Science's Mysteries – "This Far and No Further"
Dave Stein

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Abstract

Science and its underpinnings, mathematics and logic, are shaking their own foundations, with profound implications not only for the scientific method but also for the relationship between science and mysticism. For example, recent advances in quantum physics, and continual re-interpretations of earlier findings, are calling into question the notion of the detached observer – a notion fundamental to the contemporary scientific method – as well as the reductionistic approach of attempting to understand an entirety in terms of its components.

Other findings indicate that uncertainty, randomness, and inconsistency may be basic to nature, with pervasive implications for the predictive and descriptive capability of science. Indeed, it is at the level of the chaotic, quantum substrate that mystical laws may operate. As for science's foundational mathematics and logic, they rest on axioms that, in a striking parallel with some Western religions, are unprovable, consensus-based, and ultimately accepted "on faith." Beyond these gatekeepers to knowledge lies yet another. Stated differently, "This far and no further." Like religion, science has mysteries that are beyond its reach.

Increasing studies of consciousness, intuitive processes, and some of the healing modalities can be expected to magnify the limits of reductionism-based science. This is because these studies generally do not yield the repeatable results that the scientific method demands. It is envisioned that the scientific method will need to evolve to encompass subjective experiences that have been traditionally regarded as outside its realm – and that are inherent to mystical teachings and consciousness research – perhaps starting with a framework that recognizes the interconnectedness of the observer and the observed.

This paper concludes with commentary on cultural, social, and academic trends that – in parallel with developments in science – highlight the limits of reductionism.

Les mystères de la science – Jusqu'ici et pas plus loin
Dave Stein

Résumé

Les notions fondamentales propres à la science, aux mathématiques et à la logique sont remises en question, ce qui entraîne de profonds changements en ce qui touche à la méthode scientifique, mais également à la relation entre la science et le mysticisme. À titre d'exemple, les découvertes récentes en physique quantique et l'étude constante de l'interprétation des découvertes antérieures entraînent la reconsidération de la notion de l'observateur neutre, un principe fondamental de la méthode scientifique contemporaine et de la méthode réductionniste, qui tente de comprendre l'intégralité d'un concept en s'appuyant sur les éléments qui le composent.

D'autres constatations démontrent que l'incertitude, le caractère aléatoire et les incohérences constituent la base de la nature, ce qui a des répercussions profondes sur la capacité de description et de prédiction de la science. En fait, c'est au niveau du substrat quantique et chaotique que les lois mystiques semblent intervenir. Tout comme les mathématiques et la logique à la base des sciences, ces lois sont fondées sur des axiomes qui, parallèlement avec certaines religions occidentales, ne peuvent être prouvés, sont généralement acceptés et d'une certaine manière sont fondés sur la foi. Abstraction faite de ces gardiens du savoir, il existe un autre monde de connaissances. On y fait référence dans l'expression « Jusqu'ici et pas plus loin ». Tout comme la religion, le domaine de la science possède également des mystères encore inexpliqués.

Un nombre de plus en plus croissant d'études sur la conscience, sur les processus intuitifs et certaines approches de guérison devraient permettre de repousser les limites de la science fondée sur le réductionnisme. Cela s'explique par le fait que ces études ne fournissent généralement pas les résultats répétitifs que recherche la science. Il est à prévoir que la méthode scientifique devra évoluer afin d'englober les expériences subjectives qui ne sont pas intégrées traditionnellement dans ce domaine, et qui pourtant, font parties inhérentes de l'enseignement mystique et de la recherche de la conscience. Peut-être faudra-t-il commencer par reconnaître l'interdépendance entre l'observateur et le phénomène observé.

Cet article se termine par un commentaire sur les tendances culturelles, sociales et universitaires, qui parallèlement au développement de la science, soulignent les limites de l'approche réductionniste.

Los Misterios de la Ciencia, Hasta Aquí y No Más
Dave Stein

Resumen

La ciencia y sus bases, las matemáticas y la lógica, están sacudiendo sus propios fundamentos, con grandes implicaciones, no solo al método científico, sino también en las relaciones entre la ciencia y el misticismo. Por ejemplo, los recientes avances en física cuántica y las continuas reinterpretaciones de hallazgos anteriores, están cuestionando las nociones del observador no implicado, una noción al método científico contemporáneo, como también al enfoque reduccionista para tratar de entender la totalidad en términos de sus componentes constitutivos.

