QUANTUM PHYSICS, PHILOSOPHY, AND THE IMAGE OF GOD: INSIGHTS FROM WOLFGANG PAULI

by K. V. Laurikainen

Abstract. Nobel Laureate in physics Wolfgang Pauli studied philosophy and the history of ideas intensively, especially in his later years, to form an accurate ontology vis-á-vis quantum theory. Pauli's close contacts with the Swiss psychiatrist C. G. Jung gave him special qualifications for also understanding the basic problems of empirical knowledge. After Pauli's sudden death in 1958, this work was maintained mainly in his posthumously published correspondence, which so far extends only to 1939. Because Pauli's view differs essentially from the direction physics research took after the deaths of the founding fathers of quantum theory, this article attempts to describe the main features in Pauli's revolutionary thought, which is based on nature's "epistemological lesson" as revealed by Pauli's atomic research. Pauli's conclusions have important implications for various issues in Western culture, not least with the limits of science and the relation of science to religion.

Keywords: atomic physics; complementarity; Copenhagen interpretation; irrationality of reality; metaphysics; probability; quantum theory; repression of the irrational; synchronicity; uncertainty relations; unconscious; veiled reality.

During the past decade, it has become increasingly apparent that atomic theory will deeply change our concept of reality, and that there is need for a profound generalization based on quantum theory. Representatives of analytic philosophy or of the materialistic worldview have not advanced this particular search, however. In fact, work on the ontological implications of quantum mechanics has hardly begun.[1] Few people know that one of the pioneers in quantum theory, Wolfgang Pauli, made important contributions in this

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respect, which deserve to be more widely known (Pauli 1984; see also Enz and von Meyenn 1988).

A central feature of Pauli's philosophical thought is its emphasis on psychology. This has been seen as an obstacle to understanding his ontological remarks, especially because the *unconscious* plays a very important role in these remarks, and Pauli speaks of the unconscious in the Jungian rather than the Freudian sense. Many people, in fact, believe that Pauli became "mystical" in the 1950s and have lost interest in his ideas, even if they know of his epistemological work.

Here I shall try to point out some of the really profound views Pauli opened using quantum theory as a starting point. The original philosophy behind the Copenhagen interpretation of quantum phenomena, at least in the form Pauli seems to have understood it, was really revolutionary. However, the formal criticism of philosophers and the general conservatism among specialists in various fields have almost concealed these ideas. Pauli's thought, in fact, points to a need for an essential change in the direction of basic research in physics, in addition to opening new perspectives for many other important questions. It is time to reconsider his remarks.

The Irrationality of Reality

The decline of determinism in atomic physics presupposes a new conception of reality. It is possible to find "laws" for the statistical mean values of physical quantities but not for their values in individual events. Thus, the Copenhagen interpretation explicitly presupposes the abandonment of the idea of deterministic causality. This must be considered a fundamental empirical result which generally limits the possibility of the rational description of phenomena. Such description cannot concern individual events, but only their statistical mean behavior. Individual events always express something that is not describable in any rational way.[2]

It is this unpredictable scattering of individual events around the mean that Pauli emphasizes as an expression of the *irrationality of reality*. Since the Enlightenment, the "laws of nature" have been seen as an expression of the rational features of reality. In fact, the existence of such laws is what makes the rational description of phenomena possible. It is characteristic of Western thought to see such rationality as an indispensable property of reality: everything that is real is supposed to be rational. Pauli, however, attacks this basic belief, calling it the *repression of the irrational*. He asserts that this belief in rationality has been made untenable by the decline of determinism.

Western belief in rationality has a long history. When Plato conceived of the *world of ideas* as "that which truly exists," he expressed this rationalist conception of reality. Descartes, in his dualistic worldview, also presupposed that reality is, in principle, rational. This presupposition has been more and more characteristic of science since the seventeenth century, and it characterizes the general trend of basic research in physics today. However, Pauli interpreted the "epistemological lesson of atomic physics"—the decline of determinism—as an extremely important experimental result: it forces us to abandon our fundamental belief in the rationality of reality.

