Introduction

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The notion of reality is of supreme significance for our understanding of nature, the world around us, and ourselves. As the history of philosophy shows, it has been under permanent discussion at all times. Traditional discourse about reality covers the full range from basic metaphysical foundations to operational approaches concerning human kinds of gathering and utilizing knowledge, broadly speaking epistemic approaches. However, no period in time has experienced a number of moves changing and, particularly, restraining traditional concepts of reality that is comparable to the 20th century.

Early in the 20th century, quite an influential move of such a kind was due to the so-called Copenhagen interpretation of quantum mechanics, laid out essentially by Bohr, Heisenberg, and Pauli in the mid 1920s. Bohr's *dictum*, quoted by Petersen (1963, p. 12), was that "it is wrong to think that the task of physics is to find out how nature is. Physics concerns what we can say about nature." Although this standpoint was not left unopposed – Einstein, Schrödinger, and others were convinced that it *is* the task of science to find out about nature itself – epistemic, operational attitudes have set the fashion for many discussions in the philosophy of physics (and of science in general) until today.

Moreover, epistemically dominated directions have taken over in other disciplines as well. The *linguistic turn*, often ascribed to the influence of Wittgenstein in the 1930s and 1940s, is of key significance in this context. It was first spelled out explicitly by Rorty (1967) in his anthology "The Linguistic Turn: Essays in Philosophical Method". It demands, similarly to Bohr's appeal, to give up on asking how the world is but, rather, concentrating on how it is described. Philosophy of language becomes a central field in analytic philosophy, generating vast influences on phenomenology, anthropology, linguistics, semiotics, history, sociology, and others, featuring in structuralism, constructivism, and their modern successors.

In addition, philosophy of mind together with a conceptually inclined cognitive science (as opposed to experimental psychology) developed as offsprings, as it were, of the linguistic turn. The corresponding *cognitive turn* (Fuller *et al.*, 1989) redirected emphasis from language to cognition, and can be traced

to the early cognitivism of Chomsky, Minsky and Simon. Today's implications of the cognitive turn are manifest in the study of consciousness, but also have visible repercussions in literature, theater, and film. This has recently led to the notion of an *iconic turn* (Maar and Burda, 2004), based on the idea that our interaction with the world essentially relies on images: classical images in the visual arts and in contemporary media, icons in communications with fellow humans and with computer systems.

This series of examples demonstrates how far remote present philosophical and cultural trends are from traditional metaphysics and ontology. It also shows the conjoining massive restriction of the scope of discourse from the quest for the fundaments of reality to language and cognition and eventually to visualization and its ramifications. In the resulting environment, a Cartesian substance dualism or the research programs of 19th century science must appear extremely naive. On the other hand, a narrow focus always makes it likely that important things outside of it are unduly disregarded. A comprehensive and sensible account of reality is palpably unachievable by elaborate studies of visual communication alone.

It is, therefore, easy to see that the ideas about reality that dominate contemporary science, humanities, and culture need to be considerably recast for an adequately shaped worldview. Such a recast may profit from reclaiming earlier ideas, but it also requires their reformation, rearrangement, and refinement. Ultimately, such an undertaking will be viable only if it proves successful. A specific difficulty in this respect is that new concepts and notions must be tried out, without established ways to test or apply them.

The life and work of Wolfgang Pauli, one of the leading theoretical physicists of the 20th century, offer illuminating and instructive material for corresponding studies. As Pauli wrote to Carl Gustav Jung at March 31, 1953 (Meyenn, 1999, p. 95), he was "baptized as 'anti-metaphysical' instead of Roman Catholic" due to the influence of his godfather Ernst Mach. So it is no surprise that Pauli belonged to the spiritual fathers of the operationally minded, or at least ontologically abstinent, Copenhagen interpretation of reality according to quantum mechanics.

