Quantum physics: a tale of two world views

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The theme of this Congress is "Bridging Science and Spirituality." There is a wide spectrum of beliefs on this subject, ranging from the belief that the scientific world view is *inconsistent* with spiritual beliefs, to the belief that quantum physics *supports* a spiritual world view. This prompts me to ask: Can any scientific theory, even one as comprehensive and successful as quantum physics, either support or be inconsistent with a particular world view?

Science does not take place in a conceptual vacuum. It operates within a metaphysical framework that formulates the questions it seeks to answer, and that interprets the answers it obtains through experiment and observation. This framework is not testable by the methods of empirical science. One may adopt a materialistic framework of thought, ask questions that arise in this framework, and then try to make sense of the answers one obtains. One may instead adopt a spiritual framework of thought, ask questions that arise in *this* framework, and try to make sense of Nature's answers to *these* questions.

Therefore there is no such thing as "*the* scientific world view." Nobody can claim that his or her world view is the only world view that is consistent with the empirical data. What the proponents of a particular world view *may* claim is that the empirical data make more sense in the context of *their* metaphysical framework than they do in a different context. What I shall argue now is that quantum physics makes a great deal more sense in a spiritual framework of thought than it does in a materialistic one — but certainly not for the reasons that are usually adduced by New-Agers!

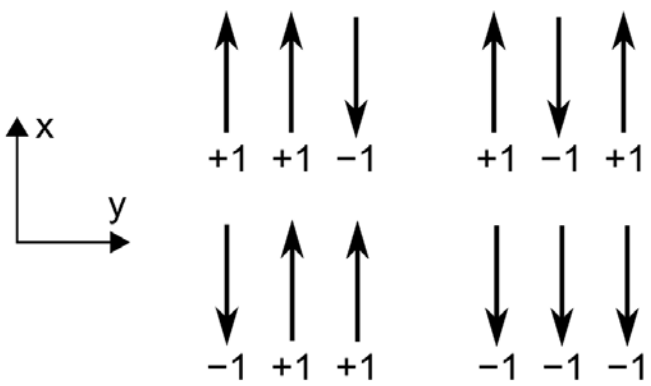
Making sense of quantum physics is one of the biggest challenges in the philosophy of science today. Not once has a reliable experiment or observation been at odds with what the theory predicts. The unsuspecting public may therefore be excused for believing that the theory's predictions are based on a model of reality, and that the accuracy of its predictions testifies to the correctness of that model. But such is not the case. The mathematical formalism of quantum physics is a probability calculus, and the events to which (and on the basis of which) it serves to assign probabilities, are measurement outcomes. The theory provides tools for calculating statistical regularities, not a model of reality that explains why the predicted regularities come out the way they do.

The crux of the matter is that quantum physics does not describe a world of interacting objects and causally related events. Yet this seems to be the only way we know how to think about the world. Just try to think about the world without thinking about interacting objects or causally related events! You can't. Hence, when we speak about the world described by quantum physics, we quite simply don't know what we are talking about.

A typical experiment performed with a quantum-physical system consists of a preparation of the system and a subsequent measurement. The language of interacting objects and causally connected events is appropriate for describing the procedures by which systems are prepared and measurements are performed, but the systems themselves can only be described in terms of statistical correlations between the various ways in which they can be prepared and the various outcomes that measurements can yield.

