Many Realisms

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Abstract

The distinction between ontic and epistemic interpretations of physical theories (due to Scheibe) is useful for distinguishing between as well as connecting together different kinds of realism. Broadly speaking, epistemic interpretations refer to the knowledge observers have of systems with respect to their empirical accessibility (in the sense of conventional engineering science), and ontic interpretations refer to systems as such, independent of any environment including observers. The epistemic realm may be associated with a contextual, empirical realism; the ontic with a context-free, holistic realism. The acts of observation and measurement are then the crucial elements needed for relating these two realms to each other. The distinction of ontic and epistemic interpretations is especially fruitful when developed in the framework of algebraic quantum theory. It serves to facilitate a better understanding of a number of the so-called enigmas and paradoxes of existing interpretations of quantum theory.

Though this framework is very appealing, it is still too simplistic if ontic *and* epistemic elements must be considered at the same level of description. To cover such situations, the concept of "relative onticity" is introduced, meaning that a term that is interpreted epistemically at one level my be interpreted ontically at another. Relative onticity leads to many realisms in the sense of many levels of description with ontic and epistemic referents at each level. The notion is inspired by the concept of ontological relativity as discussed by Quine and by Putnam. Both approaches are compared and contrasted with the quantum theoretical meaning of relative onticity. It may be speculated that at some very basic level of onticity the distinction of mental and material domains of reality becomes irrelevant. The question remains to be clarified whether this level is already addressed by contemporary quantum theory.

1 Realists, Realisms, and Realities

A *realist*, in one philosophical sense of this term, is someone who holds that the entities posed by a well-established theory exist (and may be contrasted with an anti-realist who regards such terms merely as convenient fictions). The corresponding notion of *realism* thus characterizes a descriptive concept (a theory), the referents of which can be conceived as elements of *reality*. Every scientist is a realist in a minimal sense insofar as the standard methodology of science requires that models and theories are empirically checked by such elements of reality. This check can confirm or disprove a given hypothesis. It always rests on empirical tools, e.g., measuring instruments, which are presupposed in an unsophisticated, common sense manner. For this reason and in this sense, the concepts of realism and reality are to be understood as *relative to* such tools. In spite of the option to use empirical facts and data for checking models and theories, it is, however, everything else than clear how these two domains are related to each other. There are levels of discussion at which it seems unnecessary to consider any such relationship at all, and there are other levels of discussion which require such a relationship to be explicitly taken into account.

The question of relationships between the material world with its facts or data and its apparently non-material counterpart or complement, the domain of models and theories, respectively, belongs to the oldest, most puzzling, and most controversial questions in the long history of philosophy and the history of science. One of the main reasons for its controversial nature is that the question itself is understood in different ways depending on basic assumptions concerning our conceptions of reality. What makes all approaches toward this question as well as the discussions about those approaches so difficult is the fact that those assumptions are most often implicit rather than explicitly clarified.

For many good reasons, any related inquiry has to take into account the corpus of knowledge we have acquired so far. The contemporary status of the sciences is the result of centuries of history, built upon various lines of empiricist tradition and upon the Cartesian distinction of res cogitans and res extensa. At present, there are quite a number of scientific topics touching this distinction itself. More and more aspects of mind-matter research become timely and sensible research topics, and it may be hoped that the knowledge we have acquired so far provides a sound basis for substantial progress in this field. Of course, this requires detailed work rather than mere verbal assertions or ungrounded speculations.

From the viewpoint of a philosophically informed contemporary physicist (who typically disregards any kind of "mind-over-matter" idealism), there are two general frameworks within which reality can be conceived. (For more details about these topics the reader is referred to the relevant literature, e.g., Chalmers (1996).) One of them is typically denoted as *physicalism* (or *materialism*) and expresses the idea that the basis of reality consists of the material world alone; anything like qualia, consciousness, psyche, mind, or spirit is based on the material elements and fundamental laws of physics. For physicalists, the way in which these apparently non-material higher-level properties can be explained is a follow-up question, again answered differently within different ways of thinking, using conceptual schemes such as, e.g., emergence, supervenience, or reduction. These concepts are tightly related to each other.

In general, it is helpful to keep in mind that emergence is an extremely colorful, often not well-defined concept that has to be discussed together with supervenience and reduction. Some useful sources are Silberstein (1998), Scheibe (1997), Chalmers (1996), Crutchfield (1994), Eisenhardt and Kurth (1993), Kim (1984). All these topics have to do with instabilities (of different kinds) and have been addressed in various fields such as morphogenetics, synergetics, complex systems, non-equilibrium thermodynamics, catastrophe theory, and others. It seems to be a good guess that emergence or supervenience are connected with a weak type of reduction insofar as emergent properties must not contradict fundamental laws at a basic level of description, but also neither are uniquely determined nor can be uniquely derived from that level without further (contextual or contingent) conditions. For instance, physical processes in the human brain must not violate any applicable physical laws, but by no means are these laws sufficient to understand any of the higher-level properties and functions the brain has and performs. Nevertheless, the fundamental laws of physics can be assumed to be exhaustive at the basic level, and the existence of higher-level properties does not necessarily require us to add further "fundamental laws".

The other general framework is characterized as *dualism*, ranging from ontological to epistemological and methodological versions. Briefly speaking, ontological dualism maintains that the world *consists* of mind and matter (or other, corresponding concepts) as ultimately separate "substances". Epistemological dualism refers to mind and matter as fundamentally different domains with respect to our modes of gathering and processing knowledge of the world, irrespective of what this world "as such" ("in itself") may or may not be. Methodological dualism reflects an attitude that is neutral to the claims made by the other two variants. It utilizes the mind-matter distinction as a basic, but maybe not the only possible methodological tool to inquire into the structure of the world.