A usual counterargument is that statistics and the calculus of probabilities are also rational, and therefore statistical laws of nature do not presuppose any irrationality of reality. Such rationality, however, only concerns theory and theoretical predictions. On the other hand, irrationality is encountered when theory is compared with experimental results. It is a property of *reality*. The irrationality of reality means that each rational theory is only an approximation of reality. It is incorrect to presuppose that any rational description will ever be able to reach "reality itself."

In fact, it is even incorrect to think that rational description may be able to approach reality in an asymptotic sense. The uncertainty relations of Heisenberg put a definite limit on the accuracy attainable in the statistical descriptions of reality. The irrationality of reality must be considered an essential property of reality.

In light of quantum theory, "reality itself" is seen as *veiled reality* (a term introduced by Bernard d'Espagnat [1983]). We use this term (perhaps more generally than d'Espagnat did) to describe reality in a world where causality is not deterministic but statistical: the irrationality of reality forms a "veil" that makes every rational description of reality incomplete.

In mainstream philosophy today, conceptual accuracy is required to such an extent that discussion of important questions becomes impossible. (Perhaps special mention must be made of Wittgenstein's strong influence in this direction.) However, the "irrationality" of reality cannot be defined by using exact rational concepts, and therefore people refuse to discuss questions that belong to this sphere. This refusal seems to be the main reason why Pauli's view of the foundations of modern physics has not been widely understood, even though it is the most natural view in light of the Copenhagen interpretation.

Rationality and Irrationality Defined

Because the terms *rational* and *irrational* seem to cause misunderstand-

ing, I will try to clarify them. Because the term *irrational* is often used in a different sense (meaning, for example, "contrary to reason"), one must emphasize that *irrational* in this article means the opposite of *rational,* on the analogy of irrational numbers versus rational numbers in mathematics. The *irrationality of reality* means that rational science is not able to describe everything that is real (see Laurikainen 1987). Exact definitions of irrational matters are impossible. For example, the description of an individual event cannot be unambiguous when causality is not strict but genuinely statistical (probabilistic). If events are in fact genuinely statistical, then that means there is no rational description for an individual event, but only for the mean behavior (expectation values) in a sufficiently great ensemble of similar (equally prepared) events.

Irrational here means the same as *nonrational.* Therefore one should clarify the term *rational.* However, this cannot be done in an unambiguous way. Pauli used a very strict definition of *rational.* He regarded as rational only descriptions that form part of logically correct theories—generally speaking, mathematical ones. Which matters can be described in a rational way, in this sense, remains in general an open question. The Copenhagen philosophy, however, is based on the view that individual events cannot be described in any rational way, because laws in atomic physics are genuinely probabilistic.

It can be clarifying to think, in this connection, of the categories of knowledge in Plato's philosophy. The lowest category Plato calls *doxa,* which can be defined as "beliefs" or "opinions"; these are statements made by using unscientific, everyday language. Scientific knowledge is called *dianoia.* As a typical example, Plato mentions geometry, with its "everlasting" truths. This is the category that corresponds to *rational* in Pauli's vocabulary.

In addition, Plato mentions a third category of knowledge, which is the highest one. It is called *episteme,* and it means the comprehension of the ideas in that "which really is." We might call such knowledge epistemological or metaphysical. It is *not* rational according to the vocabulary we are using now, although Plato especially appreciated it.

Pauli also held metaphysics in high esteem. He believed that it is the source of really new scientific ideas, and therefore one should not draw too strict a boundary between science and metaphysics—or define too strictly what is "rational." What must be regarded as "irrational" today may be described by rational theories in the future.

The Copenhagen interpretation, in any case, presupposes that we

must conclusively abandon strict causality and embrace statistical causality. This means that we must regard the description of individual events as definitely irrational, according to the terminology used here.

Complementarity and the Irrationality of Reality

Niels Bohr used the concept of *complementarity* to describe the nature of reality on the atomic level (see Laurikainen 1988). This concept describes the most characteristic feature of quantum mechanics. Quantum mechanics replaces the dynamic variables of classical mechanics with operators that must be defined in mutually exclusive pairs. The complementary variables of such a pair cannot simultaneously have exact values. In fact, corresponding operators can be defined simultaneously only with the aid of a commutation relation. The standard example of such a pair comprises a position coordinate and the corresponding component of the momentum. The more exactly one of such complementary variables is measured, the more inexact becomes its complementary variable, as Heisenberg's uncertainty relations state.