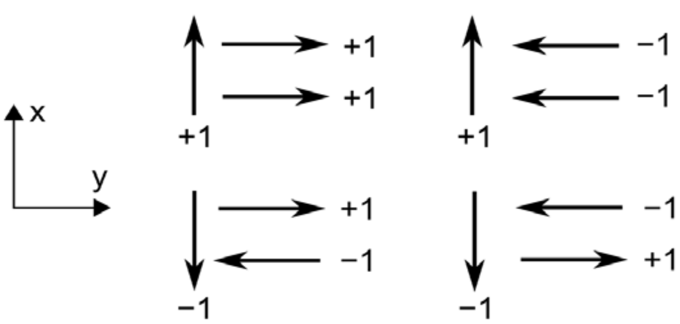
Let me illustrate this with a system containing three particles [1]. Each particle has a "spin," which is a physical quantity that can be measured with respect to any axis. There are two possible outcomes: +1 for "up" and −1 for "down" along the chosen axis. The three particles are prepared in such a way that whenever the three spins are measured with respect to the x axis, the product of the outcomes will be −1, and whenever one spin is measured with respect to the x axis and the two other spins are measured with respect to the y axis, the product of the outcomes will be +1.

Thus whenever all three spins are measured with respect to the x axis, one of these four combinations of outcomes will be obtained:



There will always be an odd number of minus signs, so that the product of the three outcomes is −1.

On the other hand, whenever one x spin and two y spins are measured, one of *these* four combinations of outcomes will be obtained:



There will always be an even number of minus signs, so that the product of the three outcomes is +1.

Let us now ask the following question: Do these measurements reveal properties that the three particles already had before the measurements were made — properties that the particles would also possess if these measurements were *not* made?

Let us assume that this is the case. The x components X_A, X_B, X_C and the y components Y_A, Y_B, Y_C of the three spins must then satisfy these four equations:

$$X_A \times X_B \times X_C = -1$$

$$X_A \times Y_B \times Y_C = +1$$

$$Y_A \times X_B \times Y_C = +1$$

$$Y_A \times Y_B \times X_C = +1$$

The first equation must hold because the product of the outcomes is −1 whenever the three x components are measured, and the remaining three equations must hold because the product of the outcomes is +1 whenever one x component and two y components are measured. But it is impossible to satisfy all four equations! To see this, we have but to multiply the last three equations with each other.

$$\begin{array}{l} X_A \times X_B \times X_C = -1 \\ \boxed{X_A \times Y_B \times Y_C} = \boxed{+1} \\ \boxed{Y_A \times X_B \times Y_C} = \boxed{+1} \\ \boxed{Y_A \times Y_B \times X_C} = \boxed{+1} \end{array}$$

$$(X_A\, Y_B\, Y_C)(Y_A\, X_B\, Y_C)(Y_A\, Y_B\, X_C) = (+1)\,(+1)\,(+1)$$

$$\Rightarrow X_A \times X_B \times X_C = +1$$

The result is the equation shown in red. Each y factor appears twice, which is to say, squared. Since each factor equals either +1 or −1, the square of each factor is +1. The y factors therefore drop out, and we are left with the result that the product of the x components of the three spins is +1.

But the first equation requires that this product be −1! The assumption that these measurements merely reveal properties that already existed before the measurements were made, thus leads to a contradiction, and therefore is wrong. These measurements do *not* reveal properties that the particles would also possess if no measurements were made. The measured spin components are created *by being measured*.

And this turns out to be true in a very general way. In the so-called quantum world, most measurable quantities — including the positions of particles, atoms, and molecules — only exist, or only have values, if they are actually measured.

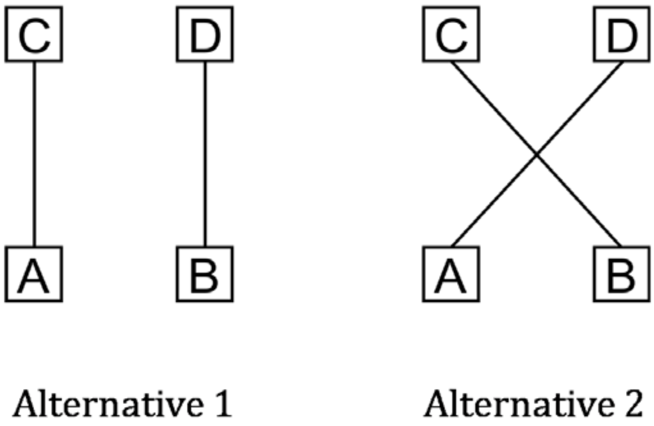
Think about what this means. If a particle detector clicks, and thereby indicates the presence of a particle in the region of space that is monitored by it, we cannot say that the detector clicked *because* a particle was present in that region. On the contrary, a particle was present in that region only *because* the detector clicked.