Otros hallazgos indican que la incertidumbre, la aleatoriedad y la inconsistencia pueden ser básicas en la naturaleza, con pentrantes implicaciones a la capacidad predictiva y descriptiva de la ciencia. De hecho, es a este nivel de sustrato cuántico caótico que las leyes místicas pueden funcionar. En cuanto a las matemáticas y lógica fundamental de la ciencia, están basadas en axiomas, con un paralelo impresionante con algunas religiones occidentales, son imposibles de demostrar, basados en consensos y al final , son aceptadas "como actos de fe". Más allá de estos guardianes al conocimiento, hay aun más. Dicho de forma diferente: "Hasta aquí y no más." Igual que la religión, la ciencia tiene misterios que están más allá de su propio alcance.

Se espera que los crecientes estudios sobre la conciencia, los procesos intuitivos y algunas modalidades de curación, amplifiquen los límites de la ciencia basada en el reduccionismo. Esto se debe a que estos estudios no producen resultados repetibles que el método científico demanda. Se contempla que el método científico deberá evolucionar para abarcar experiencias subjetivas que han sido tradicionalmente consideradas como fuera de su dominio, y que son inherentes a las enseñanzas místicas e investigación de la conciencia. Quizás, comenzando con un marco que reconozca la interconectividad entre observador y lo observado.

Este artículo concluye con un comentario de las tendencias culturales, sociales y académicas que, en paralelo con los desarrollos científicos, resaltan los limites de reduccionismo.

Mistérios da Ciência–Até Aqui e Não Mais
Dave Stein

Resumo

A ciência, sua lógica e matemática fundamentais, estão agitando seus próprios fundamentos, com implicações profundas não somente no método científico mas também na relação entre ciência e misticismo. Por exemplo, recentes avanços em física quântica, e reinterpretações contínuas de descobertas anteriores, estão pedindo que o observador tenha uma noção imparcial – uma noção fundamental para o método científico contemporâneo – bem como uma abordagem reducionística na tentativa de entender a totalidade com relação a seus componentes.

Outras descobertas indicam que a incerteza, o acaso, e a inconsistência são fatores fundamentais da natureza, com implicações difundidas na capacidade descritiva e preditiva da ciência. De fato, é a nível do substrato quântico e caótico que as leis místicas podem operar. Quanto à lógica e à matemática fundamentais da ciência, elas permanecem na hipótese que, num paralelo surpreendente com algumas religiões ocidentais, não podem ser comprovadas, baseadas num consenso e por fim são aceitas "na fé". Além dessas posições de conhecimento ainda existem outras. Declaradas de forma diferente, "Até Aqui e Não Mais". Como a religião, a ciência tem mistérios que estão além de serem alcançados.

O crescente número de estudos sobre consciência, processos intuitivos, e algumas modalidades de cura tem como expectativa aumentar os limites da ciência com base no reducionismo. Isto acontece porque estes estudos em geral não produzem os mesmos resultados repetidamente conforme exigidos pelos métodos científicos. Prevê-se que o método científico terá que evoluir para incluir experiências subjetivas que vêm sendo tradicionalmente consideradas como estando fora de seu domínio – e que são inerentes aos ensinamentos místicos e pesquisas sobre a consciência – talvez começando com uma estrutura que reconheça a interconexão do observador e do observado.

Este estudo foi concluído com comentários sobre tendências acadêmicas, culturais e sociais que – em paralelo com a evolução da ciência – destacam os limites do reducionismo.

Die Geheimnisse der Wissenschaft – Bis hierher und nicht weiter
Dave Stein

Zusammenfassung
Die Wissenschaft, und die Mathematik und Logik, die diese untermauern, zerrüttet ihre eigene Basis mit tiefgreifenden Auswirkungen nicht nur für die wissenschaftliche Methode, sondern auch für die Beziehung zwischen Wissenschaft und Mystizismus. Zum Beispiel stellen die neueren Fortschritte in der Quantenphysik und dauernde Neuinterpretationen früherer Ergebnisse nicht nur die Vorstellung eines objektiven Beobachters in Frage – eine Vorstellung, die in der gegenwärtigen wissenschaftlichen Methode grundlegend ist – sondern auch den reduktionistischen Ansatz des Versuchs, das Ganze auf der Grundlage seiner Einzelteile zu verstehen.