In its weakest (methodological) form, dualism is a prerequisite of any physicalist approach insofar as the latter presupposes a distinction between matter and something that appears to be non-material and – in one way or another – has to be related to, explained by, or even derived from the elements and laws of the material world. Within such a kind of minimal dualism, which is hard to avoid, we may use distinctions such as that of models and data, theories and facts, and so forth (compare Atmanspacher 1994a). In the present article, any dualistic kind of argument is meant at this methodological level.

For a physicalist approach, the concepts of emergence, supervenience, or reduction seem to refer explicitly to the world of material facts; they refer to a reality addressed by a certain type of realism. However, keeping in mind that this reference presupposes the (possibly nonunique) selection of a viewpoint, we may also argue that emergence, supervenience, or reduction primarily refer to our (non-material) descriptions of the material world rather than to elements of that world itself. Depending on the logical structure of those descriptions, they populate the entire spectrum between a naive *realism*, an unreflected belief in an external reality, and a radical *relativism*, hardly found attractive by working scientists who are used to dealing with or relying on the regulative power of events that do "really" happen in the material world.

Emergence, supervenience, and reduction are concepts which have been applied to facts ascribing properties to systems in the material world (i.e., in an assumed material *reality*) or in the sense of our descriptions of those properties (i.e., different kinds of *realism*). In a rough terminology, there are emergent facts and emergent theories. Mixing both of them up, inevitably leads to category mistakes and misunderstandings. The methodological dualism that helps us to avoid this must, however, not at all be understood as a predecision concerning the structure of the world and our knowledge of this world. As mentioned above, it should be understood as a tool to inquire into this structure. It may be a preliminary tool that can, for instance, lead to a precise description of its own limits.

The present contribution deals primarily with realisms (conceptions of reality). It will be argued that neither a naive realism, addressing the material world as a collection of facts that are ready for observation in a theory neutral way, nor a radical relativism with a collection of models posing facts in a theory dependent, more or less arbitrary way, is the right tool to deal with those issues properly. A specific conceptual scheme will be sketched that allows us to combine a certain kind of relativism with the belief that the material world cannot be described arbitrarily. In other words: although facts are certainly model-dependent, they are more than just illusions. There are many (contextually) correct descriptions with well-defined relationships among each other rather than just one (universally) correct description of the world – and there certainly are incorrect descriptions.

2 Ontic and Epistemic Descriptions

Assuming the methodological distinction between a material world with events, facts, or data and a mental world with concepts, models, or theories, it is possible to describe elements of the material world by elements of the mental world. The question then is how to distinguish different elements within the two domains. Modern physics, in particular quantum physics has developed tools to address this question with respect to the material world. A most important distinction in this context is that of systems (objects) and their environment. This distinction is sometimes metaphorically called the *Heisenberg cut* (Heisenberg 1936).

Together with the fact that descriptions of isolated systems are radically different from descriptions of open systems, the Heisenberg cut and the corresponding formal tools play a major role in modern quantum theory. It turns out that a proper understanding of these issues can be achieved using two different descriptions of reality; namely, the ontic and the epistemic, respectively.[1] Primas has developed this distinction in the formal framework of algebraic quantum theory (Primas 1990; see also Atmanspacher 1994b for some indications of possible limitations of this distinction). The basic structure of the ontic/epistemic distinction as it will be used subsequently can be understood according to the following rough characterization (for more details, the reader is referred to Primas 1990,1994a):

Ontic states describe all properties of a physical system exhaustively. ("Exhaustive" in this context means that an ontic state is "precisely the way it is", without any reference to epistemic knowledge or ignorance.) Ontic states are the referents of individual descriptions, the properties of the system are formalized by *intrinsic observables*.[2] Their temporal evolution (dynamics) follows *universal, deterministic laws* given by a Hamiltonian one-parameter group. As a rule, ontic states in this sense are empirically inaccessible. *Epistemic states* describe our (usually inexhaustive) knowledge of the properties of a physical system, i.e. based on a finite partition of the relevant state space. The referents of statistical descriptions are epistemic states, the properties of the system are formalized by *contextual observables*. Their temporal evolution (dynamics) follows *phenomenological, irreversible laws* which can be given by a dynamical one-parameter semigroup if the state space is properly chosen. Epistemic states are empirically accessible by definition.

Although the formalism of algebraic quantum

[1] These terms are due to Scheibe (1973) and must not be mixed up with the distinction between "ontological" and "epistemological". The distinction between ontic and epistemic descriptions can, for instance, itself be discussed as an ontological or epistemological topic, according to whether its observer-independent *existence* or its observer-dependent status as a *descriptive tool* is addressed. Moreover, Fetzer and Almeder (1993) emphasize that "an ontic answer to an epistemic question (or vice versa) normally commits a category mistake". The literature on mind-matter questions is full of such category mistakes. Numerous examples can also be found in the context of quantum physics.