There is more to perplex us. If, in our three-particle experiment, we have measured either the x components or the y components of two of the spins, we can use those four equations to predict with certainty the outcome of a measurement of the x component of the third spin. If, for instance, we have measured the x components of the first two spins, X_A and X_B, the first equation tells us what the result of a measurement of X_C will be. We can do this regardless of the order in which the measurements are made, and regardless of the distances between the three particles.

How can we explain the possibility of making these predictions? It could be that the particles are prepared in a state which determines the outcome of all three measurements, or it could be that the outcomes of each pair of measurements exert an influence on the outcome of the third measurement. These are the only explanations we can think of, and neither of them works. The first is untenable because the spin components did not exist before they were measured, and the second explanation is ruled out by the special theory of relativity, which is another corner stone of contemporary physics. Bottom line: the predictions of quantum physics cannot be explained in terms of causes and effects. This means that they cannot be explained — period.

It gets worse. We tend to think that macroscopic objects like pencils or computers are made of microscopic objects like atoms or subatomic particles, and that therefore the properties of macroscopic objects depend on the properties of their microscopic constituents. But since the properties of microscopic objects only exist when they are indicated by the behaviour of macroscopic objects, this cannot be true. Macroscopic objects are not made of microscopic ones. Particles and atoms do play a role in the creation of macroscopic objects, but we need to find another way of understanding their role.

To this end, let us imagine a physical system containing just two particles [2]. At a certain time two detectors click, indicating the presence of one particles in region A and one particle in region B. At a later time another two detectors click, indicating the presence of one particles in region C and one particle in region D. There are two ways in which this pattern of clicks can come about.



Either the particle found in C is the same as the particle that was found in A, or the particle found in C is the same as the particle that was found in B.

If the two particles carry "identity tags" — properties by which they can be distinguished — then we can find out which of the two alternatives took place. We can check whether the particle found in C is the one that was found in A or the one that was found in B. But if we cannot tell the two particles apart, we have no way of knowing which of the two alternatives took place, and then it is not the case that either the first or the second alternative took place. Once again a distinction that *we* make between two possibilities is a distinction that Nature does *not* make. The particle found in C is neither a different particle from that found in B nor a different particle from that found in A.

As long as we think that particles are intrinsically distinct things, we simply cannot make sense of that kind of behaviour. But we *can* make sense of it if we accept the implication that the particles simultaneously detected in A and in B, and again in C and in D, are *one and the same* thing. Initially this is present in *both* A and B, and later it is present in *both* C and D.

We can go further. There is no reason why the identity that is revealed by the behaviour of indistinguishable particles should cease to exist when it ceases to have observable consequences owing to the presence of identity tags. What can present itself simultaneously in different places, or with different positions, can also present itself simultaneously with differences in other properties. Bottom line: Ultimately there is but one Thing, and every existing particle is this one Thing. What is ultimately real is not a multitude of particles but a single Entity, for which science has as yet no name.

This is how physics has provided the solution to a problem that Scholastic philosophers have discussed for centuries. Imagine that you have in front of you two exactly similar objects. They are completely identical, all their properties are the same, except that they are in different places. Because they are in different places, they are different objects. The problem was this: Is the fact that the two objects are in different places the sole reason why they are different objects? Or is there another reason?

If you believe that there is another reason, you will look for it in vain, for if two objects are different, it is their properties that are different, and right now we are assuming that the two objects have exactly the same properties, except that they are in different places.

