ON THE CONCEPT OF REALNESS 

The nature of reality has been a preoccupation of philosophy from time immemorial. Here I explore rather the *concept of realness*. Beauty may be in the eye of the beholder, and truth may be a matter of debate. We say, casually, that people live in different realities, usually meaning that they experience *the* reality differently. But what can be said of realness itself: as a property of things in the objective external world or as the attribution of a subject, a quality of phenomenal experience?

## (A). What is realness?

I propose that, whatever else it means, realness is a category of experience, in the Kantian sense that space and time are *a priori* categories into which human perception is necessarily pre-cast. In modern times, this can be understood in genetic and biological terms. We experience the world as real because we simply wouldn't be here otherwise. Through natural selection, realness has come to imbue our experience of the external world, which holds over us the power of life and death. Being able and compelled to experience the world as real is a survival tool. In other words, the experience of realness is our perceptual way to acknowledge, with due respect, the power that the external world holds over us.[1] In that sense, realness is a subjective *quality* of phenomenal experience (call it $R_S$), a judgment of the mind. This quality implicitly expresses the dependent *relationship* of the organism to its world. It may or may not refer to an actual *property* of existence in that world (call it $R_O$).[2]

Of course, putting things that way is somewhat paradoxical. For, the very meaning of the real is that it has an existence independent of the subject. Even *as* subjective experience, $R_S$ normally tracks $R_O$, so that realness must certainly also be considered a property of things that are held to exist apart from the subject's perceptions. Realness is thus ambiguously both a property of the world and a property of our experience—both a property of things and a quality with which we imbue the experience of those things. These two ways of considering realness reflect two fundamental modes of cognition. Our primary mode is outward looking ($R_O$). We are natural born realists, whose biological focus is the external world. This condition results from being an organism, dependent on its environment. Just as it is natural and necessary to view many objects of attention as real and external, so it is understandable to evolve a concept of objectivity, in which the world is conceived to exist and have certain properties regardless of how it is perceived by any subject. On the other hand, our secondary mode is inward looking, to consider objects of attention to be products of our own neural processing ($R_S$).

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[1] Just as pain is our perceptual way to acknowledge tissue damage and sweetness is our perceptual way to acknowledge the nutritional benefit of sugar.

[2] If *R* is the set of all real things, the property of 'realness' is the *intension* (definition) of that set, which must be satisfied to belong to the set; in contrast, we can say that 'reality' is the *extension* of that set, consisting of the things that satisfy the definition. In every cognitive domain, including science, there are criteria to decide which things are real. In the domain of perception, the sensory experience itself of realness is the judgment that the criterion in that domain is met.

At this point I would like to introduce a notion I call the Equation of Experience. This is simply the common-sense idea that all experience, thought, and action is a co-product of subject and object.[3] Self and world are entangled as co-determinants of our experience, our thought, and our action. This fact is the origin of many human dilemmas, which perennially involve trying to distinguish the influences that come from within from those that come from without. In a given situation, to what extent is our behavior subjectively motivated and to what extent is it objectively justified? Does the world determine our experience or do we determine our experience of the world? The fact that we can pose such questions presumes an ability to view perception not as a transparent window on reality but as a subjective inner domain, a creation of the mind, a manifest show. Husserl called this the ability to "bracket" experience *as* experience. These two modes are complementary. They give us the capacity to monitor the world (including one's body as part of the world), and also the capacity to monitor our monitoring. The ability to perceive the world as real gives us naïve realism. As self-conscious beings, we have the further ability to question our perceptions, and even to question the questioning. This enables us to look before we leap, which is a handy ability for an intelligent social creature.

If subject and object are thus entangled, and experience is their co-product, how can we know reality independent of the subject? The answer is that we cannot. For creaturely reasons, we are in the (naively realist) habit of ignoring the mediacy of $R_S$ in order to *assume* the objective truth of $R_O$. While it serves us biologically to treat experience as a transparent window on the world, all that we are actually entitled to believe is that $R_S$ *tracks* or *maps* $R_O$ in a way that permits our existence.

