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The Relevance of Judgment for Philosophy of Science

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Perspectives in physics

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Abstract. Judgments and perspectives are important in science. Judgments are verdicts shaped by values, and different agents—or communities of agents—may weigh such values differently. This leads to the emergence of distinct perspectives when these communities are faced with similar situations. Recognizing that such differences in perspectives play a crucial role in scientific practice is an important philosophical insight. In this paper, we focus on physics and its philosophy, examining cases where perspectives and the judgments they inform are particularly evident. However, perspectives also play a deeper role. The perspectival nature of meta-level considerations about physics has a counterpart within physics itself: in recent decades, there has been growing recognition that quantum mechanics presents the physical world as fundamentally perspectival.

1 Introduction

In daily life, it is common to encounter differences of opinion—ideas and perspectives can vary significantly between individuals and across social or cultural groups. The situation in natural science, particularly in physics, seems quite different: the same physical theories are accepted worldwide, and the use of these theories leads to predictions that are independent of the physicist who made them or the group to which the physicist belongs. There thus appears to be little room for differing perspectives or opinions in physics.

This view can be upheld to some extent in the case of well-established physical theories whose empirical adequacy has been convincingly demonstrated. Consider, e.g., classical mechanics, electrodynamics, special and general relativity, and quantum mechanics, each within its domain of applicability. These theoretical frameworks are standard predictive tools that have been verified countless times, and their value is universally acknowledged. However, when we shift focus to other aspects of physical practice—aspects that go beyond standard predictions using well-confirmed theories—a different picture emerges. For instance, opinions about promising new research avenues often vary greatly among individual researchers and across different research communities. Even in the case of universally accepted, well-confirmed theories, perspectives can diverge widely on questions beyond empirical adequacy, such as interpretational issues. The debates about the interpretation of quantum mechanics are particularly notorious in this regard, but even in the case of physics theories, there are controversial questions of

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interpretation—e.g., concerning the status of space, time, and force. In such cases, different judgments and perspectives are common.

Judgments are shaped by viewpoints and values, and often lack the form of logically compelling arguments. As a result, different agents or groups may develop differing views when faced with similar situations. The significant role that such judgments and viewpoints play in science is an important philosophical insight. In this paper, we will illustrate the point, focusing on physics and its philosophy. We will briefly discuss several examples in which less-than-logically-compelling judgment is a key factor: perspective-dependent decisions regarding theory choice, judgments about the adequacy of explanations, and judgments concerning the correct interpretation of theoretical frameworks.

Thus, the landscape of physical theorizing and interpretation is not monolithic but rather fragmentized, allowing for a variety of points of view. Interestingly, perspectivalism appears not to be confined to meta-level considerations of physical theories and their interpretation. It seems to have a counterpart in the physical descriptions themselves. Recent foundational studies suggest that the descriptions of physical systems provided by quantum theory are perspectival in the sense that they are defined relative to reference systems. If this is correct, the physical world as described by quantum physics is fragmentized, consisting of many mutually inconsistent perspectival representations.

2 Science, Judgments, and Perspectives

It remains common to encounter the view that science is characterized by a method that allows for the logical proof of laws and theories starting from observational facts. This belief places scientific results in the same category as mathematical theorems. The idea has a long and respectable history, aligning with Aristotle's claim that humans possess a special faculty for grasping the essential nature of natural phenomena, enabling the extraction of fundamental background principles from observation. Once such self-evident axioms are established, more complex laws can be deduced through logical combination and reasoning.

The notion of an Aristotelian infallible "inner eye" was strongly challenged during the Scientific Revolution, yet empiricist ideas emerged to fulfill a similar role. For example, Newton's *Regulae Philosophandi* fostered the impression that induction, combined with careful and repeated observation, leads to indubitable general results. The development of "Inductive Logic" may have further reinforced the perception that induction is on par with systematic deductive reasoning, such as in geometry. Additionally, Kant's argument that certain fundamental aspects of natural science can be established *a priori* as necessarily true may have contributed to the idea that a unique scientific method yields certain results.