On the other hand, if you believe that the two objects in front of you are different objects for the *sole* reason that they are in different places, then what you really believe is that the two objects in front of you are one and the same object in two different places, which seems preposterous.

At last, quantum physics has settled the issue. Reality *is* preposterous. The two objects are different for the sole reason that they are in different places, and therefore they are one and the same object in different places.

When I described the behaviour, first of a system consisting of three particles, and then of a system consisting of two particles, I confronted you with the predictions of *non-relativistic* quantum physics. The non-relativistic theory makes it impossible to reductively explain the properties of a composite object in terms of the properties of its parts, and it makes it impossible to think of the parts as intrinsically distinct objects, but it still allows us treat a physical system as being composed of a definite number of parts. In the complete relativistic theory, this too is impossible. Just as a particle has a position only if its position is measured, so a relativistic quantum system contains a definite number of particles only if the number of particles it contains is measured, and this number can come out different every time it is measured.

What makes it so hard to beat sense into the quantum theory is that it answers a question that we are not in the habit of asking. The question we should be asking is not how interacting parts make up wholes but how the world is *manifested*. Quantum physics requires us to distinguish between the manifested world and the manner in which this is manifested. While the manifested world fits the familiar conceptual framework of parts that make up wholes, its manifestation cannot be understood in terms of parts that make up wholes.

Let us pause at this point to ponder how the two rival metaphysical frameworks fare. If we adopt a materialistic framework of thought, we will ask: what are the ultimate building blocks? how do they interact? and how do they combine to form the objects of everyday experience? We will then have an exceedingly hard time making sense of Nature's answers. Essentially this is because Nature fails to understand our questions.

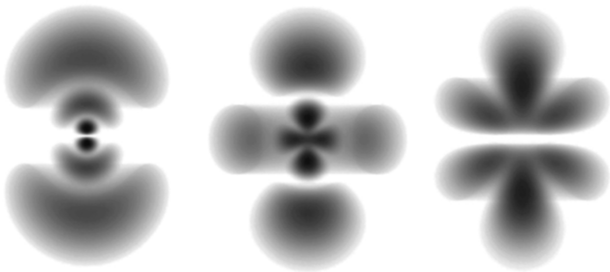
If, on the other hand, we adopt a spiritual framework of thought, we will postulate an Ultimate Reality. Because this exists independently of anything else, we may call it "Pure Being." The question we will then ask is: how does Pure Being manifest the world? And to this question quantum physics offers an exceedingly simple answer: Pure Being manifests the world by entering into reflexive spatial relations. "Reflexive" means that the relations are self-relations: Pure Being enters into relations with itself. "Spatial" means that the relations have the character of relative positions — positions that things occupy in relation to each other.

By the simple act of entering into reflexive spatial relations, Pure Being creates both matter and space. For the first result is the multitude of relations that constitute space, and the second result is a multitude of things that are related, which physicists call "particles."

Because the relations are self-relations, this multitude is apparent rather than real. Does this mean that the manifested world is unreal? Not at all, for what is instrumental in its manifestation is the multitude of *relations,* and this is real.

If these two multitudes are to manifest a particular kind of world, they must be governed by a particular set of laws. If what we want to manifest is a world of objects that take up finite amounts of space and generally behave in predictable ways, and if all we have at our disposal are reflexive spatial relations and an apparent multitude of relata, then we need to impose a very specific set of laws. And guess what? The laws that we need to impose are all the well-tested laws of physics, including those of the general theory of relativity, whose quantum-theoretic form is as yet unknown.

What is crucial for the existence of objects that take up finite amounts of space, generally behave in predictable ways, and are manifested by means of spatial relations, is that these relations are *fuzzy*.



These cloudlike images should help explain what this means. Each "cloud" represents the position of a hydrogen atom's single electron relative to the atom's nucleus. As you can see, it is indefinite or *fuzzy*.