[2] Note that the term "observable" was historically developed as a technical term for a property of a system. Prima facie it has nothing to do with the actual observability of that property.

theory is often hard to handle for specific physical applications, it offers significant clarifications concerning the basic structure and the philosophical implications of quantum theory. For instance, the modern achievements of algebraic quantum theory make clear in what sense pioneer quantum mechanics (which von Neumann (1932) implicitly formulated epistemically) as well as classical and statistical mechanics can be considered as limiting cases of a more general theory. Compared to the framework of von Neumann's monograph (1932), important extensions are obtained by giving up the irreducibility of the algebra of observables (not admitting observables which commute with every observable in the same algebra) and the restriction to locally compact state spaces (admitting only finitely many degrees of freedom). As a consequence, modern quantum physics is able to deal with open systems in addition to isolated ones, it can involve infinitely many degrees of freedom such as the modes of a radiation field, it can properly consider interactions with the environment of a system, superselection rules, classical observables, and phase transitions can be formulated which would be impossible in an irreducible algebra of observables, there are in general infinitely many representations inequivalent to the Fock representation, and non-automorphic, irreversible (hence non-unitary) dynamical evolutions can be successfully incorporated.

In addition to this remarkable progress, the mathematical rigor of algebraic quantum theory in combination with the ontic/epistemic distinction allows us to address quite a number of unresolved conceptual and interpretational problems of pioneer quantum mechanics from a new perspective. First of all, the distinction between different concepts of states as well as observables provides a much better understanding of many confusing issues in earlier conceptions, including alleged paradoxes such as those of Einstein, Podolsky, and Rosen (EPR, 1935) or Schrödinger's cat (Schrödinger 1935). Second, a clearcut characterization of these concepts is a necessary precondition to explore new approaches, beyond von Neumann's projection postulate, toward the central problem that pervades all quantum theory since its very beginning: the measurement problem. Third, a number of much-discussed interpretations of quantum theory and their variants can be appreciated more properly if they are considered from the perspective of an algebraic formulation.

This applies in particular to the deep (though notoriously vague) deliberations of Bohr, to Einstein's and Schrödinger's contributions, to Bohm's ideas on explicit and implicit orders, to Heisenberg's distinction of actuality and potentiality, or to d'Espagnat's scheme of an empirical, weakly objective reality and an observer-independent, objective (veiled) reality.[3] An important example: the core of the well-known Bohr-Einstein discussions in the 1920s and 1930s (see Jammer 1974) can be traced back to the belief that only one of the mentioned concepts of reality can be (primarily) relevant. While Bohr clearly emphasized an epistemic, contextual realism referring to the results of measurements, Einstein was deeply convinced of an ontically determined realism to which he attached a common-sense type local realism that – as we would say today – applies to an epistemic viewpoint. In the framework of algebraic quantum theory, both kinds of realism play significant roles, and even some of the formal relations between them have been clarified successfully. More details about this issue have been discussed by Howard (1985,1997).

One of the most striking differences between the concepts of ontic and epistemic states is their difference concerning operational access, i.e. observability and measurability. At first sight it might appear pointless to keep a level of description which is not related to what can be verified empirically. However, a most appealing feature at this ontic level is the existence of first principles and universal laws that cannot be obtained at the epistemic level. Furthermore, it is possible to rigorously deduce (to "GNS-construct"; cf. Primas 1994a) a proper epistemic description from the ontic description if enough details about the empirically given situation are known. This is particularly important and useful for the treatment of open and macroscopic (quantum) systems.

The distinction of ontic and epistemic states provides an important clue to understand the distinction between holistic and local realisms, i.e., concepts of reality. Ontic states and intrinsic observables refer to a holistic concept of reality and are operationally inaccessible, whereas epistemic states and contextual observables refer to a local concept of reality and are operationally accessible. It is exactly the process of observation, essentially one or another kind of pattern recognition, which represents the bridge between the two. Observation suppresses (or minimizes, respectively) the EPR correlations constituting a holistic reality and provides a level of description to which one can associate a local concept of reality with locally separate (or

[3] Since detailed discussions of these issues would be far beyond the scope of this contribution, they are omitted here. Some corresponding indications can be found as scattered remarks in recent papers by Primas (1990, 1994a, and others). Among the approaches listed above, d'Espagnat (1995) gives some hints in a non-algebraic terminology but does not substitute a yet-to-be-written systematic algebraic presentation.

"approximately" separate, respectively) objects. In this sense it is justified to say that observation generates objects by introducing a Heisenberg cut as a metaphor for the suppression of EPR correlations.

Another way to look at the distinction of ontic and epistemic states and the associated algebras of observables is the following. The ontic holistic realism of quantum theory is related to all sorts of inquiries into a context-, mind-, or observer-independent reality of the outside world. Focusing on an epistemic local realism expresses a change of perspective to the effect that the question "*What is* this independent reality?" is replaced by "*What can we know* about such a reality?" Philosophically the distinction between these two questions is very much in the spirit of Kant's distinction of transcendental idealism and empirical realism, and in this sense one may consider an ontic description as a kind of "idealization" of an epistemic description. As an empirical science, physics addresses only questions of the second kind. But on the other hand, the mathematical formalism that constitutes the formal basis of physics often leads into a way of thinking very much in accordance with the first kind of question. An instructive discussion along these lines, emphasizing those topics as non-standard realism, is due to d'Espagnat (1998).

One of the basic conceptual implications of the distinction of ontic and epistemic interpretations of reality is the fact that it is inadmissible to speak of objects and environments or their observation at the ontic level. Here is the domain of nonlocal, holistic correlations between those properties that are, technically speaking, described by non-commuting operators. Local objects and their environment are generated by a change of perspective from the ontic to the epistemic level, which generally involves the breaking of a symmetry, introduces new contexts (e.g., abstractions that are deliberately made to distinguish between "irrelevant" and "relevant" features), and is intimately related to the distinctions necessary for any kind of observation. This makes it easy to understand why ontic states are non-empirical by definition. Empirical access requires the separation of objects which are not a priori, i.e., ontically, given.