In this sense, quantum mechanics is by nature a complementary theory. The operators that replace the dynamic variables of classical mechanics are not "quantities," but they describe symbolically "something" that cannot be described in an illustrative way. The objects of quantum mechanics also remain quite abstract; they appear in certain experiments as particles, in other experiments as waves. Objects and their properties (dynamic variables) are in quantum mechanics only symbolic; if we wish to speak of the values of a given variable, we have to describe the experimental procedure to be used for measuring it.

Thus, complementarity can be seen as the most characteristic feature of quantum mechanics. We need complementary measuring procedures for investigating complementary properties of reality. Therefore the existence of an objective reality independent of the observer becomes problematic. This is the core of the complementarity philosophy of Bohr.

All the members of the Copenhagen school (especially Bohr, Heisenberg, Pauli, and Born in Göttingen) accepted the main features of Bohr's philosophy. Heisenberg, however, put more emphasis on his uncertainty principle. Pauli (and also Born) liked to present the probabilistic nature of laws (statistical causality) as the most characteristic feature of the theory.

In all these descriptions of the main features of quantum mechanics, the irrationality of reality is implied. If A and B are two complementary variables that mutually exclude each other in the sense mentioned above, then these variables can be described illustratively only in mutually exclusive ways. These descriptions necessarily contain contradictory features. As a result, any description of "reality itself" necessarily includes contradictory properties. It is thus irrational, because a rational description cannot contain contradictions. For example, an object that is both particle and wave simultaneously is irrational.

This brief exposition shows that complementarity presupposes the irrationality of reality (Laurikainen 1990). For this reason, I think that Bohr was unwilling to speak of reality at all. The ontological implications of complementarity are, in fact, the same as those of statistical causality; in both cases reality has irrational features.

Complementarity and the Psychophysical Problem

Complementarity also opens a new perspective for the mind-body problem. All the most central representatives of the Copenhagen school—Bohr, Heisenberg, and Pauli—made remarks on the subject. All abandoned Cartesian dualism and described the relation between mind and body as complementary. The most explicit description of these ideas was given by Pauli in his correspondence with Markus Fierz. Pauli, in fact, saw the psychophysical problem as the most important problem of our time. The idea of psychophysical parallelism he called a "cloud of fog" in Western culture (this being also a reference to the inadequacy of the worldview common to classical [or "normal"] science, as it is usually understood by the scientific community today).

This is the most characteristic point in Pauli's philosophy. Essentially, for Pauli, reality means a whole that contains both the "outer world" and the "inner world." An observation is always an interaction between the object, which belongs to the outer world, and the consciousness of the observer. This interaction, however, cannot be understood in the same sense as interactions between objects in the outer world. It is interaction of a kind totally unknown to classical science; it can be described as "becoming conscious of something." The signals arriving from the outer world set off a process in our unconscious psyche, and the result of this unconscious process is "becoming conscious of something," which is what *observation* means.

It is important to realize that what we call an object belonging to the outer world is actually a picture in our consciousness. This picture is a result of a complicated process in the unconscious, which can never be analyzed in detail. This process is the locus of the "veil" that hides "reality itself" from our consciousness.

It is characteristic of Pauli's thought that he emphasized the role of the unconscious in attaining empirical knowledge. He was especially interested in the concept of archetypes (the central theme in Pauli's comprehensive article on Kepler [Pauli 1952]). In Pauli's thought, the irrationality of reality is inseparable from the role of the unconscious.

Pauli described certain archetypes—inherited modes of thought characteristic of the human unconscious—as bridges between the phenomenal world and the ideas and concepts in our consciousness. The archetypes, he believed, form a connecting link between the outer world and the inner world. These are complementary expressions of reality, which is both material and psychic. Thus, these complementary elements of reality are inseparable. Only by viewing reality as a whole containing both matter and psyche can one in fact form a reliable picture of it.

Pauli was a realist because he especially emphasized the importance of a *new conception of reality* that would be compatible with atomic physics. His realism, however, was fundamentally different from a realism that aims at describing the outer world without any subjective elements of psychic origin. Pauli understood realism in a deeper sense: he found objective description of the outer world to be impossible because psychic processes in the unconscious are inextricably part of both observations and theory formation.