How can the fuzziness of a position be observed? It cannot be observed by simply making a measurement. There is nothing indefinite or fuzzy about the outcome of a single measurement. But it can be observed by taking a large number of objects with identical fuzzy positions and subjecting each object to a position measurement. The fuzziness of the *prepared* position will then be revealed by the statistical distribution of outcomes that will be obtained. Where the density of the cloud representing the electron's fuzzy position is greater, the probability of finding the electron is higher.

So now you know the reason why the mathematical formalism of quantum physics is a probability calculus, and why the events to which it serves to assign probabilities are measurement outcomes. The proper way of dealing with a quantity that is indefinite or fuzzy, is to assign probabilities to the possible outcomes of a measurement of this quantity.

These images also illustrate the fact that every description of a quantum system is a description in terms of correlations between measurement outcomes. Each cloud determines the probabilities of the possible outcomes of a position measurement, and each cloud is determined by the outcomes of three measurements: a measurement of the atom's energy, a measurement of its total angular momentum, and a measurement of the vertical component of its angular momentum.

We are also in a position now to understand why quantum systems can only be described in terms of correlations between the various ways in which they can be prepared and the various outcomes that measurements can yield. The manifestation of the world is a transition from a condition of complete indefiniteness and indistinguishability to a world of distinguishable objects with definite properties. The question then is: how can we describe what is indefinite or indistinguishable? And the answer, as we just found, is that what is indefinite or indistinguishable can only be described by assigning probabilities to the definite and distinguishable events by which the outcomes of measurements are indicated. In other words, what is instrumental in the manifestation of the world can only be described in terms of what happens in the manifested world.

Not only does quantum physics call for the distinction between the manifested world and its manifestation, it also prompts us to distinguish between two kinds of causality. One is the traditional kind, which links objects and events across time and space and allows us to make sense of what goes on in time and space. It is part of the world drama, but it does not take part in setting the stage for it. The other is the causality of the process of manifestation — the process by which Pure Being enters into reflexive spatial relations and subjects them to the laws of physics. Because this process is responsible for the creation of time and space, it obviously isn't a process that takes place in time. As prisoners of time we keep looking for the origin of the universe at the beginning of time, but this is an error of perspective, and quantum physics tells us so.

Let us pause again to see how the rival metaphysical frameworks now fare. If we adopt a spiritual framework of thought, we can explain why the laws of physics have the particular form that they do, why the mathematical formalism of quantum physics is a probability calculus, why the events it serves to correlate are measurement outcomes, and why quantum systems can only be described in terms of correlations between measurement outcomes. If, on the other hand, we adopt a materialistic framework, we don't know the answer to *any* of these questions.

Failure to distinguish between the manifested world and its manifestation has resulted in a number of spurious problems and an entire industry dedicated to solving them. This is the story of the infamous "quantum measurement problem." Normally you wouldn't think twice about how something that is possible can actually happen. To say that something is possible *means* that it can happen. Yet if one treats a tool for assigning probabilities to the possible outcomes of measurements as if it were the mathematical representation of an actual state of affairs, then it becomes impossible to explain how a measurement can turn a possible outcome into an actual one.

One solution to this conundrum that has been proposed is that actual measurement outcomes only exist in the minds of observers. The New-Age community is now sold on the idea that the so-called collapse of the wave function is caused by the consciousness of an observer, not least thanks to Fritjof Capra's bestseller *The Tao of Physics*. This, however, is but a gratuitous answer to a non-existent problem — a problem that only arises if the wave function — a tool for calculating the probabilities of measurement outcomes — is treated as if it were the mathematical description of an actual state of affairs.

Capra, like many other popular writers, confounds two separate issues. One issue concerns the *mind*-independent existence of things, the other concerns their *measurement*-independent existence. Quantum physics, I am happy to announce, allows you to think that the Moon is there even if nobody looks at it. What calls for explanation is not why the properties of a quantum system cannot be defined without reference to conscious observers — they can — but why they cannot be defined without reference to *measurements*. And we have seen why this is so. To say it again: what is instrumental in the manifestation of the world can only be described in terms of what happens in the manifested world.