Weitere Ergebnisse zeigen an, dass Unsicherheit, Zufaelligkeit und fehlende Konsistenz grundlegend in der Natur sind, mit weitreichenden Auswirkungen für die Fähigkeit der Wissenschaft vorauszusagen und zu beschreiben. Was die der Wissenschaft zugrundeliegende Mathematik und Logik angeht, so beruhen diese auf Axiomen die, in auffallender Parallelität mit westlichen Religionen nicht zu beweisen sind, auf Konsens gründen und letztendlich „auf gut Glauben" akzeptiert werden. Jenseits dieser Torhüter des Wissens liegt noch eine andere Art Wissen. Anders ausgedrückt, „bis hierher und nicht weiter." Wie in der Religion gibt es in der Wissenschaft Geheimnisse, die jenseits ihrer Reichweite liegen.

Die zunehmende Menge der Forschung über das Bewusstsein, intuitiven Erfahrungen und einige Heilungsmodalitaeten stellen wahrscheinlich die Grenzen der auf Reduktionismus gegründeten Wissenschaft heraus. Das kommt daher, weil diese Studieren im Allgemeinen nicht die wiederholbaren Ergebnisse erzielen, die die wissenschaftliche Methode fordert. Wir stellen uns vor, dass die wissenschaftliche Methode sich entwickeln muss, um subjektive Erfahrungen, die traditionellerweise als außerhalb ihres Bereichs liegend angesehen wurden – und die der mystischen Lehre und der Forschung über das Bewusstsein angehören - mit einzuschließen. Unter Umständen fangen wir mit einem Rahmen an, der die Verbindung zwischen die Beobachter und die Beobachten anerkennt.

Dieses Forschungspapier schließt mit einem Kommentar zu den kulturellen, sozialen und akademischen Trends ab, die - parallel zu Entwicklungen in der Wissenschaft - auf die Grenzen des Reduktionismus hinweisen.

INTRODUCTION

Like the religions and creation myths that predate it, contemporary science provides a framework for attempting to understand the universe. Replacing Western religious dogma with a new consensus-based scientific authority that is grounded in repeatable experiment and observation, it is itself based on a protocol known as the scientific method.

Contemporary scientific protocol is based, among other things, on the notion of the "detached observer" or experimenter, who is separate from – and impartial to – that which is observed. In this sense, and in other ways, too, it is reductionistic, attempting to understand the whole in terms

of the parts. A classic illustration is the notion of "action-at-a-distance" that underpins the inverse square law equations for gravitational force and electrostatic force. In terms of this law, a mass m_1 "over there" at a distance R "from here" exerts a force on a mass m_2 "over here"; electrical charges behave similarly.

However, scientific advances are now calling into question the notion of the detached observer, perhaps rendering him/her an anachronism. Actually, it is not always the advances themselves that are new; instead, their impacts are now becoming better understood as they are continually reinterpreted and may well be increasingly pervasive in next-generation science. For example, since the advent of quantum mechanics, it has become more readily apparent that the process of observing or measuring something influences the outcome – a phenomenon that is, however, generally inconsequential in everyday life. In a rough sense, this is because at quantum scales, the mass-energies used to make the measurements are comparable to the mass-energies of that which is being measured.[1] But the mechanism of influence does not stop here. The act of choosing the experiment itself influences the outcome. Case in point: an electron can manifest as a particle or as a wave, depending on how one chooses to observe it. One can argue that this applies in the social sciences and other walks of life as well – even in public opinion polls – since the answer to a question is often influenced by the way in which the question is framed. Thus, just how "detached" is the observer or principal investigator?

QUANTUM ENTANGLEMENT – THE END OF REDUCTIONISM?