However, there has also been a long-standing resistance to the notion that scientific discovery follows a strict inductive method. Since the late 19th century, when philosophy of science became a distinct discipline, this opposition has gained prominence. In the 20th century, Karl Popper (1959) introduced his virtually method-free "context of discovery", arguing that justification, in the traditional sense of proof, is impossible. According to Popper, the only strict methodological rule scientists should follow is the principle of falsification—eliminating empirically inadequate hypotheses as swiftly as possible.

Thomas Kuhn (1962) replaced this austere view with a model that more accurately reflects scientific practice and reinstates a role for systematic inductive reasoning. However, Kuhn's methodology does not rely on rigid inductive rules; rather, it involves reasoning based on values that, while generally compelling, may be interpreted differently in concrete cases by different scientific communities. Moreover, tensions can arise between these values when applied to actual research questions, as illustrated below.

Kuhn outlined several key values for evaluating the viability of new theoretical ideas:

Accuracy: Hypotheses should precisely align with observational data.

Consistency: Hypotheses should be internally coherent and should not contradict established background knowledge.

Broadness of Scope: Hypotheses should have wide applicability.

Simplicity: Simpler explanations should be preferred over more complex ones.

Fruitfulness: Theories that lead to correct predictions in new domains should be favored over those that only explain already known phenomena.

These methodological values are general and often open to multiple interpretations. For instance, simplicity is notoriously difficult to define, and disagreements frequently arise over which of two competing hypotheses is simpler. Furthermore, different values can sometimes be in tension. Striving for maximum accuracy, for example, may increase the likelihood of conflicting with existing background knowledge. Likewise, if simplicity is interpreted as avoiding unnecessary theoretical elements, it may conflict with fruitfulness—indeed, historical scientific developments often made use of quantities that were previously not needed. A case in point is classical electrodynamics: while it can make all its empirical predictions using only the electromagnetic fields $\boldsymbol{E}$ and $\boldsymbol{B}$, the introduction of potentials A and φ—seemingly superfluous—proved crucial for the development of quantum electrodynamics.

The role of values in scientific reasoning has become a central topic in contemporary philosophy of science. A widely discussed issue is the "underdetermination of theories by empirical evidence", where multiple theories or research programs are equally compatible with available data. In such cases, theoretical virtues like simplicity, parsimony, and explanatory power necessarily play a crucial role in assessing their relative merits (Acuña and Dieks 2014). This issue is particularly pressing in modern high-energy physics and cosmology, where limitations to what can be observed pose significant challenges.

Thus, in high-energy physics, advancing empirical research requires probing elementary particles with ever-higher energies. However, the particle accelerators needed for such investigations are becoming impractically large, with breakthrough energy scales soon demanding accelerator sizes exceeding Earth's radius. Similarly, in cosmology, observational limitations arise due to the vastness of the universe and the constraints imposed by the speed of light. Since information cannot travel faster than light, certain parts of our expanding universe are forever beyond our observational horizon. Some philosophers of science even propose that, given these obstacles, modern physics may need to embrace a more rationalist methodology, where theoretical virtues take precedence over empirical data (Dawid 2013).

Judgments that weigh competing values are thus becoming even more central to scientific methodology. While perspectives on the relative importance of these values may be personal, they often align with different sub-communities within the scientific field, leading to diverging opinions on the viability of theoretical frameworks and research directions.

A similar situation arises in the interpretation of scientific theories. The example of the ongoing debates surrounding the interpretation of quantum mechanics provides a good illustration of the broader nature of interpretative disagreements. The fundamental question in interpretative debates is: given the mathematical formalism of a scientific theory and its empirical predictions, what is the most plausible picture of reality—including the unobservable—that accords with the theory?

Generally, multiple answers to this question can be given, depending on how different values—such as visualizability, coherence, simplicity, practical usefulness and consistency with other theories—are prioritized. Moreover, the importance attached to the decision to adopt a realist rather than an instrumentalist stance evidently plays a major role in the ensuing debates.