All this would be quite academic if it remained a mere abstraction. But there are instances of this confusion of $R_S$ with $R_O$ that make a difference in life as well as in formal thought—and even in science. The common dilemma of having to sort out subjective from objective considerations in daily dealings applies to everything from negotiating personal relations, to labor disputes, to judicial arguments and international treaties. It is a growing challenge to interpret and evaluate information in news and social media. We need to understand where others are coming from, what animates ourselves, and what might be the intersubjective concerns that form a common ground of mutual interest, a consensus that can serve as the focus of cooperative problem solving.

In many ways, science purports to operate according to that ideal. Yet, science is hardly immune to confusions surrounding the distinction between subject and object, especially since it was founded on the principle of excluding the subject from its accounts of the world. In terms of the Equation of Experience, scientific method attempts to hold constant the subjective "variable" in order to examine how experience (observation/measurement) varies as a function purely of the object.[4] That is, by standardizing the subject and the experimental protocol, the idiosyncrasies of the individual observer are eliminated from the account of nature. Yet, there may remain deeper factors influencing observers in common, which elude this principle of excluding the idiosyncratic. We have a common biology as human beings, and hold common cultural assumptions and values as a scientific community. It is meaningful to ask what these commonalities themselves may impose on the scientific portrait of nature. This means identifying and questioning tacit assumptions and operating principles—such as, for example: the principle of 'sufficient reason', the 'identity of indiscernables', reification, deductionism,

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[3] This relation might be expressed symbolically as $E = f(s,o)$

[4] $E= f(o) = R_O$

determinism, mathematization, concepts of order and of probability, the principle of *ceteris paribus*, various guidelines for premise selection, even historical concepts nature itself. Let us further examine these points.

(B). Tacit collective assumptions behind the objectivity of science

1. *Reification* is a psychological action that satisfies a need to organize perception in terms of discrete objects or material substances. Processes and relationships are thereby conceived as *things*, and issues are framed in ontological rather than epistemic terms.

Ordinary experience on the human scale is naturally extended, at least metaphorically, to phenomena that lie outside that range of experience. Since ordinary experience is normally focused on the real external world, realness is often extended to phenomena that are not literally visible but which we can imagine seeing. (Thus, we may picture atoms as tiny solar systems.) Realness implies a substantiality that consists in the capacity of things to act causally upon other things and be acted upon. In science, this properly means that what is real must be able to interact causally with the observer. But because realness is also a quality we can assert, something hypothetical can be considered real though we *can't* interact with it—for example, the *multiverse* (the notion of "other universes"). It is easy enough to forget that theoretical constructs are acts of imagination.

The very idea of "interaction" presumes the realness of interacting elements ($R_O$). This is in contrast to a more epistemic or operational view, which focuses instead on the results of observation ($R_S$). An observation, in turn, may be pictured as an interaction of an instrument with the real system observed. But, this interpretation presumes the theory being tested. Alternatively, an observation could simply mean a data point. This distinction becomes increasingly important as the train of inferences from data to conceptualized reality becomes ever more complex and tenuous. The interpretation of many modern astronomical observations, like those of high-energy experiments, involves numerous assumptions. In both cases, results have only a statistical certainty. $R_O$ bears *some* relationship to $R_S$, but it is by no means direct and straightforward. The distinction remains crucial in quantum theory, where it was controversial from the start. Should the wave function be considered a tool to predict the macroscopic (visible) results of experiments, or does it describe an invisible microscopic reality? Does it describe the state of a real system or the state of our knowledge?

2. The *principle of sufficient reason* suggests there should be an answer to every reasonable question about why the world is the way it is. This was the faith at the core of Einstein's objections to the quantum theory as incomplete. The success of this faith in familiar realms, however, bears no guarantee of success in unfamiliar ones. Similarly, the *identity of indiscernables* depends on the possibility to enumerate all properties or relations pertaining to the elements of a real system. However (as we shall see below), an unequivocal list of defining properties or relations is only possible within a *deductive* system (a model). It is misleading, if not false, to assume that specified factors in a theory (such as the variables of a differential equation) exhaustively represent the real properties of a natural system. It may be that the physical variables of a theory are neither exclusive nor exhaustive, or do not even pick out clearly identifiable real properties. *Defining* them mathematically, on the other hand, *renders* them definite and seemingly comprehensive. Leibniz' two principles already assume that the

natural world *is* a deductive system; they express an expectation that nature corresponds to our models.