The proverbial plot thickens. Not only does the act of observation influence the outcome; not only does the act of choosing the experiment influence the outcome – the notion of separateness or reductionism may itself need to be re-addressed, specifically, in the context of the Einstein-Podolsky-Rosen (EPR) paradox and "gedanken experiment" first proposed in 1935 and performed years later by Alain Aspect (1982).[2] As commonly interpreted, the results of this experiment challenge the reductionistic notion of "action-at-a-distance," as this would require a superluminal signal that violates special relativity. Instead, the results suggest an interconnectedness or "quantum entanglement" that seemingly permits "instantaneous communication" among the particles involved without requiring the forbidden superluminal signal. But if the particles involved in the experiment are indeed quantum entangled, then one might ask how "separate" they are and indeed what "communication" means.[3] To a number of physicists, the results of this experiment point to a larger "system" whose properties depend on its entirety and are thus beyond analysis in terms of its components – in their parlance, nonlocality. If so, then how scalable is this notion of larger system, and with what implications to reductionist-based scientific frameworks based on an "over there" and "over here," together with a seemingly detached observer?[4]

More profoundly, if quantum entanglement calls into question the notion of "communication" and "signal" – perhaps even the notion of separate particles – then one might ask how scalable the notion of entanglement is. Conceivably it extends to the macroscopic level and to all things. Indeed, the eminent physicist David Bohm has postulated that an "unbroken wholeness" underlies the seeming separateness of the everyday world.[5]

THIS FAR – AND NO FURTHER

Compounding this challenge are other limitations inherent in science and mathematics, and now perhaps even in their foundational deductive logic – limitations that scientists themselves have been among the first to acknowledge. One such limitation is randomness. Quantum mechanics describes nature as probabilistic as opposed to deterministic. For example, the radial wave function for an electron orbiting an atom predicts the *probability* that the electron is at a distance r_1, r_2, r_3, etc. from the nucleus of the atom *when its position is measured*. It does *not* predict a specific value for the electron's distance from the nucleus. Furthermore, the radial wave function predicts radial distances at which the probability of finding the electron is relatively high, interspersed with radial distances at which the probability is *zero* – in other words, discreteness. During the early years of quantum mechanics, this probabilistic aspect of quantum mechanics was resisted by no less of a physicist than Albert Einstein himself, who is reported to have stated, "The theory [quantum mechanics] says a lot, but does not really bring us any closer to the secret of the 'old one.' I, at any rate, am convinced that *He* [God] does not throw dice" – Einstein's own role in ushering in quantum mechanics notwithstanding.[6] In response, physicist Neils Bohr, father of the Bohr Theory of the atom, allegedly retorted, "Stop telling God what to do." Years later, the prominent physicist Stephen Hawking offered his own perspective: "God not only plays dice but sometimes throws them where they cannot be seen." Hawking's quote alludes to the possibility of hidden variables; however, an alternative possibility that is gaining increasing acceptance[7] is that uncertainty and inconsistency may be intrinsic to nature and that indeed chaos may underlie the more predictable orderly macroscopic everyday world – a notion consistent with the concept of a violently fluctuating, turbulent "quantum foam" as a descriptor of space-time at small scales, turbulent to the point that directions of space and time lose their meanings. This randomness, this quantum chaos, may have profound implications for the predictive and descriptive capability of science – and it is at the level of the chaotic, quantum substrate that mystical laws may operate.

Further limiting what can be known is the Heisenberg uncertainty principle, which prohibits simultaneous knowledge, with arbitrary precision, of two conjugate variables – e.g., position and momentum (along the same axis), angular position and angular momentum (relative to the same axis of rotation), or energy uncertainty and the duration of the uncertainty. Arguably, it does not make sense to even talk about two conjugate variables simultaneously. The product of the uncertainties is *at best* on the order of Planck's constant, a lower bound. The Heisenberg uncertainty principle supports the contention by some physicists that uncertainty is basic to nature and that beyond a certain point, nature is unknowable in the objective scientific sense[8] – again with profound implication for the predictive capability of science.

But it is not only at the quantum scale that the capability to know – objectively and scientifically – is limited. At the cosmological level, the modern accepted "creation myth" – the Big Bang – may have an event horizon that puts it forever beyond human reach – a possibility suggested by the eminent physicist Stephen Hawking.

BUT NOT EVEN THIS FAR

Even the mathematics and logic that underpin science itself have their own inherent limitations. For example, in quantum logic, the Law of the Excluded Middle (i.e., that everything must be "true" or "false") no longer rigorously applies. Taken to the extreme, this challenges the notion of binary, "either-or" thinking – with possible eventual implication to "us-them" thinking and counterpoint-based identity in everyday life.