A brief look at some interpretations of quantum mechanics highlights the significance of these values. The standard (textbook) interpretation, for example, adopts a pragmatic approach, focusing on predicting the statistical outcomes of macroscopic measurements without delving into the nature of measurement itself. This standard interpretation says that measurements are ruled by a special principle (the "collapse of the wavefunction") that generates a definite measurement result; each possible result having a probability of occurring that can be calculated with the mathematical machinery of quantum mechanics. Although this textbook interpretation usually employs realist terminology (it speaks about atoms, protons, electrons, and so on), it remains vague about the nature and properties of these "quantum systems" outside of measurement contexts.

Alternative interpretations challenge the standard view for its lack of a coherent physical picture that can explain what is going on "behind the scenes of observation". The interpretation proposed by Bohm (1952), for example, seeks to rectify this by postulating that quantum mechanics is a theory about particles in the classical sense, namely visualizable microscopic objects with definite positions and trajectories. In this framework, the mathematics of quantum mechanics is interpreted as a formalism that describes how the "Bohm particles" move. In this scheme there is no special role for measurement: measuring devices consist of quantum particles, which interact with the particles composing the objects on which measurements take place. The outcome of a measurement then corresponds to some ordinary physical quantity, like the position of a pointer on a dial. This property is completely determined by the positions of the particles that together constitute the pointer. So, no special principle is needed to generate a definite measurement outcome.

The Bohm scheme is coherent, visualizable, and empirically adequate, but proves to conflict with the special theory of relativity. It turns out that the existence of a privileged inertial frame of reference must be assumed to make the Bohm scheme consistent, and this is at odds with Einstein's principle that all inertial frames are equivalent. An interpretation that does not face the latter problem is the many-worlds-interpretation (e.g., Wallace 2012): this interpretation does not introduce permanently localized particles (these were responsible for the difficulty with special relativity in the Bohm interpretation). Like the Bohm theory, the many-worlds-interpretation does not invoke a special evolution principle that is solely applicable to measurement: there is no collapse of the wavefunction. But now a new problem arises: the formalism does not predict a definite measurement outcome, since all possible outcomes remain represented in the superposition of the uncollapsed post-measurement wavefunction. The many-worlds-interpretation deals with this situation by assuming that after a successful measurement different worlds exist, each characterized by one particular measurement outcome.

While this interpretation may be argued to remove some *ad hoc* elements, it raises concerns about visualizability (e.g., of the splitting of one world into many worlds), simplicity (more worlds seem to be introduced than what is needed to account for our observations), and coherence (evolution without collapses is deterministic, which seems difficult to square with the probabilistic nature of quantum mechanics). However, many-worlds proponents argue that the simplification due to the elimination of arbitrary postulates is more important. This illustrates our earlier comment on the ambiguity of the notion of simplicity.

The debates on the interpretation of quantum mechanics illustrate that, as with scientific discovery and justification, interpretative frameworks are shaped by values and perspectives. Different scientists and sub-communities may prioritize different theoretical virtues, leading to diverse preferences. The ongoing plurality of interpretations in quantum mechanics underscores that such divergence is not merely a theoretical possibility but a reality in scientific practice.

Diversity of opinions extends to broader epistemological issues. For example, conceptions of what constitutes understanding-providing explanations are non-universal and value-dependent. Are, for instance, simplicity and unificatory power essential for generating understanding, or are causal mechanisms and visualizability indispensable? As de Regt (2017) argues, different scientific sub-communities may employ different sets of conceptual tools to provide explanations and attain understanding in different ways.

Furthermore, even the aims of science are subjects of debate. Should science aim to represent reality as it truly is (the realist position)? Should it be satisfied with empirical adequacy and constructing images of how reality *could* be, as van Fraassen (1980) suggests? Or should science renounce the goal of coherently representing unobservable reality altogether, as instrumentalists propose? Each of these positions can be defended rationally and consistently, based on differing values, perspectives, and judgments.

3 A fragmented world

The scientific community can therefore be seen as a collection of individuals and sub-communities that differ in their values and judgments regarding methodological issues and interpretations. This diversity creates a methodological landscape that is fragmented rather than monolithic. Such a conclusion may be considered hardly surprising—perspectives shape many human activities, so why not even the "hard sciences"? Moreover, science also certainly exhibits a lot of consensus, leading to a body of generally shared empirically adequate and, in this sense, objective and universal theories (leaving aside, for a moment, different "metaphysical" interpretations). So, the perspectivalism that we have discussed may be judged to be non-radical.