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If making sense of quantum physics is one of the biggest challenges in the philosophy of science today, consciousness and intentionality are among the biggest challenges in the philosophy of mind. *Consciousness* is the remarkable fact that things exist not only *independently* of us but also *for us*. This does not mean that the external world, or some part or aspect of it, is mirrored in our brains. It means that we perceive the external world by means of neural representations in our brains. *Intentionality* is the remarkable fact that instead of perceiving representations in our brains, we perceive things that exist outside of our brains.

Twenty years ago, the philosopher David Chalmers made a splash with his distinction between the so-called easy problems of consciousness (which aren't exactly easy but are considered potentially solvable by studying the brain) and the hard problem of consciousness [3]. The latter is the question how physical processes in a brain give rise to the various sensory qualities of the experienced world, along with the sense of being an experiencing self or subject. Materialist philosophers hold out the promise that this problem will one day be solved. John Searle [4] maintains that consciousness is a biological property like digestion or photosynthesis, and even asks why this isn't "screamingly obvious to anybody who's had an education?" Other philosophers are less sure. According to Jerry Fodor [5], "nobody has the slightest idea how anything material could be conscious. Nobody even knows what it would be like to have the slightest idea about how anything material could be conscious."

I think that the materialist approach to consciousness is fundamentally flawed, and this for much the same reason that quantum physics cannot be understood as describing a world of interacting constituent parts.

Quantum physics describes the transition from the unity of Pure Being to the multiplicity of the manifested world. It requires us to conceive of a new dimension, in addition to the familiar dimensions of space and time, a dimension across which this transition takes place.

The existence of consciousness likewise requires us to conceive of a new dimension, a non-spatial dimension across which the conscious self perceives what exists in space and time, a dimension that extends from the multitude of perceived objects to the unity of the perceiving subject. Just as the existence of Pure Being cannot be explained in terms of interacting atoms or subatomic particles, so the existence of the perceiving subject cannot be explained in terms of interacting neurons. The engineering approach to problem solving fails when it comes to making sense of quantum physics, and fails again when it comes to understanding consciousness.

There is a promising alternative to this approach. Beginning with Gottfried Wilhelm von Leibniz in the 17th Century, philosophers have argued that all physical properties are relational or extrinsic, and none are in a fundamental sense non-relational or intrinsic. This offers the possibility of situating consciousness among the intrinsic properties of the relata which bear the relational properties. This possibility was considered by Bertrand Russell [6] and more recently by Chalmers.

The problem with this possibility is that it is hard to imagine how the consciousnesses of a myriad of particles can constitute the unified consciousness that we enjoy. But if we take into account not only that all physical properties are relational but also that all relational properties are *reflexive*, so that the relata are identically the same Being, the idea that consciousness is an intrinsic aspect of the relata comes into its own.

If all that ultimately exists is a single, intrinsically undifferentiated Being, which manifests the world by entering into reflexive spatial relations, then consciousness — the relation between experiencing subjects and experienced objects — is but another reflexive relation. Pure Being does not simply manifest the world. It manifests the world *to itself*. It relates to the world not only as the substance that constitutes it but also as the consciousness that contains it. It is both the single substance *by* which the world exists and the ultimate self or subject *for* which the world exists.

There are many ways in which Pure Being can present itself to itself. In this evolving world, it has elected to initially present itself as its own opposite [7]. By subjecting its reflexive spatial relations to the laws of physics, it has hidden its infinite consciousness and creative freedom under the shroud of an insentient and seemingly purposeless universe, but it has done so for a purpose: to set the stage for the adventure of evolution. If we are as yet unaware of being the One Self for which the world exists, it is because what has evolved so far is only a most imperfect form of that infinite consciousness and creative freedom.

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