The Non-dual Root of Science and Religion

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Abstract

Most approaches to reconciling science and religion focus on conflicts between specific religious and scientific worldviews, but there is a more fundamental challenge to their reconciliation that is largely ignored. Modern science is conventionally regarded as a method for discovering and describing real, independently existing objects and laws of nature. The major religions of humanity, in contrast, draw their inspiration from mystics who teach that reality is fundamentally non-dual, and specifically that the distinction between subject and object is not ultimately real. Consequently, for these mystics, there is no objectively existing universe or laws for science to investigate or describe. From this perspective, the fundamental challenge of reconciling science and the mystical teachings is to explain how science is possible at all given that reality is ultimately non-dual. What is science studying if there is no objectively existing world? How can the laws of nature be understood from a non-dual perspective? After first showing that science has no need for the assumption of an objectively existing universe or laws, the author proposes that science may be viewed as a way of investigating reality that seeks order in the form of invariant relationships between empirical data (i.e., "laws"). Moreover, both empirical measurements and theoretical laws are described in science using the language of mathematics, which is based on distinctions. This view of science is thus completely compatible with a non-dual perspective, which describes the world as arising through the act of making apparent distinctions within non-dual reality. It also provides a comprehensible answer to questions such as why mathematics is so effective in describing the physical universe.

La racine non-duelle de la science et de la religion

Thomas J. McFarlane

Résumé

La plupart des approches qui tentent de réconcilier la science et la religion se centralisent sur les conflits entre une vision du monde scientifique et une vision religieuse, mais il existe un aspect fondamental, susceptible de les réconcilier, qui est souvent ignoré. Généralement parlant, la science moderne est considérée comme une méthode permettant de découvrir et de décrire des objets réels, existant indépendamment l'un de l'autre, et des lois naturelles. Les principales religions de l'humanité, en revanche, découlent de mystiques qui enseignent que la réalité est fondamentalement non-duelle, plus précisément qu'il n'y a pas de différence réelle entre le subjectif et l'objectif. Par conséquent, pour ces mystiques, il n'y a aucun univers objectivement existant, ni des lois que la science puisse étudier ni décrire. Dans cette perspective, le défi fondamental en vue de réconcilier la science et les enseignements mystiques, est d'expliquer à quoi sert la science, si l'on admet que la réalité est au bout du compte non-duelle. Comment étudier scientifiquement, s'il n'y a pas de monde existant objectivement ? Comment comprendre les lois de la nature d'un point de vue non-duel ? Après avoir d'emblée démontré que la science n'a pas besoin de l'hypothèse d'un univers existant objectivement ni de lois, l'auteur propose que la science peut être considérée comme un moyen d'enquêter sur la réalité ayant pour but d'ordonner des relations invariables entre des données empiriques (c'est-à-dire, les « lois »). En outre, les mesures empiriques et les lois théoriques sont décrites, dans la science, en utilisant le langage des mathématiques, qui repose sur des distinctions. Ce point de vue de la science est donc totalement compatible avec un point de vue non-duel, qui décrit le monde comme jaillissant de distinctions apparentes au sein d'une réalité non-duelle. Il fournit également une réponse compréhensible à des questions telles que, pourquoi les mathématiques sont si efficaces pour décrire l'univers physique.

La Raíz no-dual de la Ciencia y Religión
Thomas J. Mcfarlane

Resumen

La mayoría de los enfoques para reconciliar la ciencia y la religión se enfocan en conflictos entre específicas visiones científicas y religiosas de carácter mundial, pero existe un reto más fundamental para su reconciliación que ha sido en gran parte ignorado. La ciencia moderna es conocida convencionalmente como un método para descubrir y describir objetos reales independientemente existentes y leyes de la naturaleza. En contraste, La mayoría de las religiones de la humanidad, obtienen su inspiración de místicos los cuales enseñan que la realidad es fundamentalmente no-dual, y especifican que la distinción entre sujeto y objeto al final no es real. Consecuentemente, para estos místicos, no existe un universo objetivo o leyes para que la ciencia pueda investigar o describir. Desde esta perspectiva, el reto fundamental para reconciliar ciencia y las enseñanzas místicas es el explicar cómo es posible que exista la ciencia, siendo que al final la realidad no es dual. ¿Qué es lo que la ciencia estudia si es que no existe un mundo objetivo? ¿Cómo pueden ser comprendidas las leyes de la naturaleza desde una perspectiva no-dual? Después de demostrar que la ciencia no tiene necesidad de la asunción de un universo objetivo existente o leyes, el autor propone que la ciencia puede ser vista como una forma de investigar la realidad que busca del orden por medio de relaciones variantes entre datos empíricos (i.e.,"laws"). Además, ambos, medidas empíricas y leyes teoréticas son descritos en la ciencia utilizando el lenguaje de las matemáticas, el cual está basado en distinciones. Esta visión de la ciencia es por lo tanto completamente compatible con la perspectiva no-dual, la cual describe al mundo como emergiendo a través del acto de aparentes distinciones entre la realidad no-dual. Esto también provee una comprensiva respuesta a preguntas como por qué las matemáticas son tan efectivas para describir el universo físico.