A widespread category mistake resulting from a lack of proper ontic/epistemic distinctions and the associated distinction of holistic/local realism is reflected by the assertion that EPR correlations can be interpreted such that the parts of a holistic system communicate superluminously, i.e. with signal velocities greater than the velocity of light. The state of the system as a whole is an ontic state. If a system as a whole is to be described ontically, then it is in general inadmissible to speak of parts within this same description, and consequently there is no way to talk about communication between such parts.[4] Only if the ontic state of a system is decomposed in order to describe subsystems or parts, the result is a description in terms of epistemic states of those subsystems. They can communicate, but of course not superluminously.

Another consequence of the same category mistake is the misleading interpretation that due to EPR correlations "everything is correlated with everything else". Ontically, there is only "one thing", a system as a whole. Epistemically, where it is admissible to speak of "many things" and consequently of "everything", there are no holistic correlations. Any empirically accessible aspect of those correlations relies on the condition that parts of the environment (e.g., detection instruments) are *not* correlated.[5] All empirical evidence we have for quantum holism is obtained by "destroying" that same holism. Ironically, nonlocality can only indirectly be demonstrated in a local way, conceptually using counterfactual reasoning.

As Primas has discussed extensively (Primas 1998), the transition from an ontic to an epistemic level of description often goes hand in hand with the emergence of properties that are not defined ontically. Almost all known classical properties (in the sense of commuting observables) of objects emerge due to contexts that are not given by the intrinsic properties of an ontic interpretation, but have to be selected properly, adapted to the given situation. Some of the examples that are formally well-understood refer to properties such as chirality, temperature, or chemical potential. Another example is the emergence of irreversibility; the time evolution of ontic states is given by a one-parameter group describing a reversible dynamics.[6] The no-

[4] Other terminologies such as "uncontrollable influence" (Bohr 1935) or "passion-at-a-distance" (Shimony 1984) rather than communication or signalling are less suggestive of a direct conflict with the special theory of relativity. They indicate something like an "internal structure" of a system even when it is considered as a whole, an issue that will be taken up in the following section.

[5] Technically speaking, for every quantum system in a given pure state ϕ there is a factorization such that ϕ is a product state. This is to say that there are always (perhaps fictitious) subsystems which are *not* correlated with each other.

[6] A long-standing misunderstanding in many discussions about the approach to irreversibility as advocated by the Brussels-Austin-group of Prigogine and collaborators can be boiled down to the question whether an ontic or an epistemic interpretation is "primary" – an issue very similar to the Bohr-Einstein-controversies adressed above. The assignment of reversibility and irreversibility to ontic and epistemic levels, respectively, is not controversial: "irreversibility is an emergent property" (Petrosky and Prigogine 1997).

tion of emergence is also used (in a physicalist sense) for much more complicated and fairly little understood properties such as life or consciousness. A common tenet shared by most physicists (not every physicist is a physicalist) is the restriction of the problem of measurement to the material world alone. Consequently, observers are considered as observing apparatuses, and any consciousness of living observers remains disregarded (cf. Primas 1993, Atmanspacher 1997).

3 Relative Onticity

What is a suitable interpretation in situations which confront us with holistic *and* local features at the same level of description? In such situations, mixtures of ontic and epistemic elements are required at the same level of description, thus forbidding a unique assignment of ontic/epistemic interpretations and holistic/local realisms. (As indicated above, such a mixture is unavoidable from the very beginning since every epistemic interpretation presupposes an ontic interpretation of measuring tools.) This difficulty can be resolved if it is realized that two levels of description are not enough to cover the entire hierarchy leading from fundamental particles in basic physics up to living systems in biology and psychology. It is then suggestive to consider ontic and epistemic interpretations as *relative to* two successive levels in the hierarchy. Concerning material reality, this is particularly relevant to the study of hierarchical complex systems, and some ideas toward a corresponding formal approach have been specified elsewhere (Primas 1994b).

Let us start with an example for such a *relative onticity*[7] in the material domain of reality. From a fundamental viewpoint of quantum theory as sketched above, atoms and molecules are highly contextual objects whose properties can be described by interactions of electrons, nuclei, and their environments. However, from the viewpoint of chemistry one may not be interested in these complicated interactions, but in the shape and other features of molecules, for which it is reasonable to "ontologize" the concept of an atomic nucleus in the sense that it is considered as a whole rather than composed of protons, neutrons, or even "more basic" constituents. This leads to the description of a molecule as a contextual object resulting from the interaction of nuclei, electrons, and their environments. The ontic/epistemic distinction can then be shifted from the levels of electrons and nuclei to that of molecules. While molecules are epistemically interpreted within the first realm, they acquire an ontic interpretation within the second. In this manner, the result of a composition of ontic nuclei and electrons (the epistemic molecule) at a certain level can become "ontologized" as a basic entity (the ontic molecule) if it is viewed from a successively higher level in the hierarchy.

In a more detailed version of this example one can even address specific relationships between different levels of description. Let us discuss the concept of water as an example. At a rather basic physical level, one might think of water in terms of hydrogen and oxygen nuclei and electrons. Leaving the nuclear level of description (protons, neutrons, etc.) involves a change of perspective which, roughly speaking, abstracts from any nuclear forces due to strong interactions, and focuses on electromagnetic (Coulomb) forces. In a general sense, this abstraction leads from a description in terms of ontic states of nuclei and electrons and their properties to the epistemic concept of a water molecule, H_2O.

