PHILOSOPHER SCIENTIST—WERNER HEISENBERG:

The boundaries between philosophy and science have undergone radical changes during the course of the development of human knowledge. In antiquity, natural philosophy merged with natural science. A number of natural sciences, initially mechanics and mathematics, were separated from natural philosophy in the 17th century. In the course of its development, natural science has passed from the stage of immediate contemplation of nature to the stage of synthetic reconstruction of nature in its universality. The philosophic enterprise of our times is framing a 'world view' based on the results of natural scientific investigations in which both the philosopher and the scientist have to co-operate.

Modern Physics, particularly quantum theory has raised a host of problems, going far beyond the confines of physics itself. These relate to the nature of matter, the method of exact sciences, the concept of causality etc. Not only philosophers but outstanding physicists of our times have also reflected upon these philosophical problems. Almost all physicists who contributed to the growth and development of quantum physics also took active part in the debates over its philosophical implications. Planck (1858-1947), Einstein (1879-1955), Bohr (1885-1962) and Heisenberg (1901-1976) are foremost among those who have contributed to both science and philosophy.

The quantum physics originated as a result of discoveries made at the turn of the century by Planck and Einstein. In 1900, Planck postulated that the emission and absorption of radiation takes place in discrete quanta. This contradicts the spirit of classical physics and shakes one of its most fundamental premises; that energy transfer is continuous. In classical physics any given quantity of energy was taken to be consumed continuously in the same way that water continuously and indivisibly filled a vessel. Einstein made Planck's idea of energy quantum more revolutionary than was originally imagined by postulating that

radiation too consisted of bundles. In 1913 Neils Bohr, a Danish physicist applied the quantum hypothesis to furnish an explanation for his atomic model. To overcome difficulties in this model Bohr also put forward the famous correspondence principle according to which in the regions where a quantum of action is small and neglible the laws of quantum theory are the same as those of classical physics. Inspired by the spirit of the corresspondence principle, Heisenberg at the age of 24 wrote his famous paper on 'Quantum theoretical reinterpretation of kinematic and mechanical relations' published in 1925. Heisenberg's matrix mechanics formulation of quantum physics, constitutes a discovery which places him among the foremost scientists in the history of mankind.

For a layman quantum physics is identical with, what is generally but erroneously known as Heisenberg's indeterminacy Principle. For him Heisenberg's uncertainty relations, according to which it is not possible to specify or determine simultaneously both the position and velocity of a particle as accurately as is wished, appear to endow the microparticle with a free will. To many scientists and non-scientists this 'free will' of the material particle constitutes the material basis for an idealistically conceived 'free will'.

Naive philosophers have understood Heisenberg's discoveries as a proof of the vadidity of the most obscurantist ideas. It is true that the investigations in the micro-world have changed our conceptions of casual relationships as obtained in Newtonian mechanics, and Heisenberg's uncertainty relations do put a limit on the application of the classical ideas. In quantum mechanics mathematical determinism is valid but Laplacian determinism is not. If the micro-world were a chaos of absolutely random phenomena devoid of any law-governed relationships, then under any given conditions it would not be possible to predict the future course of any micro-process even statistically. But in quantum mechanics the behaviour of micro-entities is governed by well defined statistical laws reflecting that the behaviour of micro-entities is law governed. Philosophers,

scientists and laymen, have been engaged in unravelling the meaning of the far reaching discovery made by Heisenberg in 1925. Heisenberg himself had been a very active participant in these fierce debates till the end of his life, displaying tremendous versatility and a deep concern for all matters that related to the growth and development of mankind.

Associated with Niels Bohr from 1924-27 at Copenhagen, he untiringly developed the Copenhagen Interpretation of quantum mechanics. He wrestled with very general questions "dealing not only with the narrow problems of physics as such but also with the nature of matter and with the method of exact sciences." Uncertainty relations expressive of the irreducible disturbance due to the process of observation reflect the fact that the very process of observation results in a significant participation in the mode of existence of what is being observed. This according to Heisenberg has focused our attention on the significant epistemological question "of the extent to which it is possible to objectify scientific or any sensory experiences — the extent, in other words to which one can go from observed phenomena to an objective conclusion independent of the observer."

The Copenhagen School of quantum mechanical interpretation led by Bohr and Heisenberg provided answers to the question in the positivistic spirit. In brief, the Copenhagen Interpretation would amount to the assertion that "objective reality has evaporated" and that quantum mechanics does not represent particles, but rather our knowledge, our observations or our consciousness of particles thereby reducing the task of science to a study of our sense impressions — their structure, ordering, co-relation and regulation. This subjectivist approach reduces man — the active agent of change to the role of a passive ordering device in a world where the laws of nature are not objectively existing but happen to be a result of a coincidence — divine or otherwise. Being an active and a great scientist that Heisenberg was, he had to veer away from such a posi-

tion. As a researcher in one way or another, he acknowledged the objectivity of the laws of nature.

Heisenberg during the 30s and 40s devoted himself to various problems related to quantum mechanics and nuclear physics. During the third Reich, he came frequently under attack from Nazis for his support for Albert Einstein. He along with other physicists decided to stay in Germany during this period on the advice of Max Planck. At the end of the war he was captured by American troops and taken to England. In 1946 he returned to Germany and reorganised Kaiser Wilhelm Institute for physics in Gottingen. Since 1948 this institute is known as Max Planck Institute. Since the early 50s he had been working on a comprehensive theory of elementary particles.

Apart from numerous articles in the journals of Physics, he has contributed a great deal to the debate on the philosophical implications of quantum theory. His major philosophical works are *Philosophic Problems of Nuclear Physics* (1952), *A Physicist's Conception of Nature* (1958), *Physics and Philosophy* (1959) and *Beyond Physics* (1971).

Lately he had been adopting a position which is close to the objective idealism of Plato and Kant. He maintained that the notion of reality, that there are objective occurrences which somehow take place in time and space independently of whether or not they are observed has gone by the board. Instead he thought that "there might be a mathematical structure in nature the formulation of which the Greek philosophers had looked for. The existence of the atom, far from being a final, irreducible fact, might as Plato had thought, be traced back to the opeartion of mathematically conceivable laws of nature — to the effect of mathematical symmetries." And thus he actively engaged himself till the end of his life to work out a system where one could replace the concept of a fundamental particle with the concept of a fundamental symmetry.

Quantum physics, when sought to be reconciled with the theory of relativity, presents insurmountable problems.

These and other problems have led many scientists to seriously question the interpretation given to quantum mechanics by Bohr and Heisenberg. Doubts about the completeness and finality of quantum mechanics as interpreted by Bohr and Heisenberg are being expressed with renewed vigour. The apprehensive attitude of Einstein and Schrodinger regarding the Copenhagen Interpretation is being echoed by many more leading scientists and philosophers. The interpretation propounded by Bohr and Heisenberg may be superseded but there is no modern physics without the name and work of Heisenberg.

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