A raiz não-dual da Ciência e da Religião
Thomas J. McFarlane

Resumo

Muitas tentativas para reconciliar ciência e religião focalizam em conflitos entre religiões específicas e uma visão mundial científica, mas há um desafio fundamental nessa reconciliação que é imensamente ignorada. A ciência moderna é considerada convencionalmente como um método de descobrimento e da descrição do real; objetos existentes independentes e das leis da nutureza. As religiões principais da humanidade, em contraste, se inspiram em místicos que ensinam que a realidade é fundamentalmente não-dual, e especificamente que a distinção entre o subjetivo e o objeto não são basicamente reais. Consequentemente, para estes místicos, não há um universo objetivamente existente ou leis para a ciência investigar ou descrever. Dessa perspectiva, o desafío fundamental para reconciliar ciência e os ensinos místicos é o de explicar como a ciência é possível dado que a realidade é fundalmente não-dual. O que é o estudo da ciência se não existe objetivamente um mundo? Como podem as leis da natureza serem compreendidas de uma perspectiva não-dual? Depois dessa primeira exibição que a ciência não tem nenhuma necessidade para a suposição de um universo objetivamente existente ou de leis, o autor propõe que a ciência pode ser vista como uma maneira de investigar a realidade que procura a ordem sob a forma dos relacionamentos invariáveis entre dados observados (ex. “leis"). Além disso, as medidas pragmáticas e leis teóricas são descritas na ciência usando a linguagem da matemática, que é baseada em distinções. Essa idéia da ciência é assim completamente compatível com uma perspectiva não-dual, que descreve o mundo como que se elevando através do ato de fazer aparente distincões com a realidade não-dual. Igualmente dá uma explicação compreensível às perguntas tais como porque a matemática é tão eficaz em descrever o universo físico.

Die nicht-dualen Wurzeln der Wissenschaft und der Religion

Thomas J. McFarlane

Zusammenfassung

Bei den Bemühungen Wissenschaft und Religion in Einklang zu bringen konzentriert man sich meistens auf die Konflikte, die aus deren unterschiedlichen Weltanschauungen resultieren. Doch sollte eine wesentliche Herausforderung, die weitgehend ignoriert wird, überwunden werden. Üblicherweise betrachtet man die moderne Wissenschaft als eine Methode, um die Realität unabhängig von den vorhandenen Erscheinungsformen und Naturgesetzen zu erkennen und zu beschreiben, dies im Gegensatz zu den großen Weltreligionen, die sich von den Mystikern inspirieren lassen. Letztere lehren, dass die Realität grundsätzlich nicht dual ist und insbesondere, dass es letztendlich eigentlich keinen Unterschied zwischen einem Subjekt und einem Objekt gibt. So gibt es für diese Mystiker kein objektiv vorhandenes Universum und auch keine Gesetze, die die Wissenschaft untersuchen oder beschreiben könnte. Die Herausforderung, Wissenschaft und Religion zu verbinden, besteht lediglich hierin, der Wissenschaft zu erklären, dass die Realität letztendlich nicht dual ist. Wenn es keine objektiv vorhandene Welt gibt, was studiert dann die Wissenschaft? Wie können die Naturgesetze aus einer nicht dualen Perspektive verstanden werden? Aus dem Vorhergegangenen ergibt sich, dass die Wissenschaft bezüglich der Feststellung eines objektiv vorhandenen Universums nicht benötigt wird. Deshalb schlägt der Autor vor, die Wissenschaft als einen der Wege zu betrachten, der uns erlaubt die Realität auf Basis von unveränderlichen Zusammenhängen zwischen empirische Gegebenheiten (m.a.W. Gesetzen) zu untersuchen. Außerdem benutzt man in der Wissenschaft die Sprache der Mathematik, deren Grundlage sich auf Unterschiede bezieht, um empirische Messungen und theoretische Gesetze zu beschreiben. Diese Sichtweise über die Wissenschaft ist also vollständig kompatibel mit der nicht-dualen Perspektive; denn sie beschreibt lediglich die Welt, die erst aus der Darlegung der Unterschiede der nicht-dualen Realität entsteht. Dies ergibt auch eine nachvollziehbare Antwort auf manche Fragen u.a. warum die Mathematik so geeignet ist für die Beschreibung des physischen Universums.