A further fundamental limit to deductive reasoning – indeed to the axiomatic mathematical systems that underpin the sciences – is captured by Gödel's theorem, which itself is not exactly new. According to mathematician Kurt Gödel, the consistency of a finite mathematical system is provable only at a level external to itself, and this in turn argues against the completeness of the system.[9] In addition to giving rise to paradoxes – e.g., the Barber of Seville paradox[10] – Gödel's theorem represents an inherent limit to axiomatic mathematics and to what can be known or expressed in terms of it. This represents another fundamental limit to deductive reasoning. Indeed, science, mathematics, and logic are shaking their own foundations.

JUST THE COUNTERFACTS, PLEASE

It is not only new discoveries by which science, mathematics, and logic are "proving" their own limitations. Continual reinterpretations of old discoveries – even going back as far as Thomas Young's double slit experiment in 1802 – are playing a role as well.

In Young's double slit experiment, photons pass through two slits and impinge upon a screen (for example, photographic film). If the photons are regarded as electromagnetic waves, then wave mechanics describes and predicts the alternating bright and dark bands recorded on the photographic strip, bands that correspond respectively to constructive and destructive interference. This is straightforward.

But suppose that the intensity of the photon source is reduced to the point that only one photon is in transit at a time. Over a period of time, the photographic film still records the interference pattern that wave mechanics describes! In this case, what is interfering with what, if only one photon is in transit at a given time? What is the "wave" now, except a description of the statistical distribution of the photon paths? The fact that the interference pattern is still obtained is the impact of the path not taken – an arguably counterintuitive phenomenon known as counterfactuality, which has implications for logic and for scientific experimentation. Thus, counterfactuality can be regarded as the effect, on an observable outcome, of the *mere existence* of an alternative that did not actually occur.[11]

Continuing, if the experiment is repeated with an attempt made to identify the path through which each photon passes (e.g., by adding detectors near the two slits), then the interference pattern is destroyed and the well-known single-slit pattern is observed!

BEYOND THE HUMAN VANTAGE POINT

Perhaps the most fundamental limitation to what can be known objectively – scientifically – is the inability to (objectively) transcend the human experience. The universe is unknowable in an objective, scientific sense independent of human measurements and observations. One might regard this limitation as an extension of the anthropic principle.[12]

SCIENCE – A NEW RELIGION

Scientists have long known that science, itself a means to understand the universe, at best only describes and predicts; it does not "explain" except in terms of consistency with other accepted (that is, consensus-based) observations and facts – and as discussed above, the predictive capability of science is now under assault. At some point, science and the mathematics and logic that underpin it rest on fundamental axioms and postulates that are beyond deductive proof and accepted only by consensus and "on faith." In this sense, science differs from religion only in the level of consensus involved and the source of its authority, replacing religious teachings, doctrine, and dogma with a consensus-based scientific authority that demands, among other things, the replicability of experimental results. An additional resemblance is that science, like some religions, has its own mysteries, the answers to which lie beyond its reach.

AND NOW, PERSONAL EXPERIENCE

Although many regard science as a rebellion against religious dogma and the authority of religious establishments, especially the establishments of "revealed religions," it substituted its own authority – scientific consensus grounded in results that can be replicated – for the authority that it sought to supplant. In doing this, it has left little room for the magnified role of personal experience that is inherent in physics of consciousness research, especially personal experience that cannot be reliably replicated under seemingly controlled conditions – but that as "nonconsensus reality" (Mindell 2000, 25ff, 67, 209, 258ff, 587, 592) cannot be disproven. Indeed, contemporary science is arguably ill-equipped to accommodate anecdotal evidence beyond evidence aggregated from large statistically-significant population samples. Apart from the influence of subtle energies not yet understood, one possible reason for this non-repeatability in certain experiments is the mutual influence and indeed the entanglement of the observer with the observed. From another vantage point, non-repeatability may stem from the chaos and indeterminacy believed to underlie the more predictable and orderly macroscopic world.