One of the most important further abstractions in this context leads to the so-called Born-Oppenheimer picture, disregarding the electron mass as compared to the masses of the nuclei. In a corresponding description, the water molecule has properties which H and O nuclei did not have, e.g., the property of a nuclear frame. A special feature of nuclear frames is the chirality (handedness, see Amann 1993) of molecules. Molecular chirality is a property that emerges at an epistemic molecular level of description and is absent at any lower level. However, this is not to say that this property is just a matter of description and has no *real* impact. For instance, thalidomide is a chiral molecule. Today it is well-known that the disastrous consequences of thalidomide-based remedies in the 1960s are caused by only one of the two different chiral species. The remedies were produced as mixtures of both species.

In a thermodynamic description, other properties emerge due to consideration of *many* ($N \to \infty$) entities such as molecules. It is intuitively obvious that one single water molecule H_2O is not wet. The property of liquidity is an emergent property for which the level of a description in terms of individual molecules has to be left and replaced by a statistical or thermodynamical description. The same applies to other properties such as chemical potential or temperature, for which rigorous mathematical derivations are available (Takesaki 1970, Müller-Herold 1980). Again a remark concerning the factual "reality" of a property such as temperature: whoever has burned one's fingers once

[7] This term has been coined in discussions with Chris Nunn in the context of an attempt to understand archetypes as memes à la Dawkins (1976) and to develop a corresponding hierarchical structure (Nunn 1998, Atmanspacher 1998).

will have serious doubts that temperature might be nothing else than a descriptive tool that has nothing to do with reality.

For a molecular chemist or biologist, molecules are the building blocks of his mode of description. In this sense, their states and properties are considered ontically. A molecular biologist is not at all concerned with the justification of a molecular (Born-Oppenheimer) picture. He may, however, be interested in the way in which different phosphates (adenine, thymine, guanine, cytosine), so-called nucleotides, can be combined to different DNA sequences. For such a point of view, the phosphate molecules are entities to be described by ontic states and their properties, the different ways they are organized in DNA give rise to an epistemic description with emergent properties (genetic information, e.g., the faculty of self-reproduction) at the level of the DNA. At this conceptual level, there is an analogy between the ontic/epistemic distinction and the distinction of genotypes and phenotypes which deserves further study.

The systems and objects the "man on the street" usually deals with in everyday life are the trees, tables, bricks, icecubes, and so forth of common sense realism. It would be entirely unreasonable not to include this kind of realism in the framework suggested here. Although for a scientist a tree has to be described as a highly complicated composition of material subsystems with emergent properties of different types (solidity, texture, etc.), common sense realism holds that a tree *is* simply a tree, an object in an ontic state *having* those properties. Many trees together can form a forest, and there certainly are issues for which the forest as a whole is the right object to be addressed rather than many trees. If it is described in terms of many trees, the forest is the referent of an epistemic interpretaion. If it is described in terms of an ecosystem as a whole (e.g., for purposes of its reliable utilization; see Hauhs et al. 1998), the forest becomes relevant as the referent of an ontic interpretation.

The central issue of the general concept of relative onticity is that states and properties of a system, which belong to an epistemic interpretation at a given level of description, can be considered as ontic from the perspective of a higher level. Objects can be epistemically described to be composed of lower level objects, but alternatively they can be ontically described as wholes, giving rise to "building blocks" of higher level objects. Emergent properties at successively higher levels of description can be *formally* addressed by a change of perspective which is not uniquely given but depends on contexts and conceptual schemes that must be selected properly.

However, this does not imply that *any arbitrary* description is proper. An interesting example for an improper conceptual scheme is given by a supposed "atomic" level of description between nuclear and molecular levels. Since we do not know the interaction between atoms as "ontologized" entities, molecules must not be conceived as composed of atoms but of nuclei and electrons. Taking atoms ontologically seriously leads to problems and inconsistencies if one wants to use them for the construction of an epistemic molecular picture. Although "atomic physics" doubtlessly was a very important field of research early in the 20th century, a modern point of view suggests that it is more appropriate to consider atoms as a special chapter of molecular physics.

The entire approach discussed so far essentially looks at different levels of description in the sense of increasing diversity. Generally speaking, moving from one level to the next higher level corresponds to a symmetry breaking; in one way or another, a holistic system is considered to be broken up into parts. Such a kind of so-called "bottom-up" approach is usually assumed as a proper way to reflect the evolution of more and more complex systems in the material world. In this framework, it is, however, a natural question whether all conceivable symmetry breakings are to be regarded as feasible, or whether there are some of them which are more feasible than others. For instance, it seems plausible that the symmetry breaking of the ontic state of a *photon pair* in an EPR type situation *before* measurement generically leads to the epistemic states of *two single photons* rather than arbitrary other subsystems *after* measurement.

Teller (1989) has proposed the concept of "relational holism" in very much the same spirit. In Teller's parlance, a local realist tries to interpret EPR-type correlations in terms of nonrelational properties of the relata which underlie any such correlations. On the basis of those (subvenient) properties it should be possible to explain the correlations as supervenient. By contrast, Teller asserts that any EPR-type "correlation – as an objective property of the pair of objects taken together – is simply a fact about the pair. This fact will arise from and give rise to other facts. But it need not itself be decomposable in terms of or supervenient upon some more basic, nonrelational facts" (Teller 1989, p. 222). On the other hand, there are, of course, decompositions of a system as a whole into subsystems, such as the decomposition of a photon pair into two photons with their individual (emergent or supervenient) properties.