Remarkably, however, a much more radical form of fragmentation has been proposed in recent decades—one that applies not to scientific methodology and human preferences, but to physical reality itself. According to this view, the physical world may be objectively perspective-dependent. That is, the properties of physical objects and processes may be inherently relational, defined only in reference to other systems, independent of human judgment.

This notion of a fragmented reality was introduced by philosopher Kit Fine (2005), who suggested it as a way to rethink traditional debates about time and tense. The idea has since been further developed by Lipman (2015, 2016, 2020). The core of fragmentalism is the claim that reality is not a single, unified whole consisting of mutually compatible facts but rather a collection of distinct fragments. Each fragment contains internally consistent facts, yet different fragments may be mutually incompatible. Thus, no single, overarching description of reality is possible; instead, the totality of all fragments is needed for a complete account of the world.

As mentioned, one suggested application of fragmentalism is the nature of time: accordingly, each instant in the history of the universe should be viewed as defining a distinct fragment of the total world, namely the world at that instant. Another possible application is the special theory of relativity, where different reference frames provide equally real but differing accounts of distances, durations, and simultaneity (Lipman 2020). According to the fragmentalist view, these variations are not mere appearances but instead define different, self-consistent fragments of reality.

However, both of these applications face the objection that an alternative, unified description exists. The history of the world can be represented as a four-dimensional "block universe", and relativity naturally describes reality as placed in four-dimensional Minkowski spacetime. In these formulations, all facts are mutually compatible, and perspective-dependent facts can be derived from a single, coherent structure. This weakens the argument for treating fragments as fundamental.

The situation changes, however, when quantum mechanics is considered as a potential application of fragmentalism. An increasingly popular view holds that quantum properties are inherently relational—implying that a system's description should always be relative to another system that serves as a reference system. This idea, and its implications, will be explored in the next two sections.

4 Wigner's friend

The Nobel Prize-winning physicist Eugene Wigner (1961) introduced a thought experiment—now known as the Wigner's Friend scenario—that illustrates the naturalness of perspectivalism in quantum mechanics. In its standard formulation, the experiment involves two agents: Wigner and his friend. The friend is inside a hermetically sealed laboratory, where she measures a quantum particle, while Wigner remains outside, isolated from the events within. However, Wigner knows the initial quantum state of the laboratory and can use quantum mechanics to predict its evolution. According to standard quantum theory, the state of an isolated system (its wavefunction) evolves deterministically via the Schrödinger equation.

The quantum particle measured by Wigner's friend is in a quantum state in which there are two possible outcomes, o_1 or o_2, each with an associated probability. In more detail, the particle is in a state that is a "superposition", $c_1 |o_1\rangle + c_2 |o_2\rangle$, with c_1 and c_2 numerical coefficients, and $|o_1\rangle$ and $|o_2\rangle$ quantum states in which the first and the second possible outcome, respectively, are certain to be found. Now, textbook quantum mechanics tells us that Wigner's friend, upon performing her measurement, will register either outcome o_1 or outcome o_2, and that the particle's state will accordingly *collapse* either to $|o_1\rangle$ or $o_2\rangle$. After the measurement, Wigner's friend will attribute the value that she has found as a definite property to her particle. For example, if the particle is initially in a superposition of "spin up" and "spin down", the particle has the definite property "spin up" after the measurement outcome "up". This can be empirically verified via follow-up spin measurements: these will all have the outcome "up".

