Interrupted thought.....

Ya. A. Smorodinskiĭ

Usp. Fiz. Nauk **160**, 164–168 (July 1990)

K. V. Laurikainen, *Beyond the Atom: The Philosophical Thought of Wolfgang Pauli* (Translation of the original Finnish edition), Springer-Verlag, Berlin, Heidelberg, New York, London, 1988, 234 pp.

Once, at the end of the fourteenth century, there was a trumpeter sentry on the tower of Cracow's Marian Cathedral. He sounded the signal, "hainal" upon the appearance of an enemy. Once his melody was cut short; the trumpeter was cut down by an arrow. Since then, the sounds of the ancient "hainal", which are cut short on the same note on which it was also cut short many years ago, have resounded from the tower each day at noon.

The life of Pauli was cut short just as unexpectedly. He became 58 years old in April 1958. A sudden pain on December 5, 1958 did not allow him to finish a lecture at Zürich Polytechnic Institute; they took him to the Red Cross Hospital and placed him in Ward 137 (a sign of fate, which he didn't fail to notice). He died ten day later.

Pauli was one of the founders of quantum mechanics. His role in the development of the theory is comparable with the role of the Great Trinity: Heisenberg, Schrödinger, and Dirac. He possessed the gift to see hidden properties and always "sounded the alarm" upon the appearance of the slightest danger.

His extraordinarily critical and sharp mind could not unconditionally accept that interpretation of quantum mechanics, which one calls the Copenhagen school: all his life he thought about what role the observer, that "removed" subject who appears every time when we attempt to understand how a wave function is converted into the readings of an instrument, plays in the theory. No matter how hard we have tried, we have not succeeded in getting around the old, old question as to just what is the "real world", what is "reality". This question was the principal one for Pauli.

Pauli acquired special acuity in the 1950's, when he went deeper into thoughts about human thinking and about that arcane subject which philosophers and psychologists call the unconscious.

His thoughts were not completed, however, and he succeeded in publishing next to nothing. Of the papers from these years, one may take notice only of the brilliant paper "The Influence of Archetypal Ideas on the Formation of Theories of Natural Science by Kepler", a translation of which is given in *Physical Essays*[1]. This paper was written with strong influence by Carl Jung, with whom he was very well acquainted. Pauli saw in Kepler the beginnings of those ideas which excited him. Pauli was always very cautious in his publications. It seems that he experienced a certain dread before publishing incompletely formulated ideas. Let us remember that he even decided not to put the prediction of the neutrino in the form of a paper, but he restricted himself to only a letter (see the epilogue to the two-volume collection of his scientific works for this).

Pauli received a classical education: authors of the Middle Ages, who wrote in Latin, he read in the original. His "old-fashioned" education also showed up in his habit of writing many letters.[2] His enormous correspondence with Marcus Fierz, a former assistant to Pauli, an outstanding theoretical physicist, and a serious thinker, is still not published. Many opinions pertaining to philosophical questions of quantum mechanics are contained in this correspondence.

In the book *Atomien Tuolla Puollen* (*Beyond The Atom*), which was published in Finland in 1985, Laurikainen, a professor at Helsinki University, made an attempt at reconstructing and systematizing Pauli's philosophical opinions. An authorized English translation was finally published in 1988.[3]

Pauli's ideas, quotations from his letters to Fierz (and from some of those to N. Bohr), and also the answers of Fierz are accompanied by the comments of the author himself in Laurikainen's book. In the foreword and in several appendices, he explains his opinions on the nature of science in general and of quantum science in particular, comparing and elaborating on excerpts from the letters.

A very interesting book resulted, in which the properties of the quantum world and the effect of its enigmatic (for classical physics) properties on ideas about physical reality are drawn in sharp relief.

The circle of ideas in which Pauli meets Kepler and (let us add) Newton is associated with the surprising capability of mathematical symbols to describe physical reality or, more formally, the results of experiments. This property is defined well by Wigner's popular aphorism about the surprising effectiveness of mathematics. One cannot understand the roles of mathematics and of symbols without dealing with the question about what is physical reality. Very many differences and opinions exist in connection with this. However, almost all the answers are reminiscent of the definition of the concept of "food": "food is that which we eat". "Reality is that which really exists". For physicists, the question assumes a more limited nature: what does the wave function describe? At first, Bohr denied a direct connection of the wave function with reality and considered the wave function as a method for describing the results of different experimental arrangements.

This caused a reaction from Einstein, who could not be reconciled with a probabalistic description of a mechanical (non-stochastic) system.

In a letter to Bohr, Pauli quotes (from memory) Einstein: "The Moon has a definite position, independently of whether or not we look at it; this must not be valid for atomic objects... . An observation cannot generate elementa of reality; in the description of physical reality, there must exist something corresponding to the *probability* of observing a position, and it must exist *before* the observation itself occurred". Pauli, following Bohr, calls such independence of reality from the observer the position of the removed observer (aussenstehende Beobachter). Pauli connects his position with Bohr's Principle of Complementarity.

It is clearly evident from Pauli's letters how difficult it is to achieve a single point of view if one starts from the different positions of Einstein (completeness of the description of

nature), of Bohr (complementarity as the constancy of the elements of a physical system), and of Pauli himself, who sees the solution of this problem in the participation of the soul (psyche in Greek) in the interaction of man and nature.

Laurikainen schematically describes an observation as either an interaction between an object and an instrument (according to Bohr), or as an interaction between an object and the *psyche* of the observer, considering the instrument as only an extension of the observer's sense organs (according to Pauli). In this sense, reality for Pauli appears only as a "clouded" reality or a "transcendental" reality, terms which d'Espagna introduced.