Introduction

Science and religion are typically understood today as significantly different approaches to understanding the world and humanity's place in it. *Science* in the present paper refers specifically to empirical science, i.e., the investigation of the world according to the scientific method, which involves formulating empirically falsifiable hypotheses, testing the hypotheses in controlled experiments, and revising the hypotheses accordingly. Scientific theories, however, are conventionally understood as representing natural laws of an objectively existing physical reality (a position known as scientific realism). Moreover, modern science has been commonly associated with scientific materialism (also known as metaphysical naturalism), which rejects supernatural explanations and concepts. Consequently, it is at odds with notions of a reality beyond the physical (e.g., notions of God, soul, or spirit) that are fundamental to religion. Moreover, the notion of a non-dual reality, which is a common testimony of the mystics, is fundamentally incompatible with both scientific materialism and scientific realism, which posit an objective reality existing independent of subjective observation.

One approach to viewing the relationship between science and religion is to separate them into "non-overlapping magisteria,"[1] segregating each to its distinct domain. This approach requires that science refrains from denying the reality of a supernatural reality and that religion refrains from making claims regarding the natural world. However, a non-dual reality cannot be confined to a supernatural domain that is divided from a natural domain. Thus, if the non-dual nature of reality is to be accepted as an essential core of religion, the two magisteria cannot be divided. Instead, reconciliation requires a comprehensive and integrative view of all of reality.

Some attempts at integrative reconciliation have been based on suggestive parallels between specific scientific and religious worldviews.[2] [3] This approach, however, attempts to connect the two domains on the superficial level of particular scientific and religious worldviews. As a result, when the scientific worldview shifts, the connection may well be lost. For a durable reconciliation, a connection at the deeper roots of both science and religion is needed. Another problem with this approach is that it fails to reconcile the notion of a non-dual reality with the conflicting notion of scientific realism.

The first two sections of this paper examine in more detail the core of religion and the core of science in order to clearly identify the fundamental barriers to reconciliation. The sections that follow then propose a way to dissolve these barriers and discover a deep and lasting connection between them.

The Core of Religion

Despite the differences in doctrines and rituals of the major religious traditions of the world, there is a significant agreement among the testimony of the contemplative mystics of these traditions.[4] While their teachings are expressed differently due to differences in culture, language, and other factors, they share a number of core principles and practices. In the present paper, a mystic is defined as someone who adheres to these core principles.