Another mechanism for non-repeatability is the possibility of hidden variables, that is, subtle influences that are not taken into account or perhaps not even understood. For example, recent research suggests a correlation between space meteorology – for example, the variations in the Schumann resonances with solar activity – and the effectiveness of intuitive processes and some healing modalities (Oschman 2000, 97-104, 107-110). Other research corroborates the power of intention, that is, "mind over matter" – results for which vary according to test subject and other influences (Jahn and Dunne 1987, 46, 52, 72; Oschman 2000, 227). Additional subtle influences that have been proposed are local geological conditions (Oschman 2000, 187) and local electric and magnetic fields including magnetic shielding (Oschman 2000, 97-98; Higgins 2007; Higgins 2010).

THE SOCIAL AND CULTURAL CONFLUENCE

Although randomness, uncertainty, counterfactuality, inherent limitations of axiomatic frameworks, and the demise of the detached observer herald profound changes in the scientific method (albeit not immediately), these changes are not happening in isolation. Indeed, social and cultural factors may well magnify the impacts of these limitations. With the increased interaction among the cultures of the world – for example, via travel, communications, commerce, and education (including self-development) – there is an increased cross-flow of ideas, philosophies, and perspectives among peoples, cultures, and regions. In comparison with cultures generally characterized as "Western," Asian cultures are generally more holistic and less reductionistic in their approach to nearly everything, including philosophy, religion, medicine, business relationships, and even warfare. This is underscored by the fact that in contrast with the individualism that characterizes the United States and parts of Europe, Asian cultures tend to be more group and personal relationship oriented.[13] A confluence of Asian cultural influences and advances in particle physics may pave the way for a scientific method that is less reductionistic than the present one – and indeed the term "particle" itself has a reductionistic connotation.

To this confluence one might add the complex interrelationships among environmental, economic policy, and business decisions – interrelationships illustrated by ripple effects that sometimes progress full circle and that are not captured by near-term focused utility functions.[14] One can envision that these complex interrelationships will give rise not only to more holistic approaches to social issues but also to a way of thinking beyond "us-them" – a way that synergizes with the complementary holistic framework that is emerging in science and through Asian cultural influences.

Foresight studies[15] and the organizations that enable and support them might well be a fourth player in this confluence. By their very nature, foresight studies are holistic and interdisciplinary as they examine the cross-cutting implications of technology advances, social trends, and policy decisions – implications far beyond the realm of the academic departments that mirror the departments in governments and corporations. Furthermore, foresight studies and analyses require more than extrapolative thinking – they require discontinuous, nonlinear thinking that anticipates the otherwise unexpected events, known in the profession as "wild cards."

THE OUTLOOK

Religion and contemporary science face a common challenge – people are seeking answers that are seemingly beyond both. In this quest, an increased role can be expected for personal experience that is not readily accommodated either by consensus-based religions or by contemporary science.

A complete characterization of the scientific method to come would be premature, as "this far and no further" itself recedes with time. One can be sure that there will be scientific advances that are not yet envisioned. Like many scientific laws and findings before them, the Heisenberg uncertainty principle, quantum logic, counterfactuality, and even Gödel's theorem may themselves be overturned someday, as scientific principles, laws, and discoveries are rarely final.

Nonetheless, it is reasonable to anticipate a new scientific method that emerges from the seeming irreconcilability of personal experience and the entangled observer with the scientific method and consensus-based science – one that encompasses subjective experiences that are inherent to consciousness research, perhaps starting with a framework that recognizes the interconnectedness of the observer and the observed. One can expect the new scientific method to be based on complementary ways of thinking that even challenge traditional notions of academic authority – experiential in addition to consensus-based, and holistic in addition to deductive and reductionistic.

Equally premature would be speculation on the remaining "tenure" of the scientific method as we presently know it. Less disputable is the growing possibility for substantial changes in scientific protocol.

In addition, mutual enrichment of the physical sciences, cultural cross-flow, the social sciences, and foresight studies can be anticipated. For example, one might anticipate enhanced awareness to the complex interdependencies ("entanglements") that characterize social issues – and perhaps even a re-convergence of science and mysticism.