So far, Pauli could simply appear as one of the early representatives of the trends sketched above. What makes his case particularly interesting, though, is his own "turn" back into metaphysics and ontology. This turn was initiated in the middle of his life, in the early 1930s, when he met the psychiatrist Jung at Zurich. Pauli adopted Jung's depth psychology rapidly and intensely. As a consequence, he started to develop and explore concepts going beyond his previous epistemic stance and tried to reconcile physics as a science of the material world with its non-material psychological counterpart. In a letter to Fierz of August 12, 1948, he wrote (Meyenn, 1993, p. 559):

> "When the layman says 'reality', he usually thinks that he is talking about something self-evident and well-known; whereas to me it appears to be the most important and exceedingly difficult task of our time to establish a new idea of reality."

Pauli addressed this issue only rarely in his regular publications, for example in his extensive essay on Kepler (Pauli, 1952), his article about central ideas of Jung's psychology (Pauli, 1954), and his historical account of Western science (Pauli, 1956). Nevertheless, as he expressed in a letter to Born of January 21, 1951, he saw his lasting impact beyond his achievements in physics in "the ideas that I communicate more or less directly to a small circle of scholars and friends" (Meyenn, 1996, p. 243). The main medium of communication for these ideas was his extraordinarily numerous correspondence in his letters. He used them mainly for two purposes: (i) to criticize work which he thought was wrong or, worse, not even wrong, and (ii) to discuss his speculative ideas beyond physics with colleagues. Pauli's complete correspondence has been so excellently edited by Karl von Meyenn[3] that it can now serve as an immensely rich source for studies of Pauli's extraphysical ideas.

This was one of the motives for a conference on *Wolfgang Pauli's Philosophical Ideas and Contemporary Science*, on which the present volume is based. The idea originated from a proposal by Ulrich Müller-Herold who, with his ingenious combination of persuasive and convincing talents, put together a board of organizers including himself, Karl von Meyenn, Reinhard Nesper, and the editors of this volume. He arranged that the conference could be held in May 2007 at the Centro Stefano Franscini at Monte Verità (Ascona, Switzerland), with both its splendid environment and its superb service. And, together with Reinhard Nesper and his staff, he made sure that all financial and administrational matters were lined up perfectly.[4]

Another reason for the conference, after an earlier predecessor in June 1993 at the same place (Atmanspacher *et al.*, 1995), was to relate Pauli's ideas to new developments in contemporary science and philosophy. The 1993 conference was held in cooperation with the Jung Institute Zurich and, accordingly, had a strong Jungian component. Since then, a number of prominent innovative developments related to Pauli's views occurred in fields other than Jung's psychology (see Atmanspacher and Primas, 2006). For this reason, Jungian perspectives were deliberately less considered, though not completely avoided, for the invitation of speakers for the 2007 conference.

Its main topics can be assigned to four areas: basic ideas in the philosophy of science and of mind, their relations to different notions of time, research about how creative insight operates, and new developments in biological evolutionary theory, especially epigenetics. Beyond those areas, there are two

[3] It contains more than 7000 pages in eight volumes, published over a quarter of a century between 1979 and 2005. Front-runners in the list of exchange partners are Heisenberg with 460 letters and Fierz with 350 letters. Jung and his circle are represented with 300 letters, and Bohr follows with 150 letters. Pauli's largely unpublished correspondence with Paul Rosbaud is estimated with 300 letters, but only few of them are presently accessible.

[4] The website at `http://www.solid.ethz.ch/pauli-conference/` provides some retrospective impressions of the conference and contains interesting photographs of Pauli, some of which are widely unknown.

contributions to this volume which may serve the reader as introductory material. First there is the article by *Karl von Meyenn* on the role that Pauli's correspondence plays for the study of his philosophical ideas. It addresses in detail Pauli's education in the positivist spirit of Mach and the Vienna circle, and then his departure from it.