Instead of Cartesian dualism, the concept of complementarity is needed in order to describe the relation between psyche and matter. We experience reality as psychic phenomena of the inner world, and material phenomena as part of the outer world, but everything we experience in fact takes place in our consciousness. These two worlds are aspects of a reality that is neither mental nor material, but which we experience in complementary ways—much as we conceptualize atomic objects as particles or waves.

The interaction of the two "worlds" is, however, a connection fundamentally different from the interactions between objects in the phenomenal world, as described in the "laws of nature." If we try to describe this interaction, we can probably learn something of the complementary relations in quantum physics. We must notice, however, that we are here discussing processes of the unconscious, which

can never be described with the same logical rigor as processes in the phenomenal world.

According to this view, physics and psychology are complementary sciences. One has to take both into account in order to arrive at a reliable picture of reality. The struggle for a realism that only concerns the outer world is, therefore, unfounded in principle.

SYNCHRONICITY

In 1952 C. G. Jung and Wolfgang Pauli jointly published *Naturerklärung und Psyche* (an English edition, *The Interpretation of Nature and the Psyche,* was published in 1955). This volume was the result of discussions begun in the early thirties concerning the influence of the unconscious on our conception of reality. In this book Jung published his idea of synchronicity; his article has also been published separately under the title *Synchronicity: An Acausal Connecting Principle* (1973).

The common denominator in the two independent articles that made up the volume of 1952 was the concept of archetypes. This concept had played an important role in Jung's thought since the beginning of the twenties, but its meaning underwent considerable change through the years. In the beginning, Jung used the term *archetype* to refer to the more or less concrete "primordial images" created by frequently repeated similar experiences. Later the concept assumed an increasingly abstract form, and it is scarcely wrong to guess that discussions with Pauli influenced this change in the concept of archetypes, so that it gradually assumed extreme abstractness (Pauli 1954).

In 1944 Jung suffered a very severe heart attack, during which he experienced strong visions that had a central influence on his later work. Afterwards he emphasized the role of the archetypes as an abstract bridge between the psyche and the material world. He coined the word *psychoid* to refer to a reality as much related to matter as to the psyche. He saw archetypes as the basic form of psychoid reality.

This idea was very close to Pauli's thought. At the beginning of his article on Kepler (1952), Pauli wrote of the "ordering operators and image-formers"—the archetypes—that "function as the sought-for bridge between the sense perceptions and the ideas and are, accordingly, a necessary presupposition even for evolving a scientific theory of nature." Simultaneously, Pauli warned against identifying archetypes with any ideas capable of a rational description. He saw

archetypes as *abstract* "orderers" in the depths of the unconscious, irrational by nature.

The bridge between psyche and matter Jung later called *synchronicity*. He came to this concept from his work as a psychotherapist, in which some nonrepeatable phenomena seemed to play a very important role. In these phenomena, a strongly emotional psychic state coincided with a perception of an event in the outer world, both inner and outer event having a similar structure that could be interpreted as expressing a similar meaning. In one well-known example, one of Jung's patients had dreamed of a golden scarab; an almost identical beetle appeared in Jung's office just as the patient was recounting his dream to Jung. Such coincidences of phenomena in the inner and in the outer world often have a strong effect on the psychic life of the person who experiences them. Many religious experiences are of this nature. Such coincidences are often experienced as mysterious: signs of the numinous.

Such coincidences seem to be typical chance phenomena escaping any causal explanation. Pauli found an analogy in physical events governed by statistical laws. Each individual event is independent of all the others, and they randomly fluctuate in the manner of "chance events." However, in combination, these individual events form a whole that is governed by statistical law. Because this law unites individual events to a whole, it implies a new type of orderedness (or connection between chance events).

Similarly, Jung saw "synchronistic" events as expressions of an "acausal connecting principle" in the world. According to Jung, it is necessary to assume that phenomena are governed, not only by causality—which has been the only basis for scientific explanation so far—but also by another ordering principle that is related to the *meaning* of events.

The concepts of synchronicity and of archetypes belong to the realm of the irrational. Therefore, their exact definition is impossible. Pauli had the feeling that these concepts open a totally new perspective for science, and he also thought that the statistical laws of atomic physics form a first definite step on this path.