Clearly, it would be desirable to have a way of explaining that certain decompositions of a system as a whole are more natural than others. Slight variations of the context should not in general (but can in exceptional cases) result in different epistemic states. This is a requirement that can typically be taken into account by stability considerations. What we want is that certain decompositions of a holistic system are more stable, more robust than others. A first attempt into this direction has been indicated by Amann and Atmanspacher (1998). This means that any ontic, holistic level of description does already carry some inherent tendencies for more or less stable decompositions. A forest is more likely to be decomposed into individual trees rather than into strange mixtures of them. In this sense, holistic systems are *not* totally void of internal distinctions. It is an unresolved problem how such "preformed tendencies" for the stability of certain decompositions can be taken into account formally. It may be speculated that elements of "top-down" thinking could play a role in this regard, thus closing a self-referential loop between any pair of ontic and epistemic interpretations at any level of description. Such a scheme would imply that ontic and epistemic interpretations mutually depend on each other, thus rendering any ultimate "primacy" of one over the other as ill-posed.

4 Ontological Relativity

The formal concept of "relative onticity" resembles to some extent the (less formal) discussion of "ontological relativity" as introduced by Quine (1969). In this essay, Quine argues that if there is one ontology that fulfills a given theory, then there is more than one. This claim is the crux of his doctrine of ontological relativity, claiming that it makes no sense to say what the objects of a theory are, beyond saying how to interpret or reinterpret that theory in another. Moreover (Quine 1969, p. 53): "Ontological relativity is not to be clarified by any distinction between kinds of universal predication – unfactual and factual, external and internal. It is not a question of universal predication. When questions regarding the ontology of a theory are meaningless absolutely, and become meaningful relative to a background theory, this is not in general because the background theory has a wider universe. One is tempted ... to suppose that it is; but one is then wrong. What makes ontological questions meaningless when taken absolutely is not universality but circularity. A question of the form "What is an F?" can be answered only by recourse to a further term: "An F is a G." The answer makes only relative sense: sense relative to the uncritical acceptance of "G"."[8]

For Quine, any question as to the "quiddity" (the "whatness") of a thing is meaningless unless a conceptual scheme is specified relative to which it is discussed. It is not the uniqueness of such a scheme, e.g., any "theory of everything" with universally given referents, but the faculty of reinterpretation of one scheme in another which belongs to the important features of scientific work. Nevertheless, Quine encourages "ontological commitment" in the sense that a most proper conceptual frame should be preferred for the interpretation of a theory. The circularity which he mentions as the crucial point of ontological relativity expresses itself in an inscrutability of reference. This stresses his conviction that the issue of reference causes the problems necessitating ontological relativity, not the unique assignment of referents as objects in the external world of a realist (cf. Gibson 1995).

After his farewell to functionalism (cf. Chalmers 1996), Putnam (1981,1987) has developed a related kind of ontological relativity within an approach rejecting both naive (spectator) realism and relativism. His approach rather attempts to reconcile the two and was first called "internal realism", later sometimes modified to "pragmatic realism". Ontological (sometimes conceptual) relativity is a central feature of Putnam's internal realism, but it differs from Quine's usage of the term in an important detail. In an interview with Burri (1994),[9] Putnam characterized Quine's ontological relativity as due to the impossibility of a uniquely fixed relationship of our concepts to the totality of objects which those concepts refer to. Putnam's own position is more radical insofar as he questions that we know what we mean when we speak of a totality of objects: "If we start with the notion of a totality of objects it becomes entirely untransparent how our terms – maybe except those referring to sense data – can refer in a fixed way. But from this I have not concluded that no term other than sense data terms refer in a fixed way; rather I have concluded that the premises leading to such a conclusion must be wrong. In this context I basically think of the assumption that we know what we mean when we speak of a totality of all objects." (Burri 1994, p. 185)

[8] In this spirit, the concept of quantum holism does only make sense relative to the uncritical acceptance of measuring tools that are *not* EPR-correlated.

[9] To our knowledge, this interview of January 14, 1994 (given at Cambridge, Massachusetts) is the most recent source directly addressing the issues of interest for the present discussion.

Considering the perspective of quantum holism, this position is highly sensible. If an object can only be reasonably defined within the framework of some preselected conceptual scheme, as Putnam's internal realism holds, then it is evident that any definition of an object is only relevant within a given context, i.e., objects are "ontologically relative" entities. But Putnam's point of departure is *not* quantum holism; it is our common sense realism, refering to a "a usage of the word 'object' which we cannot change without loss of its meaning. The notion of an object roots in speaking of tables, chairs, and bricks. Tables, chairs, and bricks are objects in a fundamental sense of the word." (Burri 1994, p. 182) "The actual problem is to work out the difference between our common sense realism on one side and a transcendental or physical, respectively, realism on the other. Currently I try to criticize physical realism from the viewpoint of common sense realism." (Burri 1994, p. 177)

Concerning the main features of this position, Putnam admits that his "ideas keep being subject to change. At present I see the crucial points other than immediately after the turn. The publications which I wrote by the end of 1976 ... finished a period of my thinking in which I began to see more and more clearly that the semantics underlying classical realism are hopelessly metaphysical. In particular, I became convinced that numerous concepts of metaphysical realism are untenable, for example the idea that one can reasonably talk about 'all entities' – as if the terms 'entity' or 'object' had a unique, fixed meaning – as well as the illusion that there is an answer to the question of which objects the world consists. Later I called this conviction 'internal realism' or 'conceptual relativity'. It rests upon the idea that there is a real world, but it does not dictate its own descriptions to us. Internal realism does not imply 'anything goes' but rather accounts for the fact that there are many descriptions of the world, depending on our interests and questions, and on what we intend to do with the answers to those questions. The assumption that certain descriptions cover the world as it is in itself seems to be pointless to me." (Burri 1994, p. 177f)