In the second paper, *Domenico Giulini* gives an in-depth account of the role of symmetry principles in Pauli's work in physics. Fundamental symmetries were central in his thinking, and he warned against violating symmetry groups without good reasons.[5] This made his critical attitude in physics sometimes productive (e.g., prediction of the neutrino), but sometimes also obstructive (e.g., parity violation). It is interesting to see how symmetry principles also feature in Pauli's ideas beyond physics, for which Giulini indicates a pertinent example deserving further study.

The predominantly philosophical papers circulate around the idea of dual-aspect thinking and complementarity as a special variant thereof. *William Seager* presents an introduction to dual-aspect approaches as a combination of ontological monism with epistemological dualism. He traces this scheme back to Spinoza, where a self-contained *causa sui* creates many manifestations. Seager suggests that Pauli's ideas of mind and matter are much closer to Spinoza than this is visible in his writings. Spinoza's *causa sui* can be related to both Plato's archetypal *ideas* and to Jung's *unus mundus*, a basic form of reality of which the mental and the material are regarded as aspects.

Dual-aspect approaches to the mind-matter problem have been advertised again by physicists, for instance, by Bohm (1990) or by d'Espagnat (1999). None of them, however, has been worked out to an extent at which it leads beyond Pauli's or where it might even become operationally useful. A particularly promising feature of Pauli's dual aspects is their proposed complementarity.

Colloquially speaking, two descriptions of a situation are complementary if they are both necessary for a complete description of that situation and at the same time incompatible with each other. A precise characterization of complementarity as a logic with restricted sentential connectivity (which figures prominently in contemporary investigations under the name *partial Boolean algebras*) is due to Strauss (1936). It generalizes both classical and quantum logic and provides a formal basis to apply the concept of complementarity beyond quantum physics. In the present collection *Peter beim Graben and Harald Atmanspacher* show how this leads to deeper insight into the structure of epistemic descriptions of *classical* dynamical systems.

In the area of consciousness studies, established in the early 1990s, Chalmers (1996) proposed dual-aspect thinking as a way to address the "hard problem" of relating first-person and third-person accounts of consciousness to each other. Modifying Chalmers' approach, *Max Velmans* finds that complementarity offers a suitable framework for many of the properties that he

[5] See the letter of Pauli to Peierls of February 19, 1957 (Meyenn, 2005a, p. 244).

conceives as important. In his own "reflexive monism" he combines the reflexivity of phenomenal and neuronal aspects of a mind-brain with its ontically monistic, unified totality.

A specific example of complementarity applied to the mental domain is described in the article by *Harald Atmanspacher, Thomas Filk, and Hartmann Römer*. This example refers to a purely cognitive account (without invoking possible brain mechanisms as neural correlates) of the bistable perception of ambiguous stimuli. Based on the complementarity of the dynamics of spontaneous reversals between the two perceived states and the dynamics of observing those states, they present a formal model (the "Necker-Zeno model") that is confirmed by a number of non-trivial experimental results. Their paper ends with the challenging proposal of a temporal variant of entanglement, a nonlocality in time, for unstable mental states.

Joachim Klose, in his contribution, reminds us of a non-mainstream philosophical approach which, nevertheless, has received increasing attention in recent years: Whitehead's process philosophy. On Whitehead's account, the basic elements of reality are "actual entities", conceived similar to Leibniz's monads, but in permanent interaction. Other than pointlike events in physical spacetime, actual entities are extended in space and time. They have both a mental and a physical pole, appearing as their coexisting aspects. This picture is central in the approach of Stapp (2007), which Klose discusses as a current attempt to use Whitehead for an interpretation of quantum theory including the mental.

Complementarity of mind and matter and the problem of time are the two basic topics that *Hans Primas* links to each other in his article. He proposes that mind and matter may be related via a temporal domain serving as an interface between atemporal material and mental domains. In the temporal domain, he distinguishes tenseless and tensed time, referring to the parameter time of physics and to our experiential distinction of past, present, and future, respectively. Primas understands these two concepts of time as contextual descriptive tools, emerging from an epistemic symmetry breaking of an underlying non-Boolean reality, the *unus mundus*. The mental and the physical arise as complementary and holistically correlated decompositions of this transcendental reality.

