Erwin Schrodinger - His Life and Views*

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It is indeed most appropriate that the Devi Ahalya Viswavidyalaya and the Centre For Advanced Technology Indore, have jointly organised this Refresher Course in Theoretical Physics on the occasion of the birth centenary of Erwin Schrodinger, one of the greatest scientists of the century and one of the founding fathers of Wave/Quantum Mechanics.

I became familiar with the name Schrodinger, much before I learnt quantum mechanics. I come from an extremely orthodox and religious family of Ayurvedic doctors and had an early exposure to the Bhagavad Gita and the Vedantha philosophy through regular lectures and discourses in my own house. One of my brothers had a great interest in philosophy, both oriental and occidental and was an avid reader of books on science that had a bearing on philosophy. Another brother had communist leanings, with the result that the house was flooded with books on philosophy and science. In my school and college days I read books like Grammar of Science by Karl Pearson, the limitations of Science by J.W.N. Sullivan, Mysterious Universe by Sir James Jeans and also Karl Marx's Das Capita, Hegel's Dialectic Materialism and C.E.M. Joad's guide to philosophy, and the books on philosophy and science by Eddington. The name of Schrodinger figured prominently in many of these books. Naturally with this background, I entered the Physics honours Course at the Central College Bangalore, with many questions and with the fervent hope that these will be answered through a study of modern physics.

One of the books by Schrodinger that appeared during my honours course days was What is Life ? - the book that had a profound influence on many physicists; some of them gave up physics, went into modern biology and won Nobel Prize.

...2.

* Talk delivered at the inauguration of Refresher Course in Theoretical Physics organised at Indore on the occasion of Erwin Schrodinger's Birth Centenary.

In this inaugural talk, I will not deal with Quantum Mechanics at all. There are many others lecturing in this course who are better qualified to talk on this topic. I will briefly outline the life history of Erwin Schrodinger, touch upon his views on the interpretation of quantum mechanics and then go on to his views on philosophical implications of modern science, evolutionary theory and his reference to the Vedantha Philosophy. In doing this I will quote extensively from his own writings.

Erwin Schrodinger was born in Vienna, Capital of Austria, on August 12, 1887. His father Rudolf was a businessman trading in linoleum, but had studied Botany and was the author of several articles on plant genetics. He also had professional interest in Italian Paintings. In his early days Erwin Schrodinger was considerably influenced by his father. Schrodinger was trained at home till he was eleven years when he entered the Gymnasium where he was educated in mathematics, physics, poetry, drama and logic of philosophy. A great advantage that Schrodinger had was that his grandmother was english which helped him to speak and write english well.

Schrodinger entered the university of Vienna in 1906 - the year the famous classical physicist Boltzman died. At the university Schrodinger came under the influence of Fritz Hasenohrl, Franz Exner and Kohlrausch. He served as an assistant to Exner during the period 1910 - 1914, and published several papers on magnetism, dielectrics, atmospheric acoustics, radio activity, X-rays and Brownian motion.

With the declaration of War in 1914, Schrodinger had to leave Vienna; He became an artillary officer in the Southern front. By 1918, Schrodinger had developed considerable interest in philosophy through the readings of Spinoza, Schopenhauer, Mach, Richard Simon, and

Richard Avenarius. Till 1920, he spent short spells as an assistant to Max Wien at Jena and later was a professor at Stutgart and Breslau. He moved to Zurich in 1921 to occupy the chair that had been held by Einstein and Von Laue and came into contact with Herman Weyl and Peter Debye. During the period 1921-27 Schrodinger published papers on General Relativity, probability theory, dielectric phenomena, three colour and four colour theories of vision. He familiarized himself with the early work on specific heats, Bohr's theory of the atom, statistical mechanics of gases, de Broglie's ideas of matter waves.

Schrodinger's crucial papers on Wave Mechanics that fetched him the Nobel Prize were written when he was 39 years old, rather a late age compared to Dirac, Einstein, Bohr, Heisenberg, Uhlenbeck, Goudsmit and Jordan who all did their most important work when they were in their twenties.

Schrodinger moved to Berlin in 1927 to take the place of Max Planck who had retired. Here he came in close contact with Einstein, Planck, and Von Laue. The years 1926-28 saw the union of matrix and wave mechanics, the statistical interpretation of quantum mechanics by Max Born, the transformation theory by Dirac and the formulation of the uncertainity principle by Heisenberg. Gottingen, Copenhagen and Cambridge became the hot centres of theoretical physics.
The statistical interpretation of quantum mechanics and the dualistic aspects of quantum theory were not to the entire liking of Einstein, Planck, Von Laue and Schrodinger - a dis-satisfaction that persisted almost to the end of their lives.

In 1933 Adolf Hitler came to power in Germany, and the persecution of jews began in many ways. Eventhough Schrodinger himself was an 'aryan' and had a catholic background and could have stayed on in Berlin, he decided to quit and move out of Germany. He became temporarily a fellow in the Magdelen College at Oxford. In the same year 1933, he was awarded the Nobel Prize along with Paul Dirac.