Obviously, synchronicity is a concept related to the psychophysical problem. It is important to note that statistical laws in physics have also created discussions concerning the psychophysical problem, as was mentioned above. Pauli, who had the most profound view of the philosophical significance of statistical laws, emphasized the psychophysical problem as the most important problem of our time. The philosophical consequences of this view remained, however, rather unclear for him. These questions were certainly in Pauli's mind when

he wrote in a letter that he belonged to a generation that saw really deep problems but was unable to solve them. He was astonished to see that the younger generation was not aware of these problems at all.

Now there are signs that such problems are strongly affective in the collective unconscious of our time.

Metaphysical Roots of Science

It is not only impossible but very dangerous to try to exclude all "metaphysics" from science. Unfortunately, positivistic philosophy and later analytical philosophy, in their fight against unclear concepts and propositions, have tried to limit science and "scientific" philosophy in a way that cuts their strongest roots and isolates science and philosophy from the deepest questions of human existence. All the most important new views in science have at first been "metaphysical," and an attempt to draw a clear borderline between science and metaphysics implies that really deep changes in the basis of science are impossible.

In a symposium on the foundations of modern physics held in Joensuu in August 1987 (Laurikainen 1987),[3] some people were disturbed by philosophical remarks concerning the nature of atomic reality and the role of the observer in atomic physics. Some said that physicists have so much to do that they have no time to think about such philosophical questions. Some of the theories under discussion, however, explicitly concerned the foundations of quantum mechanics, presupposing certain changes in the "philosophy" of the Copenhagen interpretation. It was claimed that Bohr and Heisenberg did not have time for philosophy either, when they created their most important ideas, and that the discussion concerning philosophy began later, being primarily the concern of philosophers, not of physicists.

C.F. v. Weizsäcker then emphasized that it is not possible to leave the philosophy of physics to professional philosophers; physicists must develop it simultaneously with physics. When quantum mechanics was created, it was not possible to draw a boundary between physics and philosophy. In fact, creating a new form of physics and introducing certain new philosophical views came to the same thing.

I agree with him and would further contend that the same is true for all the most important phases in the development of physics. With good reason, Newton, Einstein, and Bohr are ranked among the great philosophers, and they developed their most important philosophical ideas in conjunction with their work in physics. Their

philosophical remarks do not satisfy the formal requirements of analytical philosophy—they must be called "metaphysical"—but from exactly these metaphysical remarks new trends in physics have arisen.

Pauli emphasized in his letter that "what is called metaphysics and what something else is a question of taste." In his opinion, attempts to exclude metaphysics from science are pure stupidity. His repeated remarks on the "repression of the irrational" in Western science and the new perspective he opened in this connection seem antithetical to the formal tendencies that analytical philosophy represents. (In this respect, materialistic philosophy has similar formal tendencies.)

Science and Religion

The idea of the irrationality of reality opens new views concerning the limits of science and the relation between knowledge and belief. One implication is the need to accept metaphysics. That is, one must accept attempts to describe features in reality that are not describable in a clear, rational way. There is not even any strict boundary between science and mysticism, between "hard science" and "internal experience." There are "two ways to truth," both of which have to be acknowledged as necessary if we do not want to cut off essential features of reality on purely formal grounds.

I see religion as complementary to science in the search for "truth" —that is, in attempts to form a picture of reality. This new, complementary perspective for understanding the relation of science to religion requires reevaluation of many important questions, both in science and in theology, but we cannot go into these problems here. In general they exceed my personal knowledge and abilities.

I will only point out that Kant's philosophy, which still influences thought in theology and many other fields, is not compatible with modern atomic physics. The deep separation of humanistic sciences from natural sciences characteristic of Western culture springs partly from Kant's conception of reality. This separation must be overcome if one has in mind a conception of reality in which the material outer world and the spiritual inner world are fused into a complementary reality.

Kant's philosophy presupposes abandoning all the traditional arguments concerning the existence of God that are based on empirical fact. These only concern the phenomenal world, whereas religion belongs to the sphere of the internal (noumenal) world. But if the external and internal worlds are fused into one reality, this remark is not valid. In order to clearly differentiate between this view and

prevailing attitudes, I shall discuss the image of God as based on the conception of reality described here.