All these approaches, as different as they are in detail, reflect Pauli's (1952) vision that "it would be most satisfactory if physis and psyche could be conceived as complementary aspects of the same reality". Pauli speculated that the nature of this reality might have to do with the collective unconscious in the sense of Jung, without space and time and other categories with which the sciences of today operate. We know next to nothing about such a reality. Which symmetry of the *unus mundus* may be broken such that time emerges? Under which transformations would the description of an *unus mundus* be invariant, and how could such an invariance be detected? Why should a decomposition into tensed and tenseless, physical and mental domains be preferrable to others? Or, if it is not, what are other relevant decompositions?

These and more fundamental questions come to mind immediately, and they remain unanswered so far.

Ideas of the preceding contributions are taken up and merged in the article by *Georg Franck and Harald Atmanspacher*. If mind-matter relations can be rephrased in terms of relations between tensed and tenseless time, then the tension between the intensity of *mental presence* and the duration of the *temporal present*, of nowness, may be a key to further insight concerning the mind-matter problem. The authors outline some ideas of how cognitive time scales predicted by the Necker-Zeno model might indicate degrees of mental presence. Ultimately, this leads to the question where the most primordial forms of mental presence, or primary consciousness, begin: Some form of panpsychism is the price to be paid for the conceptual elegance of dual-aspect thinking, but maybe this price is just appropriate for the explanatory surplus to be gained.

Another feature of mind and matter as complementary aspects of a holistic *unus mundus* was proposed by Jung (1952) after long discussions with Pauli: synchronicity. *François Martin and Giuliana Galli Carminati* discuss synchronicity as an acausal (interaction-free) correlation between mental and physical states. They explain the seemingly paradoxical character of such correlations as a classical illusion comparable with delayed-choice experiments, where it *seems as if* results can be manipulated by changes of the past. Different from physical entanglement, it is a decisive feature of synchronistic relations that the correlated states share some subjectively experienced meaning. Martin and Galli Carminati outline a model of how meaningful emotional states can give rise to synchronistic effects between individuals.

If synchronistic correlations reflect the lost holism, or a broken symmetry, of the *unus mundus*, it becomes a pressing question how this fundamental reality can be conceived. Both Jung and Pauli speculated that basic elements of the collective unconscious, fundamental archetypes, might be interesting candidates in this respect. *Arthur Miller* elucidates this idea with an example from Pauli's biography. He recalls how Pauli comments his step from the three known degrees of freedom of the electron to a fourth, the electron spin, which led him to the formulation of the exclusion principle. From the viewpoint of his psychological development, Pauli interpreted this as a transition from a "trinitarian" to a "quaternarian" attitude, thus expressing the role of numbers as qualitative archetypal concepts (unity, duality, trinity, quaternity, ...) rather than tools for quantification.

Pauli – and with him other first-rate mathematicians like Hardy, Gödel, Penrose or Connes – looked for archetypal elements in the sense of Platonic ideas as the basis of mathematical truth. Since this Platonic conception of archetypes cannot be tested scientifically, *Rafael Núñez* suggests in his article to understand the foundations of mathematics as a product of the embodied human mind. He reinterprets a number of aspects of Jungian archetypes in terms of "image schemas", conceived as providing the link between cognition and language in contemporary cognitive neuroscience.

These different usages of the notion of archetype in different contexts might indicate a way to connect the situation shaped by linguistic and cognitive movements back to more ontological deliberations about the nature of reality. Any attempt at "recasting reality" must seriously take into account the present body of scientific knowledge and constructively use its results to refine earlier approaches. Pauli's vision of a "new idea of reality" strongly needs the substantial achievements of contemporary science (and the ability to distinguish them from the extraneous) for its realization.