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In 1936, Schrodinger had two offers of professorship - one at the University of Edinburgh and the other at Graz in Austria his home country. He decided to go back to Austria. However this could last only for about two years since in 1938, Hitler annexed Austria. Schrodinger who was by then 51, had to leave Austria and find a job elsewhere. This was the time when he was offered professorship by one of the universities in India. However a meeting with President de Valera of Ireland, at Rome changed the course of his life for the next 16 years. De Valera who was a mathematician himself had set up the Dublin Institute For Advanced Studies and invited Schrodinger to be its first Director. Schrodinger took up this position in 1940 and stayed on till 1956.

During the period that Schrodinger was at Dublin he published papers on Space time structure, Unified field theory, Meson Fields, Non-Linear Electrodynamics, Quantum Mechanics and Statistics. Many of his philosophical and popular writings were also done during this period. Due to health problems Schrodinger moved to Vienna in 1956 as an emeritus professor. He published two major works (i) Might Energy be a Statistical Concept and (ii) What is real ?

He died on January 04, 1961.

Among the many books that Schrodinger has written, we may mention the following which give an idea of the breadth of his interest. Collected papers on Wave Mechanics (1927); Science and Human Temperment (1935); What is Life ? (1944); The Physical Aspect of Living Cell (1944); Statistical Thermodynamics (1946); Space Time Strucutre (1950); Nature and Greeks (1954); Expanding Universe (1956); Science, Theory and Man (1957); Mind and Matter (1958), My View of the World 1964 (published after his death).

<u>On the interpretation of quantum mechanics.</u>

In the matter of the interpretation of quantum mechanics, Schrodinger was in the company of Einstein, de Broglie, and David Bohm the

the socalled hidden variable theorists, rather than Bohr and Heisenberg, the scientists behind the Copenhagen interpretation.

Schrodinger subscribed to the view that particles in the same state are physically different, the wave function gives a statistical description of an ensemble of particles, and is therefore necessarily incomplete in the description of a single particle. A single unmeasured particle takes only one path that is usually unpredictable. Particles in the same state show measurable differences because they were physically different before measurement. In contrast according to the Copenhagen interpretation, all particles in the same quantum state are physically identical. The wave function gives a complete account of the physical behaviour of a single particle. A single unmeasured particle takes all the paths open to it and quantum randomness is responsible for the measured differences between identical unmeasured particles. This is a topic on which diversity of opinion continues to exist eventhough the statistical interpretation is the basis of practically all calculations and predictions in the case of specific problems in quantum mechanics and is the only one that works.

Schrodinger believed that comprehensible explanations must have casual explanations, which in the case of some phenomena could be formulated on the basis of chance. However he felt that the interpretation of quantum mechanics on the basis of the statistical behaviour of particles as incomprehensible.

On Deficiencies of Science.

Schrodinger had strong views on the deficiencies of science. On this aspect he emphasised " the scientific picture of the world is very deficient. It gives a lot of factual information, puts all our experience in a magnificiently consistent order, but is ghastly silent about all and sundry that is really near our heart, that really matter to us. It cannot tell us a word about red and blue,

bitter and sweet, physical pain, physical delight. It knows nothing of beautiful and ugly, good or bad, God and eternity ".

"Science sometimes pretends to answer questions in these domains, but the answers are often so silly that we are not inclined to take them seriously. So we do not belong to this material world that science constructs for us. We are not in it. We are Spectators. It allows you to imagine that the total display is that of a mechanical clock which for all that science knows could go on just the same as it does without there being consciousness, will, endeavour, pain, delight and responsibility connected with it, though they actually are. And the reason for this disconcerting situation is just this : that for purposes of constructing the external world, we have used greatly simplifying device of cutting our own personality out - removing it - hence it is gone - it has evaporated - it is ostensibly not needed"

Schrodinger strongly felt that the scientific attitude has to be rebuilt and science made anew. Commenting on the External World, World in Common, reality and identity, Schrodinger says

" I get to know the external world through my sense perceptions. The same applies to every one else. The worlds thus produced are, if we allow for differences in perspectives, etc, very much the same so that in general we use the singular 'World'. But because each person's sense world is strictly private and not directly accessible to any one else, this agreement is strange. Is it due to the existence of a World of bodies which are the causes of sense impressions and roughly produce the same impressions in every one ? "

Schrodinger thinks that this is not so.

" I have no hesitation in declaring quite bluntly that the acceptance of a really existing material world as an explanation of the facts that we find in the end that we are empirically in the same environment is mystical and metaphysical "

...7.

On Vedantha.

It is at this point, when he is considering the question of the reality of the external world that he refers to the philosophy of vedantha and describes it as follows:

" All living beings belong together in as much as we are in reality sides or aspects of one single being - which perhaps in western terminology be called God while in the upanishads its name is Brahman. A comparison used in Hinduism is of the many almost identical images which a many faceted diamond makes of one object such as the Sun".

Having made this point about Vedantha, he emphasises

" As presented in the Vedas, this idea is thickly overgrown with references to bizarre Brahminic rites and foolish superstitions as one can see who has recourse to the best sources available in German."

