under these transformations or conservation of these in the interactions - CPT-theorem of Pauli that if one of the operators is not conserved, at least one other also must not be conserved leaving to five possibilities. ~~This was recently test~~ Recent examination of this by Lee & Yang for a particular interaction viz β-decay: $n^0 \to p^+ + e^- + \nu^0$ who showed that P and C are not conserved in this interaction. Expt of Wu on Co^{60} verifying this. This leads

to a great revolution in physics of supreme importance ~~almost~~ comparable with Rutherford's discoveries. These show that ν^0 is a right-handed ~~helix~~ screw & $\bar{\nu}^0$ a left-handed one & mirror images are nothing! How wonderful this would be for ugly women & how tantalising for beautiful ones! C is also not conserved & hence T may or may not be conserved, and expts. have not yet decided this. Strong, e.m & weak interactions $1 : 10^{-2} : 10^{-14}$.
(p-n) (p-e) (β-decay)

Strange particles & strangeness (~~S=0 for all known ones~~, $S = +1$ for K^0 & K^+, $S = -1$ for K^- & $\bar{K}^0$, ~~S=-1~~ Σ^+, Σ^0 & Σ^{-1}, and $S = -2$ to heaviest hyperon Ξ^- & $S = 0$ for others) – Decay of strange particles called strange interactions – question of conservation of C, P, T in several interactions, in particular P conserved in strong interactions & perhaps in strange ones also. ~~various~~ question of lepton conservation – Great complexity at present time of nature of several conservation laws & their interaction & two-component theories. ~~Physicists~~ Many these problems were not even questions a year ago & we cannot complain that there are no answers. Physicists of today is back in the position of the Chemist in the last century where elements & their properties were given i.e. in the pre-Rutherford era. We have not yet got 92 particles (only 32) & no. of properties might not still be equal to the no. of things a chemist can measure, but the situation is rapidly approaching this stage & we must ~~have~~ find some common reason soon i.e. soon establish parity in nature. It is strange that nature should know the difference between a right handed & left handed screws (Wu's expt). At least if CP invariance is valid, then the world we see in a mirror would obey different physical laws but would obey same physical laws as an anti-world & this difference may be due to an accident in the history of ~~the~~ our part of the Universe. If CP is conserved, so would be T; otherwise if T be not conserved due to C & P being both not conserved, this leads to difficulties in statistical mechanics & thermodynamics also about reactions & reversible reactions & to speculations about ~~at~~ some previous history of the Universe condns of extreme densities & extreme temperatures ordinary thermodynamics did not hold. ~~Two points of view held about further progress of elem. particle physics~~

~~Galt~~ Among the elem. particles photon & neutrino appear the most romantic – Some words about photon from de Broglie – As regards the mysterious particle ν^0 its interest, apart from having helped in proving violation of P in weak interactions, it affords possibilities of application when we go ~~to still further interactions~~ further to still weaker interactions. I have said a few words about parity in nature re. living & non-living matter & we might also consider parity as between sdly large & sdly large aggregations of matter which are subject to phenomena of gravitation & cosmology. So far general rel. theory of gravitation has not been absorbed into the main stream of quantum mechanics. Gravitational attraction as compared with other interactions is the weakest of the order of 10^{-34} (cf. β decay $\sim 10^{-14}$). If gravitational theory be quantised & we can talk of 'gravitons' as elementary particles, it would be most interesting to find how they are related to the neutrinos. For this the great open questions of cosmology dealing with the "boundary condns" satisfied by the Universe at its beginning have to be answered by observation.