3. *Deductionism* is the credo that nature can be formally modeled, even exhaustively, by defined constructs. Deductionism reduces reality to a product of definitions, a formalism, effectively a machine. This is the basis of the philosophy of mechanism, since a machine is conceptually a deductive system. While such things are human artifacts and not found in nature, their appeal lies in appearing to promise a clear and complete account. The perennial dream of a completed theoretical science—a theory of everything—assumes that physical reality is finally exhaustible in thought; that there must be a bottom to the complexity of nature and an end to inquiry about the fundamentals, if not the details, of physical reality. It assumes that the world *is* something definite (with, for example a calculable information content), which can be fully captured in mathematical expressions.[5]

4. *Determinism* is the basis of the mechanist philosophy, and of the hope to predict all natural phenomena or events from first principles. A deterministic system is one where an input of parameter values leads to a definite output. If you know the state of the system at one time, you can in principle know it at a future *or* past time. Deterministic systems are "reversible" simply because their equations are time-reversible. However, this time reversibility of *equations* does not imply that the real systems they model are dynamically reversible, much less that time itself can run backwards. In fact, there *are* no deterministic systems in nature; differential equations describe only fictional idealizations, and most real physical processes are irreversible.

Idealization worked in classical physics because the systems studied (such as orbiting planets) are simple and relatively isolated from influences other than those few represented in the equations. Such massive systems are also not significantly disturbed by observation itself. This latter condition, especially, could no longer be assumed in the microscopic systems studied in the quantum realm. Nevertheless, the equations there are similarly deterministic by definition, even though they predict only the probable outcomes of experiments. Deductionism fosters the misleading expectation that a deeper level of causality can be found, with equations that predict precise actualities, not just statistical averages. Yet, even on the macroscopic scale, the effectiveness of equations depends on the precision of measurable inputs.

Determinism is a property of the well-defined system, a machine, a literal or conceptual artifact. Real phenomena are not such artifacts. Hence, determinism is not an objective property of physical reality but a projection of wishful thinking that works in special cases. It reflects the rational expectation that the world can be understood and precisely mapped, as proposed in the principle of sufficient reason. Determinism applies to the model, not to the reality it models. While causality is traditionally considered a metaphysical (rather than logical) relationship, the states of a deterministic system are *logically entailed* rather than caused in some metaphysical sense.

5. The *mathematization* of science is by now so taken for granted that some thinkers now assume physical reality to consist literally *of* mathematics. Platonism aside, mathematics is a descriptive tool. The purposes for which the tool is used, and the syntax it imposes as the language of

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[5] This convenience may be the motivation behind the current reification of knowledge as *information*, conceived even as a new ontological basis of physics. (Since information is digital, the universe must be digital!)

science, powerfully influence our concepts of nature and relationship to it. The assumption that natural reality can be captured, in the special idealizations to which mathematics applies, is a corollary of the belief that reality can be contained in human definitions at all. There may be a scientific price to pay for such oversimplifications, as well as cultural and ecological ones.

Computerization provides a powerful new tool for science and society; it also provides the neo-mechanist metaphor for nature itself. The digital computer is the contemporary model for mind, or at least for "intelligence." The universe itself is also seen by some as a sort of computer. The digital computer is psychologically significant because it translates into technology an age-old dream to directly program reality, literally at one's finger tips. Computation reflects the architecture of human thought, which is then projected back upon physical reality as its very organization. For example, the universe appears to present discrete aspects to the observer; the *definitional* or *ideal* discreteness (embodied in the digital) is projected back upon nature as a fundamental property giving rise to that appearance. But, quantum discreteness (an empirical result and an unsolved mystery) should not be confused with, or assumed to follow from, the definitional discreteness of information (a digital concept, true by definition).

6. The concept of *order* is relative to context and history. A pile of books on the floor may appear disordered (high entropy), compared to neatly shelved books in alphabetic order. However, the appearance of order depends on the intentions and actions of agents involved. If the books had been carefully laid out on the floor according to their relevance in a research project, for example, their order in this arrangement would be more significant than if they had remained alphabetized on the shelf. Entropy, like information, is treated as an objective property of real systems, without taking into account the human aims that shape its use as a concept. But the role of information, in the ordinary sense, is to inform human agents, and entropy was originally conceived to measure the efficiency of machines, which are human constructs.