Schrodinger however comes back to the central theme of Vedantha with the following lines:

" But setting this aside, it seems to me that the really serious conclusion drawn by the Indian thinkers for this "doctrine of identity" are two (i) ethical to which we should gladly subscribe and (ii) eschatological which we must, I suppose, reject.

Commenting on the eschatological aspect, he condemns the ideas of cycle of birth and death, the karma theory, the idea of salvation, caste system etc.

On Metaphysics.

Schrodinger rejected the Machian positivism that the important elements of our 'World in Common' are data themselves. According to him " bare results of observations do not have explanatory power. Science requires assertions about reality which go beyond any logical consequences derived from data. Phenomena of value judgement, wonder, riddle finding which do not refer to any particular aspect

...8.

of experience, but to experience as a whole, and furthermore have impressed themselves not on idiots, but on highly competant minds, seem to indicate to me that we encounter in our experience relationships which have never, even in their general form, been grasped either by formal logic or still less exact science; relationships which keep forcing us towards metaphysics - that is towards something that transcends what is directly accessible to experience - however much we may flourish a death certificate bearing no less valid signature than that of Kant himself "

Schrodinger was convinced that we must go beyond formal methods of inductive and deductive logic, in more intuitive ways, if we are to achieve comprehensive pictures of the whole and even particular events. He goes on to say:

" A real elimination of metaphysics (more than physics) means taking the soul out of both art and science and turning them into skeletons incapable of any further development "

" In the course of the last hundred years, the Western World has achieved a quite enormous development in one particular direction - a thorough knowledge of what underlies spatio temporal events (Physics and Chemistry) and based on this a fantastic abundance of 'Mechanisms' in the widest sense have been constructed to extend the sphere of influence of human will (technology).

I am very far from holding that this is the most significant thing that has been happening in Europe during this period ".

These views of Schrodinger are also reflected in the writings of Max Planck in his book 'Universe in the Light of Modern Physics'. Planck says:

" There have been times when science and philosophy have been alien, if not actually antagonistic to each other. These times have passed. Philosophers have realised that they have no right to dictate to scientists their aims and methods for attaining them; and scientists have learnt that the starting point of their investigations does not

lie solely in the perceptions of the senses and that science cannot exist without some small portion of metaphysics. Modern physics impresses us particularly with the truth of the doctrine which teaches that there are realities existing apart from perceptions and that there are problems and conflicts where these realities are of greater value to us than the richest treasures of the world of experience."

On Life Processes and Evolution.

Schrodinger also pondered over the mechanisms behind life processes and the effects of quantum mechanical considerations on these processes. He was of the opinion that quantum mechanics contributes to an explanation of the form and stability of living systems and at the same time supplants statistical mechanics to provide an understanding of the degree of chance involved in evolutionary mutations. He wondered to what extent do physical and chemical laws relavant to non-living fluids apply to life. Is randomness increased, order reduced ? What happens to second law of thermodynamics ?
Schrodinger's point is that living systems fight the approach to equilibrium by acquiring ordered materials from environment, which have low entropy values. Plants acquire high energy photons from the Sun involving low entropy values - large amount of negative entropy pass on to animals that consume them.

" Schrodinger raises the question whether man will evolve further. He points out that some of the species the tortoise, the crocodile etc, have reached the end of their evolutionary possibilities a very long time back, yet they have not vanished. What about man ? What will happen to him ultimately ?
According to Schrodinger, if we go stricIty according to Darwin's theory, several arguments militate against further evolution.
He points out that improved medical care has resulted in 'indiscriminate saving of life' from an evolutionary point of view, which may contribute to slowing down or reversal of evolution. Wars and disasters which

...10.

contribute to restore balance do not seem adequate to counteract the effect of medical care. Schrodinger adopting the ideas of Julian Huxley envisages an alternate scenario : He argues that while the Lamarkian theory of the inheritance of acquired characteristics can be discredited, there could be what he calls feigned Lamorkism in the following sense : there is a casual connection between the functioning - being put to use - of a character, organ, property, and its being developed in the course of generations and gradually improved for the purpose for which it is profitably used. Thus environment and usage lead to preferential survival and in a sense to the appearance of acquired characteristics.

In this line of thinking further evolution of man may be controlled by man. Our biological destiny must not be taken as unalterable destiny that is decided by laws of nature only.

Schrodinger points out " increasing mechanisation and stupidization of most manufacturing processes would lead to degenerate our organic intelligence with tendency at repression of handicrafts, spreading of tedious and boring assembly line work - good brains, sharp eyes and clean hands become superfluous; Our aim should be to reinstate interesting and intelligent competition of single human beings "

Schrodinger is one of those scientists who not only contributed to the development of an important field of physical science - Quantum Mechanics, but also thought and made others think deeply on many fundamental questions - reality, mind, consciousness, evolution etc. His writings have inspired generations of students and scientists and will continue to do so in the future.

I am happy to inaugurate this course on theoretical physics that has been organised to commemorate his birth centenary. I am sure that the well thought out course given by some of the experts in the field, will benefit the large number of participants that have come from many universities and research centres in the country.

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