However, Wigner is outside and has not performed a measurement. He must therefore describe everything that went on inside the laboratory by means of the Schrödinger equation, without collapses. This will lead to an "entangled state", namely $c_1 |o_1\rangle |F_1\rangle + c_2 |o_2\rangle |F_2\rangle$ for the combined system of Friend and particle, where $|F_1\rangle$ and $|F_2\rangle$ are states in which the Friend has registered outcome o_1 or o_2, respectively. In this state of Wigner's friend plus particle, both possible outcomes coexist in superposition (the situation is analogous to that of the famous Schrödinger cat paradox, in which there is a superposition of a state according to which the cat lives and a state in which the cat has died). The presence of this entangled state implies that neither the friend nor the particle has a definite property associated with a single outcome. Rather, the states of the friend and the particle are "mixed", containing components of both possibilities. Technically, the states are density operators obtained through "partial tracing", representing *improper* mixtures (as opposed to *proper* mixtures that represent our ignorance about which outcome is actually present).

The important conceptual point is that after the measurement, the external observer describes the particle and the other contents of the laboratory in a way that is inconsistent with how the internal observer describes them. Crucially, the external description in terms of the superposition of the two possible internal outcomes, is not subjective in the sense of being due to a lack of knowledge of what the internal observer found. The external observer can perform a measurement on the sealed laboratory that verifies the correctness of assigning a superposed state. His description therefore corresponds to a *physical fact*. If the external observer would instead use a description of the laboratory that implies that one of the two results has become definite in the measurement, while adding that he does not know which one has actually been realized, his predictions would be incorrect.

In his original article, Wigner (1961) attempted to remove the apparent conflict between the internal and external descriptions by postulating a special role for *consciousness*: he assumed that a collapse takes place, as an objective physical event, as soon as the first *conscious* observer performs a measurement. On this assumption, the friend's measurement collapses the state also from Wigner's point of view, so that Wigner is forced to abandon the collapse-less Schrödinger equation. Both Wigner and his friend must in this case describe the post-measurement situation with a collapsed state, so that the inconsistency disappears. However, as many commentators have argued, this maneuver replaces the original problem by even deeper problems relating consciousness. What counts as consciousness? How should consciousness interact with the material world?

We mentioned above that the use of a collapsed state by the external observer leads to predictions that are incorrect, and this by itself should of course decide the issue. However, a word of caution is in order here: An experiment with an external observer performing a quantum measurement on a sealed laboratory with a conscious being inside has never been performed. So, the inadequacy of the collapsed state in such cases has not been tested directly. However, experiments with semi-classical objects suggest that there is no limitation to the applicability of the superposition principle, and inductive reasoning on this basis makes the occurrence of collapses unlikely. This, together with the unresolved questions concerning consciousness, make Wigner's solution unattractive.

An alternative resolution, proposed by Ghirardi, Rimini, and Weber (1986), replaces the role of consciousness with spontaneous objective collapses occurring as part of natural physical processes. In their theory, collapses of the wave function occur spontaneously and randomly, with a very small probability at the (sub)microscopic level; but this probability grows with the number of particles involved and becomes virtually 1 in the case of macroscopic systems. In the Wigner's friend case it would accordingly be practically certain that the friend's macroscopic measurement induces a collapse. Wigner's collapse-free calculations with Schrödinger evolution would therefore lead to incorrect results. This GRW theory of objective collapses is different from quantum mechanics, though, since it predicts the near impossibility of macroscopic superpositions. This seems to contradict recent empirical results. As far as present evidence goes, there is no sign of a failure of the standard quantum mechanical predictions, which allow macroscopic superpositions---even if they are difficult to detect because of so-called decoherence processes. Since no evidence currently supports GRW-like deviations from quantum theory, and since we are interested in the question of how quantum mechanics may describe the physical world, we will not pursue the GRW-approach further.