The old argument from design has, in fact, gained new strength from the development of modern physics. The trend has been toward increasingly general theories that enable one to deduce an increasing number of facts from a small number of basic principles (axioms). This development, in turn, has clearly brought to light a beautiful logical structure in physical reality—strong evidence of a rational origin of existence that is superior to human intelligence. On the other hand, human intelligence seems to be related to this superior intelligence because we are increasingly able to unveil the beautiful secrets of nature. In religious language, this is expressed in the metaphor that humans are created in the image of God.

Causality—the possibility of describing natural phenomena in a rational way—is an expression of God's intelligence. The simple idea of deterministic causality must, however, be abandoned and replaced by the idea of statistical causality. For some physicists, including me, this observation has spoken very strongly for the existence of God and for God's presence in nature. The argument is as follows.

Statistical laws can only be found by studying ensembles of similar events. Since each individual event is, in principle, independent of all the others (individual systems in the ensemble are "windowless monads," in the language of Leibniz), there must be something in reality that "takes care" of the *whole* so that statistical mean values correspond to the "natural law." Such connections between events cannot be expressed in the form of causal laws. Rather, they represent a physical expression of synchronicity (in the sense of C.G. Jung), of a new connecting principle, which also finds expressions in psychic phenomena and in the relation between spirit and matter.

This new connecting principle can also be interpreted as an expression of God's presence. God "takes care" of the whole, which always behaves according to the law. Such an idea has gone totally unnoticed in an age when the idea of deterministic causality has dominated our entire culture. However, this "irrationality" is the creative element of reality. It is the origin of the meaning of existence. It is an expression of something that guides phenomena.

Causality, which is the rational element of reality, is related to the past. It is an expression of the conservative side of reality. Will is related to the future. It guides phenomena in a purposeful way—but speaking of such things, we must remember that we are describing something "irrational"—that is, something that cannot be described with the accuracy philosophers nowadays generally require of scientific language.

Here we meet the limits of science and approach the realm of belief and religion. Only if we accept the intuitive way of comprehending reality, only if we have *belief,* can we see such *wholes* as we are now considering. In this vision, God is seen as the basis of all natural phenomena: on one hand, the basis of the invariant structure that we find in nature and are able to describe, more or less, in a rational way; but simultaneously, the basis of the changes that take place in this structure. God finds an expression both in the causal "laws of nature" and in the freedom that can be seen in the great variety of individual events. God can be described as a being who is present in everything that takes place, and the origin of existence. But this existence means, not only *invariance* in the rational, Platonic sense, but also, and simultaneously, *change,* because of the irrationality that is an essential characteristic of everything that is.

In the Christian vocabulary the image of God, if formed on the basis of science, concerns not the special revelation in the Bible, but the so-called general revelation. It is worth stating, however, that the idea of statistical causality reflects quite central Christian ideas, namely, the relation between *law and grace,* or between God's *justice and love.* (For a discussion of these issues on the basis of complementarity, see Bolyki 1980).

Statistical causality is an expression of the new conception of causality presented in a form suitable for mathematical sciences, but it also corresponds—I wish to state—to central ideas in the Christian image of God. The idea of causality corresponds to the Judaic image of God, which one-sidedly emphasizes the law. Statistical causality also contains this idea, for (as in Christian doctrine) the law also remains valid within the "second covenant": "one jot or one tittle shall in no wise pass away from the law." However, it is not law that is fundamental but *grace.* And grace finds its analogue in the freedom characteristic of statistical causality—the very irrationality of reality that cannot be understood by reason. I believe that this freedom provides the meaning of existence.

NOTES

1. An account of the ontological views concerning quantum theory has recently been given in a popular form, in Herbert 1985. For a more scholarly treatment, see Jammer 1974.

2. Pauli analyzed the fundamental significance of statistical causality very clearly in his letter to Fierz (13 October 1951), in Pauli Letter Collection (PLC), Geneva 23, Switzerland (Scientific Information Service, CERN, CH-1211). See also Pauli's editorial in *Dialectica* 2, no. 3/4 (1948).

3. The irrationality of reality is one of the central themes in Laurikainen's *Beyond the Atom* (1988); see especially chap. 8. For remarks concerning physics research on the basis of the picture of complementarity described here, see Laurikainen 1990.

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