Many properties of the actual universe, far from equilibrium, appear startlingly improbable when considered as the result of a random shuffle of theoretical parameters. But this impression involves a dubious metaphor, which attempts to assimilate the complexity of the world to artificial situations such as a role of dice or shuffle of cards. Cosmologists estimate the vanishingly negligible odds that a universe supporting life could arise from "randomly chosen" values of parameters of the standard model of particle physics or the current model of cosmology. Given that there is but *one* universe, however, such calculations seem spurious; the very notion of a universe randomly generated among others is a theoretical fancy. The question of how initial conditions are "chosen" is ambiguous. It could imply some physical selection process.[6] It could equally be the theorist who specifies the initial or boundary condition, as in the running of computer simulations.

Selection by chance may be likened to the outcome of unstable equilibrium. It seems more reasonable to explain the values of fundamental parameters by looking to *stable* equilibrium—attractor states insensitive to initial conditions. Rather than an explanation designed to overcome a specious improbability, one could seek a scenario in which parameters or initial conditions tend toward the state concerned. Moreover, "parameters" must not be seen in isolation, as though they could be varied independently as in a controlled experiment; it is the total package of multiple causes that corresponds to the attractor state.

7. The principle of *ceteris paribus* ("all things being equal") evaluates effects where there are

[6] Such as Lee Smolin's black hole theory of cosmological natural selection.

multiple causes, by examining one factor at a time with others assumed constant. Experiments, of course, are *designed* to allow one factor to vary in isolation, by deliberately excluding others. Factors in a computer simulation are controllable by definition. But the universe, so far as we know, is not a controlled experiment nor a simulation. Identifiable factors may operate in concert in real self-organizing processes, so that changing one necessarily changes others.

8. While there may be an indefinite number of factors at work in the real world, no explicit meta-rule guides the *selection of basic premises*, except perhaps Occam's Razor and notions of elegance or economy. (Following Leibniz, for example, Gregory Chaitin proposes that natural laws are the most economical descriptions of the data.) Time and space are *presumed* as backgrounds in both classical and quantum physics, even for situations such as the very early universe, in which time-keeping processes could not yet exist and where extreme densities made spatial separation meaningless. It is possible to reduce the number of parameters—even to eliminate such fundamental factors as time or space from physical description—but only by introducing other concepts judged to be yet more fundamental in some discretionary hierarchy.

9. The guiding *metaphor* of science, for understanding (and imitating) nature, is still the machine, the modern version of which is the digital computer. While scientific theories or models are conceptual machines, the universe itself is not literally a machine, let alone a computer. The older metaphor of the universe as an organism has long been forgotten or suppressed, but may come back into fashion as the mechanist metaphor reaches its limits.

10. A guiding principle of the scientific revolution was the belief, within the Semitic religions, that the material world has no *immanent reality* of its own. As a divine creation, it has only the *derived* reality of an artisanal product or manufactured thing. In some religious doctrines, the very realness of things is God's doing and *not* an inherent property of the world; everything, including nature and one's own private experience, happens moment to moment by divine grace and decree. The Deists modified this article of faith to the extent that God created the world (a machine) then left it alone to follow prescribed rules until it eventually runs down like a clock (or breaks down). Newton borrowed from Plato the idea that the "system of the world" would need to have its order restored periodically by divine intervention. He also left to God whatever he could not explain by mechanical principles, such as the force of gravitation as action at a distance and the stability of the solar system. Plato's primal chaos, Newton's God-of-the-gaps, and the $19^{th}$-century heat death of the universe all implied that matter is inert, without self-organizing or self-maintaining capabilities, in fact without any power or reality of its own, but only that bestowed by its Designer.[7]

In contemporary science, the theorist replaces God as the agent who specifies the properties of the creation (i.e., the parameters of the theoretical model) and its initial state. The ultimate expression of this hubris is the notion that the universe itself is a simulation, perhaps programmed by alien scientists! It is far more plausible that the universe is self-organizing and self-maintaining, neither created by gods nor by aliens, and not necessarily decipherable by theorists.

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[7] This sentiment was not universal. To Leibniz, for example, *vis viva* (kinetic energy) was the immanent force that animates things in nature, an active power of things to affect one another—in modern parlance, the ability to do work. Newton focused rather on *vis mortua* (momentum), any change of which he considered to be the passive result of forces applied from outside the system.