There are two points of view held at present about the future of elem. particle physics, (i) the optimistic one that things will be satisfactorily settled in about 30 years ~~as for example~~ since so far in almost every known case this is the period that has elapsed between the recognition of a puzzling phenomena & the birth of a new idea explaining it, for eg 30 years from Faraday to Maxwell, from Maxwell to Hertz 30 years & so on. (ii) the pessimistic view believing in a larger time scale & placing the present position as that of the 18th century successors of Newton. It took 150 years from Newton to Hamilton, 200 years from Newton to Maxwell. Quantum Mechanics however great his genius could not have been discovered by anyone without the deep math. analysis of Hamilton and the deep physical content of Maxwell's theory. In ~~twenty~~ 30 years an important innovation may arise out of gravitational & astronomical observations relating to cosmological questions made possible by elaborate equipment assembled in Sputniks ~~interplanetary~~ space. There would still be need however for a deep math. analysis of the type that Hamilton did for Newton's dynamics. The existing quantum field theories certainly contain deep mathematical depths (although most physicists think it is already too mathematical) which will need the genius of a Gauss, or an Euler to plumb; ~~This is perhaps one of the reasons why I chose this subject for lecturing at a mathematical conference.~~ and such attempts may enrich mathematics itself. As we have seen in our own life time, all fields of mathematics including the most abstract ones have been annexed by the theoretical physicist with perhaps a few exceptions like Ramanujan's theorem on prime numbers & ~~theorems on integral functions which in our~~ President Dr. ~~Ganapathy Iyer has specialised in~~

We welcome workers in elementary particle physics into the domain of mathematics, in spite of the fact that it is defined as a subject in which one does know what he is talking about & in which ~~he should not know~~ it is important that he should not know what he is talking about. ~~such~~

Para 1 – A creative ~~process~~ mind in any branch of knowledge is ~~the discovery of~~ a mind that looks for unexpected likenesses ~~likeness~~. The childlike vision of Einstein has a poet's innocence & Planck felt a poetic excitement when he discovered, no, created the quantum. Modern science is less preoccupied with less facts than relations, & this new vision is a search for structure & it is also marked in modern art. Abstract sculpture often looks like an exercise in topology because the sculptor shares the vision of the topologist.

Para 3(1) is that it inevitably arises whenever conditions permit, given enough time, and that life is a part of the order of nature & that the concept of God is equivalent to the concept of order of Nature

Para 3 (2) (i) clear & simple statements the opposite of which could not be defended
(ii) "deep truths" viz statements in which the opposite also contains deep truth.

The further one departs from the physical sciences with their special efforts to achieve rigorousness in thinking, the more deep truths abound.

Para 3 (3) Confronting any phenomenon in living organisms, the biologist has always to ask three questions each independent of the others, the question of mechanism (how does it work?), the question of adaptation (what does it do for the mechanism?) and the twin questions of embryogeny & evolution (how did it come about?). The complementarity consists of the fact that one understands only when all the three have been considered. Of these three questions, only the first has a substantial place in physics or chemistry

Para 3 (4): of the way that we usually picture the dead & the living & it reflects the age of these sciences. The physical sciences are old, and in that time the distance between fact & explanation has lengthened; their very concepts are unrealistic (mathematical). The biological sciences are young, so that fact & theory look alike; the new entities which have been created to underlie the facts are still representational rather than abstract. How much more extravagant the biological sciences will become when they are as old as the physical sciences!

Para 4. create stir for a long time, because physicists had been accustomed to regard inside of atoms as a field of speculation for

—

Thurber – Men, Women & Dogs (1944), p. 107 (London, Hamish Hamilton).

Gamow – 1, 2, 3 ... ∞ – neutrinos came into physics through the back door, but now occupy an unshakable position – discovered by the method of reductio ad absurdum – Energy Conservation in β-decay – thief or gang of thieves found by detectives of science; Baghdad thieves – this method alone available because it could not be observed directly by other physical means – light stopped by a thin metallic filament, X & γ-radiations would require several inches of lead, but a beam of neutrinos would go without much difficulty through the thickness of several light years of lead! nuclear recoil compared with ordinary guns where a faster projectile would produce a stronger recoil than a slower one, but nuclear recoil is same whether a fast or slow electron is ejected; the solving the riddle is that the recoil is balanced by the neutrino, another proof of its existence