In his version of ontological relativity, Putnam wants to maintain a meaningful concept of reference and gives up the concept of a totality of uniquely defined objects as a precondition for any attempt to fix references once and for ever. Objects cannot be uniquely defined, but they can be defined with respect to conceptual frames. Within a preselected frame, it is then possible to establish reference without inscrutability. Putnam's discussion of water on a twin earth is illuminating in this context. If inhabitants of a "twin earth" use the term water to refer to a chemical substance other than H_2O (say XYZ), then Putnam holds that due to the best of our knowledge ("expert knowledge") the *proper* referent of "water" – at the level of a molecular description – is H_2O in the external world; H_2O is the extensional referent of "water". Putnam's example can only roughly be sketched here, for more details see Putnam (1975), Putnam (1981, Sect. II). It seems to be related to what Quine calls ontological commitment, but other than Quine's, Putnam's ontological commitment explicitly takes extensions into account. Quine's ontological relativity relates to inscrutability of reference, Putnam's relates to non-uniqueness of objects. (For other viewpoints in this discussion, see Searle 1983, Sec. 8, and Chalmers 1996, Sec. I.2.4.)

In Putnam's thinking, conceptual schemes serve a purpose very similar to contextual representations in the framework of quantum theory. In this regard, relative onticity and ontological relativity are tightly related to each other. They both refer to the domain of empirical (local) realism where objects have to be described relative to a context. Both Putnam's internal realism and the realism of quantum theory agree with regard to a basic assertion according to which there is a "real world as such". The starting point for Putnam differs from the starting point of a quantum theoretical perspective. For Putnam, objects in a fundamental sense are common sense objects such as "tables, bricks, icecubes". From the viewpoint of quantum theory, a universe of discourse in a fundamental sense does simply not consist of objects (although every quantum theoretical statement presupposes such objects, e.g., observational tools). Objects at each level of description are generated by symmetry breakings within a holistic universe of discourse, addressed by a holistic realism. The concept of relative onticity entails a recursive application of formal transformation principles (some classes of which are well-known, see Primas 1998), translating between successive levels of description. Such principles or even rules of transformation are called for (at least by Quine), but not given in the framework of Putnam's or Quine's ontological relativity. In the scheme of relative onticity, common sense objects are objects just in a very special contextual framework, high up in the hierarchy of descriptions. But nevertheless they are considered as "real" objects in an external reality.

In his more recent writings, Putnam often refers to Kant and his distinction between (empirical) realism and (transcendental) idealism. It seems that the philosophy of Kant had an important impact on

Putnam's way of thinking: "Only after I rejected metaphysical realism I began to understand what is correct in Kant's philosophy. Nevertheless, I am not a Kantian idealist. But he was the first philosopher who saw that we do not simply represent the world. To describe the world does not mean to represent it. It seems to me that this is an important insight." (Burri 1994, p. 178)

"[Kant] does not doubt that there is some mind-independent reality; for him this is virtually a postulate of reason. He refers to the elements of this mind-independent reality in various terms: thing-in-itself (Ding an sich); the noumenal objects or noumena; collectively, the noumenal world. But we can form no real conception of these noumenal things; even the notion of a noumenal world is a kind of limit of thought (Grenzbegriff) rather than a clear concept. Today the notion of a noumenal world is perceived to be an unnnecessary metaphysical element in Kant's thought. (But perhaps Kant is right: perhaps we can't help thinking that there is somehow a mind-independent ground for our experience even if attempts to talk about it lead at once to nonsence.) At the same time, talk of ordinary empirical objects is not talk of things-in-themselves but only talk of things-for-us." (Putnam 1981, p. 61)

"Internal realism says that the notion of a 'thing in itself' makes no sense; and *not* because 'we cannot know the things in themselves'. This was Kant's reason, but Kant, although admitting that the notion of a thing in itself *might* be 'empty', still allowed it to possess a formal kind of sense. Internal realism says that we don't know what we are talking about when we talk about 'things in themselves'. And that means that the dichotomy between 'intrinsic' properties and properties which are not intrinsic also collapses – collapses because the 'intrinsic' properties were supposed to be just the properties things have in 'themselves'. The thing in itself and the property the thing has 'in itself' belong to the same circle of ideas, and it is time to admit that what the circle encloses is worthless territory." (Putnam 1987, p. 36)

According to these selected quotations, it is Putnam's view that we can only reasonably talk about the empirically accessible world of ontologically relative objects. Their relativity is due to different conceptual schemes with extensional referents in a real world. The concept of things-in-themselves has to be rejected not only as empirically empty but primarily because they do not make sense. It has to be added that for Putnam "making sense" means more precisely: making sense in the sense of common sense. In other words, it is the absurdity of things-in-themselves that causes Putnam to reject them – although he admits that the concept of a (noumenal) world independent of empirical access may be an unavoidable idea.

The perspective of modern quantum theory offers an interesting alternative to Putnam's viewpoint. Putnam's (and Kant's) empirical realism is the local realism of any working scientist. Objects as the referents of local realism are always contextual, they are relevant with respect to a conceptual scheme corresponding to a preselected level of description. The states of those objects are epistemic at this level. On the other hand, it is also possible that there are ontic states at the same level, e.g., molecules described as wholes rather than described as consisting of nuclei and electrons. These ontic states refer to a holistic realism which – from the perspective of an empirical (local) realism – seems as "absurd" as Putnam claims. However, it does so for other reasons and with other implications.