The article by *Michael Öllinger and Günther Knoblich* is devoted to the psychology of insight, another contemporary topic of rapidly growing attention. The authors begin with an overview of early work by Gestalt psychologists such as Köhler, Wertheimer, and Duncker from the 1920s to the 1940s. Based on their results, different cognitive approaches have been developed subsequently, and the tedious experimental paradigms of current work show that the achieved understanding of insight progresses in very small steps. While current research on creative insight shows why solutions to difficult problems often occur suddenly and involuntarily, it cannot explain the intriguing creative experiences of a Gauss or a Poincaré, as described by Hadamard (1954). What made these men of genius so extraordinary (cf. Simonton, 1988, for corresponding ideas) is a question beyond those asked in ordinary insight research.

A particularly astonishing example is the Indian mathematician Ramanujan (1887–1920). With almost no training in mathematics and no access to mathematical libraries he had, at the age of 25, discovered and rediscovered more than 3000 mathematical theorems. After 30 years of studies of his notebooks all these theorems are now proven by methods unknown to himself, but the roads that led Ramanujan to his results have remained enigmatic for the most part. Ramanujan did not try to solve problems – he insisted that his insights were revealed to him by a family deity (see Kanigel, 1999).[6]

A further area of vivid interest to Pauli was biological evolution, addressed by *Linda van Speybroeck*. Pauli found that at least three critical issues were not sufficiently clarified by the standard neo-Darwinian picture of random mutations plus selection factors: Are the probabilities for the evolution of species estimated properly ? Are there environmental effects on genomes ? Is efficient causation enough to explain evolutionary mechanisms ? The first two questions are intensely studied in recent research on adaptive *non-random* mutations and on epigenetics, i.e. inheritable changes of phenotype *without* genotype changes. Only twenty years ago, such ideas were considered utmost heretical *vis-a-vis* the central dogmas of full-blown neo-Darwinism (see Jablonka and

[6] Skills with similarly mysterious origin are known in the context of the so-called *savant syndrome*, which gains increasing attention in current research. It refers to a rare condition in which persons with developmental disorders have one or more areas of expertise, ability or brilliance that are in contrast with the individual's overall limitations. For more details see Treffert (2006).

Lamb, 2005, for a review). Concerning the third question, however, there is still no evidence that teleology or final causes need to be involved, something that Pauli had in mind when he speculated about evolution as a series of meaningful events akin to synchronicity.

In correspondence with Delbrück, Weisskopf, Pittendrigh, Bohr and Elsasser, Pauli wrote about biological evolution in astonishing detail. And although Delbrück accused him of participating in a "plot of unemployed theoretical physicists against biology",[7] the recent development of genetics showed that Pauli's concerns were highly relevant. Additional unexplored territory, not so evident for him in his time, appears in connections between evolution and learning. One crucial point here is the riddle of the so-called major transitions in evolution (Maynard Smith and Szathmáry, 1995), resembling the phenomenon of punctuated equilibrium. Another one would be the role of epigenetic processes in neurons and associated progress in our understanding of neural plasticity based on Hebbian learning (Hebb, 1949).

In one way or another, the contents of this volume focus on new developments in philosophy and science in the light of Pauli's conjectures and speculations of more than half a century ago. In some cases, distinct progress is already visible, in others it can only be anticipated. Future generations of scholars will be able to see more clearly in which directions and with which understanding the concept of reality will develop. And they will be able to assess more distinctly the role which Pauli's expectations will play in this process:[8]

> "My personal opinion is that in a future science reality will be neither 'mental' nor 'physical' but somehow both of them and somehow neither of them. ... Today both (micro-) physics and psychology (of the unconscious) deal with an *invisible* reality (or 'posit' such a reality, as philosophers say). As a consequence one has to be 'prepared' (old-Bohr-style) to find properties different from those of the macro-world."

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[7] Quoted from a letter of Pauli to Elsasser of September 30, 1958 (Meyenn, 2005b, p. 1271).

[8] Quoted from a letter of Pauli to Pais of August 17, 1950 (Meyenn, 1996, p. 152f).

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