Collapse theory of novae & supernovae of the rapid contraction of the entire stellar body in about a few days – Gamow's theory that the real cause is due to the mass formation of neutrinos which is the right agent to remove the surplus energy from the interior of a contracting star since the entire body of the star is just as transparent for neutrinos as ~~the~~ a window pane is for ordinary light. The actual process through successive formation of unstable nuclei retaining electrons, rejecting them & so on, but only neutrinos going off

de Broglie – Light is the fastest of messengers. Light has no need of support for its propagation. Light is the purest form of the ~~em~~ e.m.f. Light first revealed duality of waves & corpuscles; Einstein's light quantum hypothesis, Compton & Raman effects. Universe with light condensing into matter visible through light itself & perhaps one day when time has ended, the Universe ~~may~~ becomes pure by dissolving into light – laws of probability. corpuscular & wave aspects playing a game of hide & seek. Relation bet. microphysics & biology – Jordan's theory of several "genes" in contemporary biology. mammal belongs to a macroscopic world – Grey matter of the brain cell. Science is a great ornament & it is an implement of wonderful use. In the world of man ~~and~~ man has been able to show the force of his intelligence; if he wishes to survive, he should show the wisdom of his will.

(1) I shall now call upon Dr. S. N. Biswas to give his talk on anharmonic interactions. Before doing so, I might say a few words by way of introduction. Dr. Biswas has had a distinguished career having taking his Ph. D. at the Adelaide University working on rel. quant. mechanics with Prof. H. S. Green. He later worked at the T. I. F. R., Bombay, and is at present Professor of Physics at the Delhi University working on problems relating to particle Physics.

Having heard him speak yesterday, I wish to point out to him that this Hall is not acoustically perfect, and I shall therefore take the privilege of the Chairman of a meeting in requesting him to speak louder. I might remind him that the pressure of sound is measured in decibles & a zero decibel corresponds to a voice hardly audible at a distance of 3 ft. But the saving grace lies in the fact that sound intensity varies exponentially with the pressure.

Now Dr. Biswas

(2) Dr. Gyanmohan is an M. Sc from the B.H.U. and later took his Ph. D. at Iowa State University his work relating to axiomatic field theory. This is quite encouraging since I have a feeling that field theoretic aspects do not find much favour with particle physicists, and I hope you will put this aspect in proper perspective. He was later Asstt. Director at the N. P. L, and is now a professor ~~the Chairman~~ of the Deptt of Physics at I. I. T. Kanpur. ~~I am glad to tell you that~~ He has also specialised in theory of Regge trajectories and poles which subject ~~always~~ also helps the prediction of new particles ~~from~~ on the basis of those already known, and although it might look pedestrian when compared with the SU(3) technique, it has its own curious phraseology of daughters & conspiracies. I don't know if Dr. Gyan Mohan is going to deal with ~~talk about~~ these in his talk today on "Studies in Relativistic wave mechanics".

Dr Gyan Mohan.

(A) For reference.

(1) Astronomy & Cosmology by A.P. Rowe.

(2) Astronomy by Donald H. Menzel

(3) Developments in High energy Physics – Proc. Int. Conf. 1970 edited by P. Urban – Springer-Verlag

The article (11) by R.U. Sexl on General relativity & gravitational Collapse.

(4) Issues of Dublin Inst. of advanced studies Nos (2), (5), (6), (7)

(5) Talking about Relativity by J.L. Synge (North-Holland)

(6) Bergmann's book on the Riddle of gravitation.

(7) Comm. Phys - Math, Vol. 32, No. 10, 1966 on a linear theory of gravitation without potential by Paul Kustaanheimo.

(8) Sc. American, Jan. 1971. p. 48 – The nature of Pulsars

(9) Proc. Relativity Conference held at Cincinnati, Ohio (Plenum Press, 1970)

(10) Book by F. Hoyle on the Nature of the Universe (A Pelican book – Penguin books)

(11) Selected Lectures of the Roy. Soc. Vol 3 (1970) – Bakerian Lecture by Fred Hoyle.

(12) Vistas in Astronomy – Vol. 12 (Pergamon 1970) – H.N. Russell Comm. Vol.

(13) M.N.R.A.S. – Vol 141, p. 445 – Article on Quasars & Cosmology.