Another escape route from the inconsistency is to deny the universal validity of quantum mechanics. If quantum mechanics does not apply to macroscopic systems, then Wigner cannot assign a quantum state to the macroscopic laboratory. It sometimes is suggested that the founding fathers of quantum mechanics believed that there exists a dividing line in Nature, on one side of which quantum mechanics is valid, with classical physics obtaining on the other sides. This suggestion is not infrequent in the older literature. However, modern historical scholarship opposes this interpretation of the views of pioneers like Bohr, Heisenberg and von Neumann. These physicists had no qualms about using quantum mechanics for describing the behavior of macroscopic objects. Relevant here is the doctrine of the arbitrariness of the place of the "cut" between classical and quantum descriptions: according to von Neumann (1932) this "cut" can be pushed arbitrarily far into the macroscopic world, a view that was also defended by Heisenberg (Bacciagaluppi and Crull, 2009). Macroscopic devices may therefore certainly be treated quantum mechanically, and there is no boundary to the applicability of quantum theory to the physical world. For a concrete illustration, think of Bohr's (1949) application of Heisenberg's indeterminacy principle to a macroscopic two-slit screen, in his famous discussion with Einstein about quantum interference experiments. The cut that marks the dividing line between descriptions with quantum and classical concepts must be given an epistemic rather than an ontic status (Dieks (2016) provides more details). An important additional consideration, already mentioned several times, is that the assumption that macroscopic systems are fundamentally classical is at odds with present-day experimental physics. So-called Schrödinger cat states, i.e., superpositions of quantum states of quasi-macroscopic systems, are now routinely prepared in the laboratory. Rejecting the universal applicability of quantum theory is thus certainly not an attractive way of escaping Wigner's paradox.

We are left with the original problem posed by Wigner's thought experiment: How can the definite outcome observed within the laboratory be reconciled with the non-definiteness required by an external observer's description?

5 Quantum perspectivalism

A natural conclusion to draw from the paradox of Wigner's friend is that different observers may have different *perspectives*, according to which different quantities possess definite values (Rovelli 1996; Bene and Dieks 2002; Conroy 2012; Dieks 2009, 2019, 2022, 2025). In the concrete case of the Wigner's friend scenario, the experiment in the laboratory has a definite outcome *from the perspective of Wigner's friend*. Moreover, from the friend's perspective, after the measurement the measured particle is characterized by a definite property corresponding to the outcome that was found. By contrast, *from Wigner's perspective* there is no definite result of the experiment. From Wigner's viewpoint the entire lab, including his friend, the particle and the devices used in the experiment, should be described with a superposed quantum state in which all possible outcomes are represented. The properties that Wigner assigns to the laboratory should be in accordance with this superposed state. In technical terms: for Wigner only those physical quantities are definite whose representative operators have the superposed lab state as an eigenstate. This leads to a property attribution that is different from the one applicable to Wigner's friend. The contradiction between internal and external descriptions is thus dissolved: the two descriptions are not absolute but relative to a perspective, and these perspectives are different in the two cases.

So, we arrive at a perspectival interpretation of quantum mechanics, in which the internal perspective in the laboratory differs from the external perspective. This interpretation follows the mathematical structure of no-collapse quantum mechanics (so-called unitary quantum mechanics) in a natural way. Indeed, in the post-measurement state $c_1 |o_1\rangle |F_1\rangle + c_2 |o_2\rangle |F_2\rangle$, the states of Wigner's friend in which she has registered either the outcome o_1 or o_2 are correlated with particle states belonging to exactly that same outcome, and the interpretation says that these "relative particle states" represent her perspective once she has registered one of these outcomes. In contrast, the state of Wigner and the laboratory, before Wigner has made any measurement, can be written as $(c_1 |o_1\rangle |F_1\rangle + c_2 |o_2\rangle |F_2\rangle) |W\rangle$, so that Wigner is correlated with the complete superposed laboratory state. So, reasoning in the same way as in the case of the friend, this superposition is his relative state. It represents his perspective and the physical properties he must attribute to the laboratory and its contents.

In the Wigner's friend scenario two humans make measurements and become aware of outcomes, and for ease of expression we have referred, when talking about the different perspectives, to "points of view". This could create the impression that we are discussing ordinary perspectives or subjective viewpoints, of the kind that occur in daily experience. For example, when we walk around an object, we view that object from different angles, and these angles correspond to different perspectives in the everyday sense. Perspectival views of this kind, however, can be reduced to absolute ("monadic") properties of the object and the observer, respectively. Indeed, given the position and the dimensions of the object, and the position of the observer, the corresponding perspectival description is completely fixed. So, according to classical physics, perspectives are not fundamental but secondary, in the sense of derivable. Fundamental quantities, by contrast, are monadic, both according to classical physics and everyday experience: they represent properties possessed by an object independently of whether it is observed or not, and independently of the presence of other objects. Paradigmatic quantities of this kind are mass, charge, length, height and width. Relational quantities in classical physics are reducible to monadic properties of this kind; for example, if John is *taller* than Pete, this is due to the fact that John's *length* is greater than Pete's.