Quantum holism invalidates the concept of objects at any level to which it is applied in terms of an ontic interpretation. In this regard, things-in-themselves are not relevant as empirically accessible entities and it does indeed not even make sense to address them as separable entities. (As discussed in the preceding section, one might nevertheless think of some kind of tendency that objects with emergent properties can be obtained by moving to another, higher level of description.) However, quantum holism indicates that this has to be understood as an encouragement to question an unrestricted application of common sense realism beyond its significance as a necessary precondition for gaining empirical access to quantum holism by classical, uncorrelated measuring tools.

This is a decisive difference from Putnam's viewpoint. He interprets absurdity in the sense of common sense as an argument for rejecting conceptual schemes that are absurd in this sense. Quantum holism interprets such absurdity as an argument for questioning common sense if it is applied beyond its proper domain.[10] Of course, arguments of this latter type have to be investigated extremely carefully before they can be accepted. The present state of discussions in the foundations of quantum theory with its necessarily indirect, but overwhelming empirical evidence for holism provides strong evidence

[10] In the early days of quantum theory, in 1922, Heisenberg once asked Bohr: "If the interior structure of the atoms is so inaccessible to any illustrative description as you say, if we actually don't have any language to talk about this structure, will we ever be able then to understand the atoms?" Bohr hesitated for a moment, then he said: "We will. But at the same time we will understand the proper meaning of 'understanding'." (Heisenberg 1969, p. 64)

that its apparent "absurdity" must be taken seriously. Quantum holism might give us the right hint to understand Kant's transcendental idealism more properly than in terms of things-in-themselves.

5 Speculative Remarks on Mind and Matter

There is a considerable non-mainstream tradition of physicists who have suggested that quantum measurement has to do with consciousness. One of the pioneers of this conception is Wigner, among its more recent advocates are – with different arguments – Penrose and Stapp. Quite a number of publications addressing the relationship between the philosophy of quantum theory and the philosophy of mind over the last decade (cf. the overview by Butterfield 1995) shows that there is a steadily growing interest in this idea. Already in the mid 1940s, and presumably as an offspring from his extensive discussions with Pauli, Jung has discussed a distinction similar in spirit to that of epistemic and ontic states with respect to conscious and unconscious levels in the mental world.[11] In an afterword to his essay "On the nature of the psyche" (Jung 1971), Jung quotes Pauli with the statement that "the epistemological situation with regard to the concepts 'conscious' and 'unconscious' seems to offer a pretty close analogy to the ... situation in physics. ... From the standpoint of the psychologist, the 'observed system' would consist not of physical objects only, but would also include the unconscious, while consciousness would be assigned the role of 'observing medium'." In other words: mental objects and their mental environments are conceived to be generated by the transformation of elements of the unconscious into consciously and empirically accessible categories.

Analogous to the material world, it might be appropriate to consider the possibility of different levels of descriptions, regarded as elements of a mental world, providing a whole spectrum between the most fundamental and the most contextual ones. One end of this spectrum would refer to a "most ontic" level of description, serving as a limiting case, meaning that it has no broken symmetry at all. At the other end, we would find a "most epistemic" level of elements of a cultural environment, manifesting themselves in individual human psyches. A nice example is given by national or regional versions of cultural key ideas by contrast with more general versions. A certain element of a cultural environment may have ontic meaning with respect to a local environment whereas it is regarded as epistemic in a larger scope. Cartesian dualism is epistemic from the viewpoint of a worldwide cultural perspective, from which it can be regarded as a regional version of the more general principle of duality. However, it represents a concept that has implicitly acquired almost ontic (collective and unconscious) features within the narrower scope of traditional Western science and technology. An additional appealing feature of such a multilayered scheme is the fact that there are many ways to draw distinctions (break symmetries) at every level. Each distinction is contextual relative to the preceding level and generates its own specific features.

Applying the idea of relative onticity, it is conceivable that under suitable conditions epistemic elements at a certain level of description can be transformed into ontic elements when considered from the perspective of the next higher level. In other words: explicit elements of the sociocultural environment at a certain epoch can become implicitly ontic elements in a later epoch, thus leading to additional (archetypal) features in the collective unconscious in Jung's parlance. In addition to the Cartesian distinction, other basic concepts of traditional science such as determinism, causality, and locality may serve to provide further examples. What was once explicitly "invented", has later to be "discovered" as an implicit assumption underlying a new epistemic level. Such processes can be expected whenever a new epistemic level in the hierarchy of descriptions *emerges*, rendering the preceding one as its own ontic basis. More details of this picture, particularly with respect to the concept of archetypes, have been addressed by Nunn (1998) and Atmanspacher (1998).

Jung and Pauli (and others) have speculated that at a level which is "ontic enough" the symmetry breaking according to the Cartesian distinction of matter and mind dissolves, providing an "unus mundus" in which fundamental physics and depth psychology refer to the same unbroken reality (see Atmanspacher and Primas 1996). Such a scenario points toward an interesting alternative to the idea that consciousness (mind) emerges as a higher level property of the brain (matter) just as, roughly speaking, liquidity emerges as a higher level property of water (see, e.g., Searle 1984). The Pauli-Jung approach considers the mind-matter distinction as a fundamental symmetry breaking at a very primordial level of description. In this scheme, *both*

[11] Pauli's position in this regard was ambivalent: though he always stressed the fact that quantum theory refers to the material world alone, there are letters by Pauli in which he expressed his uneasiness with that state of affairs (see Atmanspacher and Primas 1996).

mind and matter are emergent domains of description (not only mind emerges from matter), used to describe the world in terms of the corresponding distinction. The holistic features of modern quantum theory might induce and even support speculations of this kind. At present, however, the available knowledge about these extremely difficult issues is far from sufficient to flesh out the corresponding ideas. It remains mandatory to distinguish sound results from wishful thinking.

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