It is a little strange that none of the participants in the disputes conducted face-to-face or in print emphasizes the simple circumstance that quantum mechanics is complete in that meaning of the word that its equations enable one to predict the behavior of a system with maximum completeness if the initial data are specified, but are necessarily incomplete (limited by the Heisenberg uncertainty). Therefore, one needs to shift the center of gravity of the discussion to a discussion of the initial data that are necessary to describe a quantum dynamical system. But in any event, even towards the middle of our century the question as to just what is reality has not been clarified to any extent, and has rather become even more challenging.

Pauli saw a way out of the confused problem of reality in Bohr's Complementarity Principle and in the semimystical symbolic ideas of the ancients. The return of the psyche to science, turning to the philosophy of Plato, more precisely, to neo-Platonics and to the role of inborn ideas in apprehending reality, proved to be essential for Pauli. Just these ideas, which were developed by Kant and Schopenhauer in the previous century, led Pauli towards psychology and especially towards its development in the works of Jung.

Descartes in the seventeenth century decisively separated the spiritual (res cogitans) from the material (*res extentus*). Pauli attempts somehow to return to old ideas. For him, the elements of reality contain two pairs of contrasts: compensating pairs (for example, the two types of electric charges), and complementary pairs (non-commutative, like coordinates and momenta). His objective was to include consciousness in reality. He saw an exciting example in psychology, in the confrontation of the conscious and the unconscious. The complementarity of matter and thought, and of science and religion in Bohr's statements, and even the magical Yang, Yin sign included by Bohr in his own coat of arms appeared to Pauli to be signs of the philosophy of the future.

The role played by alchemy (Newton) and astrology (Kepler) in the research of scientists of the past was not insignificant.

Pauli's idol Johannes Kepler saw in astrology a justification of the long-range interactions of the psyches of the Sun and planets replaced in the "New Astronomy" by the concept of force, contrary to the generally accepted at that time principle of contact interaction in the sublunar universe and of perpetual circular motion of the heavenly bodies in the universe beyond the Moon that have been set in motion by a skilled "clockmaker".

Pauli was fascinated with Kepler's dispute with the Rosicrucian Fludd who was brilliant in his own way. Fludd denied the legitimacy of using mathematics and insisted on a method of symbols which he adopted on the basis of astrology.[4] Kepler (and, apparently, Pauli himself) saw this as a disputable subject and considered the dispute useful. Another example is the fascination of Isaac Newton with alchemy during the last period of his life. This fascination is not a whim of genius, but is the discovery of a new world with its own laws that are connected with a developed symbolism but not with equations. Finally, the opinions of Newton and Goethe on the nature of light are one more example.

In all these examples, a logical chain of argument proves to be sharply incompatible complementary for the opponents.

Pauli, who included the conscious and unconscious in describing the interaction of the observer with an object, borrowed the idea of "tetrad nature" from Fludd, the opponent of Kepler. For Pauli, scientific theories were either "tetradic", constructed of four basic elements, or "triadic" (just as for Kepler), constructed on strictly mathematical arguments.[5]

One must notice that it is very difficult to give formal definitions for these two types of theories. Even in the article about Kepler, mentioned above, it is difficult to undestand the tetradic ideas of Fludd. Here it is sufficient to emphasize the difference in evaluating the role of the unconscious.

Pauli includes Heisenberg, with whom he studied with Bohr at almost the same time, also among his opponents.

Heisenberg thought of an experiment as a transformation of *potential* possibilities into a *real* one without going into a more detailed analysis of these concepts.

We shall never know how the painful searches by Pauli for both the truth and also for a criterion of authenticity might have been concluded. But even what we learn with surprise from the content of his letters compels us to believe that an extension of ideas (one may consider them as metaphysical, restoring to this concept the true meaning of "*supraphysical*" instead of "*pseudophysical*" science) about reality and about the role of consciousness in apprehending the world is a field that is open for science. The ideas of Jung about archetype and the ideas of quantum physics may prove to be not so incompatible. Perhaps one can see an analogy in the investigations of the nature of numbers in the last century and Dedekind's discovery. His arguments about the cuts of the number axis are somewhat reminiscent of the discussions about the "cut" between instrument and observer. But perhaps the further path is closed to man, and the quantum picture created by him is the limit of accessible knowledge. One does not want to believe in such a pessimistic conclusion. In reading Laurikainen's book, all the time one thinks about where we are going; towards a medieval (or, following current fashion, towards a more modern, oriental) mysticism, or towards some Great Truth. Readers must decide this for themselves, and in this lies the value of the book that has been reviewed and the interest in it.

[1]An anthology of the scientific works of W. Pauli in two volumes has been published in 1975 (Vol. 1) and 1977 (Vol. 2) by "Nauka" Press in the series *Classics of Science* [in Russian]. For his popular papers, see: Pauli W., *Physical Essays* [in Russian], (Ya. A. Smorodinskii, editor), Nauka, M., 1975. (Note by Transl. Ed. In English the Collected Scientific Papers by Wolfgang Pauli have been published in two volumes by Interscience, N.Y., 1964).

[2]Two volumes of his correspondence, a small part of it, has been published by Springer-Verlag ("Briefwechsel", 1983–1985). Publication is continuing.

[3]We note that the original German texts of all quotations are given in the book and this, in many cases, enables one to avoid the losses of meaning that are unavoidable upon translation of texts written by Pauli.

[4]Unfortunately, the "mystical" pages were omitted in the translation of Pauli's paper about Kepler in the anthology *Physical Essays*, as they did not conform to official opinions on philosophy in the 1960's.

[5]One may say that a triad nature is a reference to the Trinity, the three-in-one nature of God. Philosophers of our time add a fourth component, Man, to the Trinity.

Translated by Frederick R. West