The quantum perspectives that we are introducing here are very different: they are not derivable from monadic physical properties. The perspectivalism that we are introducing here does not suppose that the particle in the laboratory of Wigner's friend has well-defined properties in itself from which the two perspectival descriptions can be derived. The opposite is the case: the descriptions are irreducible perspectival, in this case with respect to the observer in question.

So, summing up, according to quantum perspectivalism (Dieks 2022, 2025) properties of quantum systems are not monadic but relational, defined with respect to another system. In order to determine such perspectival properties, one needs to determine the total quantum state involving both the object system and the reference system (as illustrated by the example of Wigner's friend). The perspectival properties are encoded in this total state through the relative states of systems with respect to other systems.

It is important to emphasize that the perspectives, thus defined, are objective and have nothing to do with whether or not conscious observers are present. Therefore, one could reformulate the story of Wigner's friend without referring to Wigner, his friend, or other humans. If Wigner and his friend are replaced by inanimate detection devices, the analysis and its conclusions will not change. In this case the perspectival properties are defined with respect to the detection devices. The above formulas for total states and the relative states derived from them remain the same in this case. But $|F\rangle$ and $|W\rangle$ will now refer to, e.g., detection devices. In general, quantum perspectives can be defined relative to any physical system.

Quantum perspectivalism requires a major revision of our thinking about physical objects. In classical physics, and according to common sense, the physical quantities that characterize an object are determined by the nature of the object itself, independently of observers or contexts. Relational properties (for example, mutual distance) are derivable from these absolute properties (e.g., relative distances are derivable from absolute positions). It follows that the *values* of classical relational quantities may vary with perspectives, i.e., frames of reference or observers. For example, for a co-moving observer the velocity of an object vanishes, whereas this velocity has a non-zero value for other observers. But it also follows that it will never happen, in classical physics, that for one observer velocity is an applicable notion, while it fails to be so for others. Quantum perspectivalism breaks with this traditional way of conceptualizing objects and their properties. It proposes a quite general perspective-dependence of the applicability of concepts, according to which different quantum perspectives cannot be glued together to form one encompassing consistent picture. Indeed, according to quantum perspectivalism the physical world itself is *fragmented*, consisting of mutually conflicting perspectives.

6 Summary and conclusions

Recent philosophy of science has increasingly recognized the role of value-laden perspectives in various contexts, such as scientific heuristics, the evaluation of new hypotheses, the merits of different types of explanation, and debates on the ontological interpretation of scientific theories. While rational discussion remains possible, values shape the premises of these debates. Differences in the relative importance assigned to such values often lead to multiple, equally respectable perspectives, challenging older views that saw science and scientific progress as governed by a fixed, rigorous method.

Remarkably, a similar shift has emerged within fundamental physics, moving from absolute, monadic descriptions of physical systems to fundamentally relational and perspectival accounts. This perspectivalism aligns well with the mathematical structure of no-collapse quantum mechanics, where the properties of physical systems can be defined relative to other systems (reference systems). According to perspectivalism, instead of asking whether an object possesses a particular property, one must specify a reference system: *Does it have this property with respect to that system?*

According to quantum perspectivalism, different perspectives generally cannot be combined into a single, overarching view. Instead of reconciling them in a classical manner, one must rely on the mathematical formalism of quantum mechanics to assign properties relative to different reference systems—illustrated, for example, by the Wigner's friend paradox. However, while this perspectival incompatibility is revolutionary, it does not eliminate classical notions of objectivity and truth. Within any given perspective, measurement outcomes and descriptions remain objectively valid, accurately reflecting actual states of affairs—though these states of affaires are themselves perspective-dependent. So, the for science essential difference between true and false statements remains in place: true statements refer to actual facts, false statements don't. It is correct that facts themselves become perspectival, but this does not entail a breakdown of realism or objectivity.