11. The *agency of the scientist* is traditionally excluded in the name of objectivity. But, science no more provides a transparent window on the world than does natural perception. Like the perceptual model, the scientific model tracks or maps the external world, in ways that complement and extend ordinary cognition. In neither case is the map the territory. While every scientist knows this, it behooves us to understand the biological and cultural motivations of this map and the constraints they might impose. The scientist must be included in the scientific portrait of nature.

(C). Realness in the domain of ordinary cognition.

Scientific theory extends our vision of reality just as scientific instruments extend our sensory abilities. In the 19th century, Helmholtz inverted the metaphor by proposing that ordinary perception works, in a non-conscious way, like scientific theorizing does consciously. He called this perceptual modelling process 'unconscious inference'. The brain's job is to make sense of incoming sensory information, just as the scientist's job is to make sense of data gathered in experiment or observation. It is important to keep in mind, however, that the scientist benefits from prior knowledge derived from ordinary perception, whereas the brain is literally sealed within the skull, with only an indirect access to the external world through its sensory inputs and motor outputs. The world to the brain is a black box, whose contents must be inferred. To the scientist also, the world is a black box, even though it appears open to ordinary perception.

The situation for the brain is that it must *invent* its model of the world ($R_S$)—whether on the level of ordinary perception or of scientific theory. Either way, the brain's epistemic challenge is like that of piloting a submarine purely on the basis of instrument readings. (The unique proviso of this metaphor is that the navigator—the brain—has never been outside the "submarine," which has no portholes, hatches, or periscope!) The navigator can do no more than coordinate instrument readings with each other and with control settings, learning to move safely by trial and error. Any notion of what lies outside the hull (even the concept of 'outside' and the concept of 'moving') is an act of imagination. What validates any such notion is that it works to steer clear of menacing "objects" in such a way as to avoid damage or destruction.

Accumulated experience of what thus *works* is represented in a model that encapsulates that information. This internal model is dynamic and real-time, continually updated by new sensory data in some version of predictive processing. The model of space populated by objects is projected as real and external. That is, we do not experience the model *per se*, but the world it models, so that operating within the model is effectively operating in the world. A current metaphor for this situation is virtual reality. The brain's model of the world is a virtual reality that, for human beings at least, includes a representation of the body and the self.[8]

In this picture of the brain's epistemic circumstance, the apparent realness of the external world is a necessary by-product of the model doing its job in a way that permits survival. This success belongs not only to the individual brain but also to the species through natural selection. The fact that we are here thinking about such things attests to the cognitive adequacy of our perception. What about the cognitive adequacy of science?

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[8] In the virtual reality metaphor, an "avatar": a character appearing in the VR to represent the player.

(D). Realness in domains outside ordinary cognition.

Realness in the perceptual domain is a function of survival. Seeing the world as we do does not mean that the world "is" that way in some absolute sense, but that seeing it thus has at least not prevented our continuing existence. Can the same be said for science as an extended form of cognition? Does science seek the truth of nature, human empowerment, or something else? Will it permit our continuing existence?

It seems obvious at first blush that science has greatly aided the human species, at least as measured by reproductive success. In many ways, the median individual as a statistic also seems better off than in pre-scientific times. This apparent progress fuels enthusiasm for the benefits of technology and the ideology of progress and economic growth. However, the uneven distribution of benefits into extremes of wealth and poverty, and the environmental effects of technology, make it difficult to evaluate such "progress." Like the turkey being fattened for Thanksgiving, it is possible that we are lulled by this appearance into an acceptance that could lead to our doom. The best we can say is: so far so good.

Faith in science as a true (or at least useful) vision of reality is the counterpart of our faith in the testimony of the senses. By and large, so far both have proven reliable for "practical" purposes and reproductive success. While the brain builds realness into perception as an expression of faith in its unconscious inferences, science has other, more formal ways to assess the adequacy of its models and its conscious inferences. The existence of such protocols does not free us psychologically from the need or desire to project realness into these formal constructs, as though doing so somehow lends support to them. Borrowing the realness of ordinary things does not prove our ideas about extraordinary things. Reification of concepts is a natural tendency, which extends to objects of thought the organization of the perceptual domain in terms of literally substantial objects. But that does not prevent it from being misguided.