APPENDIX – THE EINSTEIN-PODOLSKY-ROSEN (EPR) PARADOX AND ALAIN ASPECT'S EXPERIMENT

Alain Aspect's 1982 experiment, based on the Einstein-Podolsky-Rosen "gedanken experiment," demonstrated the quantum entanglement of two particles emitted by a system – the alternative being a superluminal signal that is forbidden by special relativity. The experiment is based on a quantum mechanical property known as "spin" (not the same as mechanical spin in everyday life). Specifically, it is based on the fact that spin is a conserved quantity and that quantum mechanics permits knowledge and measurement along only one spin projection axis at a time – for example, left-right *or* up-down but not both. (Electrons, for example, have spin projections of □(1/2)(h/2□) where h is Planck's constant. For brevity, this is often expressed as □1/2, where the signs differentiate between left and right or up and down.) Subsequent measurement of spin projection along another axis destroys the knowledge gained from the first measurement.

In Alain Aspect's experiment, a system--M--emits two particles--A and B--in opposite directions. As spin is a conserved vector quantity, the total spin of M, A, and B after the emission must equal the spin of M prior to the emission. This forces the vector sum of A's spin projection and B's spin projection to equal zero. Thus, if A has spin up, B must have spin down. Until measured, the spin of A and B are indeterminate.

In one variation of the experiment, the choice of axis against which to measure the spin projections of particles A and B was made *after the particles were emitted and in transit*. If the up-down axis is chosen and a measurement of particle A indicates that it is spin up, then particle B must somehow instantaneously "know" that its spin must be down. If the left-right axis is chosen and particle A is found to be spin left, then particle B must again instantaneously know that it must be spin right. Thus, particle B (not measured) must somehow instantaneously

"know" to manifest a spin opposite to that of A, relative to an axis chosen after the particles are emitted. But such an instantaneous communication requires the forbidden superluminal signal.

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[1] As a macroscopic analogy, consider using a thermometer with a bulb the size of a basketball to measure the temperature of water in a bathtub. Unless the thermometer bulb and the bathtub water are at thermal equilibrium at the outset, the very immersion of the large bulb into the water itself changes the water's temperature, the "accuracy" of the thermometer notwithstanding.

[2] See Appendix.

[3] An extremely crude analogy – consider a fish in an aquarium and two observers, each looking through a separate side of the aquarium. If the observers are somehow unaware of each other's presence, the movements of the "two" observed fish will be correlated – as one might expect, considering that they are the same fish!

[4] The interconnectedness has a possible parallel with the Ayurvedic perspective of the observer, the observed, and the process of observing.

[5] Interpreted in this context, the New Testament passage – "As ye do unto the least of my brethren, so ye do unto me" – can be regarded as a quantum mechanical statement.

[6] In 1921, Albert Einstein was awarded the Nobel Prize for his research on the photoelectric effect, a quantum phenomenon.

[7] For example, Rosen discusses this at length.

[8] *Ibid*.

[9] (Actually, this is one of his theorems.) In 1931, mathematician Kurt Gödel proved that no axiomatic mathematical system can prove its own consistency and completeness through deductive reasoning.

[10] It has been argued that paradoxes and pseudo-paradoxes – for example, the legendary barber who "shaves himself if and only if he does *not* shave himself" – are inevitable consequences of finite axiomatic systems.

[11] Hypothetical analogy – suppose that the macroscopic world behaved similarly, and imagine a person driving from point A to point B with a choice of several possible routes. Even if the vehicle is the only one on the road at the time (such that traffic volume is not a factor), the mere existence of routes not traversed influences the driver's experience of the route chosen! The implications of the double slit experiment, and of the more elaborate similar experiments that followed it, continue to be subjects of study.

[12] In one of its simple forms, the anthropic principle states that the universe is the way that it is because otherwise we (humans) would not be here to notice.

[13] These cultural differences are discussed at length by Groff.

[14] For example, employer downsizing in a given geographic area can precipitate ripple effects in which progressively fewer people can afford any company's goods and services, in turn leading to more layoffs in a vicious circle sense. A wave of home foreclosures can result in neighborhood blight, ultimately impacting the very financial institutions that initiated the foreclosure actions. Pollution in one part of the world recognizes no geopolitical boundaries and can have far-reaching impacts across the globe. Uncompensated overtime and a workaholic culture entail hidden healthcare costs.

[15] Also known as future studies.