Within each perspective a consistent picture of the world can be presented. By contrast, facts from different perspectives will often be incompatible with each other, so that the total world is fragmented, in the sense of fragmentalism. Nevertheless, there exists a certain order governing these fragments, which is encoded in the total quantum state. This peculiar combination of a fragmented collection of facts and an overarching abstract principle deserves further analysis.

References

Acuña, P. and Dieks, D. (2014) "Another look at empirical equivalence and underdetermination of theory choice", *European Journal for Philosophy of Science*, 4:153–180.

Bacciagaluppi, G. and Crull, E. (2009) "Heisenberg (and Schrödinger, and Pauli) on hidden variables", *Studies in History and Philosophy of Modern Physics*, 40: 374–382.

Bene, G. and Dieks, D. (2002) "A perspectival version of the modal interpretation of quantum mechanics and the origin of macroscopic behavior", *Foundations of Physics*, 32: 645–671.

Bohm, D. (1952) "A Suggested Interpretation of the Quantum Theory in Terms of 'Hidden' Variables", *Physical Review*, 85: 166–193.

Conroy, C. (2012) "The relative facts interpretation and Everett's note added in proof", *Studies in History and Philosophy of Modern Physics*, 43: 112–120.

Dawid, R. (2013) *String Theory and the Scientific Method.* Cambridge: Cambridge University Press.

De Regt, H. (2017) *Understanding Scientific Understanding.* Oxford: Oxford University Press.

Dieks, D. (2009) "Objectivity in perspective: Relationism in the interpretation of quantum mechanics", *Foundations of Physics*, 39: 760–775.

Dieks, D. (2016) "Niels Bohr and the formalism of quantum mechanics", in Faye, J. and Folse, H. J., eds., *Niels Bohr and the Philosophy of Physics; Twenty-First-Century Perspectives.* London: Bloomsbury Academic, 303–334.

Dieks, D. (2019) "Quantum Mechanics and Perspectivalism", in Lombardi, O., Fortin, S., López, C. and Holik, F., eds., *Quantum Worlds. Perspectives on the Ontology of Quantum Mechanics.* Cambridge: Cambridge University Press, 51–70.

Dieks, D. (2022) "Perspectival Quantum Realism", *Foundations of Physics,* 52: 95.

Dieks, D. (2025) "Radical Perspectivalism, Locality and Relativity", *Foundations of Physics*, 55:30.

Fine, K. (2005) "Tense and Reality", in *Modality and Tense: Philosophical Papers.* Oxford: Oxford University Press, 261–320.

Ghirardi, G. C., Rimini, A. and Weber, T. (1986). "Unified dynamics for microscopic and macroscopic systems", *Physical Review D*, 34: 470–491.

Kuhn, T. (1962) *The Structure of Scientific Revolutions.* Chicago: University of Chicago Press.

Lipman, M. A. (2015) "On Fine's fragmentalism", *Philosophical Studies*, 172: 3119–3133.

Lipman, M. A. (2016) "Perspectival Variance and Worldly Fragmentation", *Australasian Journal of Philosophy*, 94: 42–57.

Lipman, M. A. (2020) "On the fragmentalist interpretation of special relativity", *Philosophical Studies* 177: 21–37.

Popper, K. (1959) *The Logic of Scientific Discovery.* London: Hutchinson & Co.

Rovelli, C. (1996) "Relational Quantum Mechanics", *International Journal of Theoretical Physics*, 35: 1637–1678.

van Fraassen, B. (1980) *The Scientific Image.* Oxford: Oxford University Press.

von Neumann, J. (1932) *Mathematische Grundlagen der Quantentheorie.* Berlin: Springer. English translation (1955): *Mathematical Foundations of Quantum Mechanics.* Princeton: Princeton University Press.

Wallace, D. (2012) *The Emergent Multiverse.* Oxford: Oxford University Press.

Wigner, E. (1961) "Remarks on the mind–body problem", in Good, I. J., ed., *The scientist speculates.* New York: Basic Books, 284–302.