Are the theoretical objects of quantum theory real, in the way that we hold objects on the macroscopic scale to be real? Are the objects of cosmological theories real in that way? At both extremes of scale, we deal with things not directly perceivable with the natural senses; both involve vulnerable long chains of inference from available data. Of course, ordinary perception (which seems so tangible, direct, and reliable) also involves chains of (unconscious) inference. Our continuing existence confirms their robustness. The perceptual experience of realness reflects the tacit confidence the brain has in its unconscious inferences. Yet, these pertain largely to the macroscopic domain available to the senses, in which our ordinary interactions with the environment take place. Is the brain entitled to such confidence in its conscious constructs, when they pertain to domains beyond the senses? Should realism apply there too?

Einstein's answer was a resounding yes. The famous EPR paper effectively defines a 'real' element of a physical system to be one that can be predicted by the theoretical system with one hundred percent certainty.[9] That is, the theoretical model corresponds perfectly with at least some of the reality modelled, even if the latter is invisible or cannot be clearly conceived. This

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[9] "*If, without in any way disturbing a system, we can predict with certainty (i.e., with probability equal to unity) the value of a physical quantity, then there exists an element of physical reality corresponding to this physical quantity.*" [A. Einstein, B. Podolsky, and N. Rosen "Can Quantum-Mechanical Description of Physical Reality Be Considered Complete?" Physical Review Vol 47 May 1935 (italics theirs)] Apparently, Einstein himself was not happy about the appearance of this definition in the paper.

basically expresses faith in the principle of sufficient reason, that the human mind can exhaustively map reality.

The debate between Einstein's realism and Bohr's more positivist approach reflects the general philosophical question of whether physics describes the world itself or human knowledge about it. A description can be complete if it refers to the state of knowledge, yet incomplete if it purports to describe reality.[10] In that sense, Bohr and Einstein were talking at cross-purposes. From a realist perspective, at a given time a macroscopic object is either in the box defining a space or not. There can be no intermediate state between being there and not being there; or between an exploded and an unexploded bomb; or between a live and a dead cat. From that point of view, a description of the box's content as a "superposition" of being present and not being present is not only incomplete but nonsense. However, the "box" is an artificial imposition, nonexistent in nature. From Bohr's perspective, in the microscopic realm the best we can do is to run a series of trials in which we find that identical bombs explode on average a certain proportion of the times, cats are dead some of the times. Quantum theory describes the (statistical) type of knowledge we can have of that realm, given our macroscopic scale; it cannot be expected to describe a reality we cannot access in the familiar terms of the world we do access.

The Uncertainty Principle is not an effect of some intrinsic discontinuity in the world so much as an effect of scale: the medium of investigation is of the same order of scale as the objects of investigation. The photons of light by which we see and measure ordinary objects scarcely affect those objects, but not so for microscopic objects. This is the case whether the relative energies are thought of as discrete or continuous.[11] The ambiguity of the phenomena (wave or particle) is itself reified as the "wave-particle duality."

The classical assumption (realism) is that objects or systems have their real properties apart from how (or whether) we observe them. That simply reflects common experience, in which the world seems to be there even when we are not looking. A second measurement upon a system can be the same (or predictably different) because the first measurement did not alter the system significantly. This assumption cannot hold when the interaction itself significantly changes the phenomenon observed.

The two great revolutions of modern physics concern the medium and act of observation or measurement: in particular, the finite speed and the finite graininess of light. Both spelled the end of naïve realism in physics, of an unmediated vision of the world in which the act of observation played no physical part. Unlike in the mesoscopic realm humans had been used to, henceforth in the realms of the very large and the very small the medium of observation would play a crucial role. Yet, the general truth is that our knowledge is always mediated by some interaction. As Heisenberg famously put it: "What we observe is not nature in itself but nature exposed to our method of questioning."

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[10] Perhaps the shift in Einstein's campaign, from arguing against the consistency of the existing quantum theory to arguing against its completeness, might have been influenced by his chats with Kurt Gödel. According to Gödel's theorems, not all of *mathematical* truth can be formalized. It seems Einstein stopped short of concluding, in a parallel way, that not all of *physical* reality can be formalized.

[11] The ancient conundrum of the continuum versus the discrete is a separate issue.