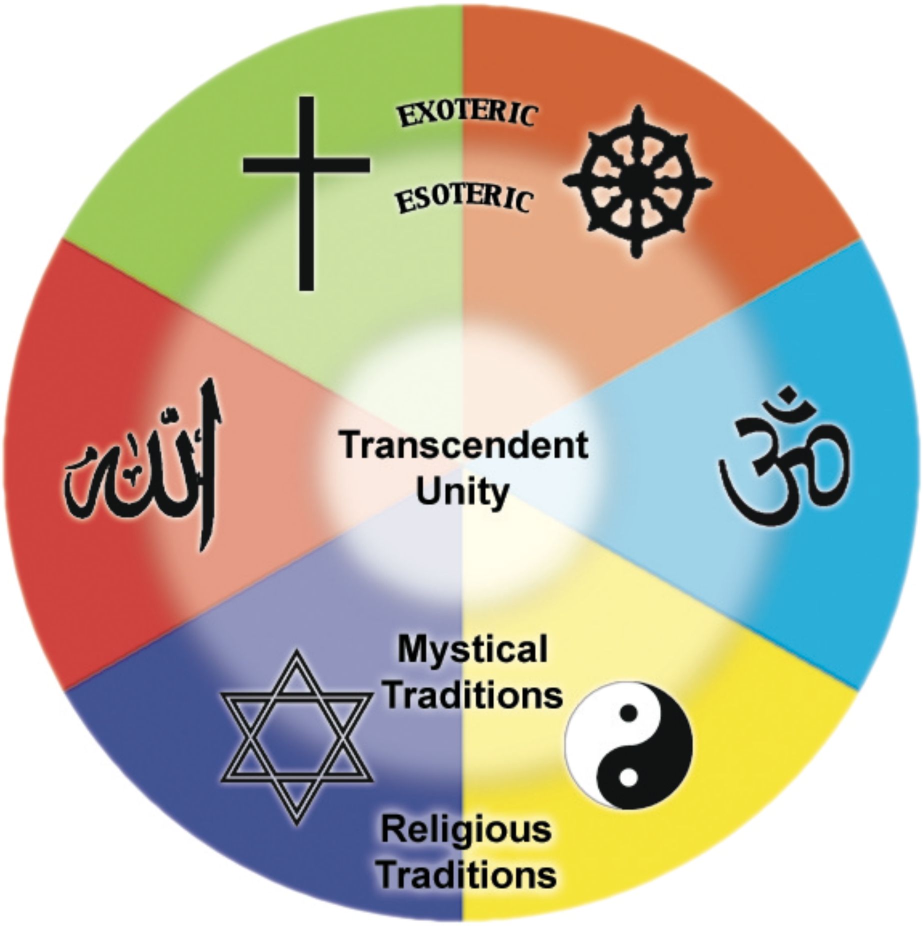

Fig. 1. Religions differ in their exoteric doctrines but share common principles within their esoteric (mystical) traditions, converging at a non-dual core.

First of all, mystics testify that reality is ultimately non-dual, and in particular, there is no true division between subject and object, self and world, soul and God. Although human experience is typically dualistic (e.g., world and self are experienced as separate), mystics claim that this is a mistaken perception. Another core teaching of the mystics is that the ultimate truth about reality cannot be expressed in words or grasped by thought because words and thoughts are based upon distinctions and duality, so they cannot, even in principle, describe non-dual reality. Thus, from a mystic's perspective, even religious scriptures and doctrines do not capture the truth. Nonetheless, although the mind can never grasp non-dual reality, the mystics testify that it is possible to directly realize this non-dual truth. Indeed, such a realization, which reveals the ultimate identity of oneself with reality, is what frees one from the suffering that results from dualistic experience. For the mystic, the soteriological power of religion ultimately derives from this non-dual truth and the possibility of realizing it.

To facilitate such a realization, mystics teach a variety of contemplative practices, which also share common features across the traditions. Among these features are practices to help free the mind from distractions, practices to inquire into the nature of experience, and practices to foster virtues such as love and compassion. Thus, mystics view religion as providing a means for mystical transformation, in which teachings are taken not as fixed beliefs but as instructions for individuals to directly investigate reality for themselves, leading ultimately to a direct realization of non-dual reality.

Thus, insofar as such mystics can be found within the diverse major religious traditions of humanity, there is a common core to these religions, defined by these common principles and practices of the mystics. In addition, the non-dual reality itself may also be viewed as a common core, insofar as it transcends religious doctrine and indeed all distinctions whatsoever.[5] This view of religion, of course, is not necessarily shared by other members of these religious traditions, some of whom view religious truth as based fundamentally and literally upon scripture. Indeed, some mystics have been charged with heresy by religious authorities due to such differences of view. Despite these tensions, however, many mystics are revered within religious traditions as being among its greatest teachers and reformers.

Having identified the non-dual teachings and practices of the mystics as representing a common core of religions, the next section identifies the core of science. Then follows a discussion of the deep connection of the core of science with the non-dual core of religion.

The Core of Science

Science has had impressive success producing ever more comprehensive, precise, and powerful theories. Arguably the most natural explanation for this success is the doctrine of scientific realism, which understands scientific theories as describing an objectively existing physical reality. As Einstein stated, "The belief in an external world independent of the perceiving subject is the basis of all natural science."[6] Nonetheless, there have been several prominent modern philosophers who have rejected or challenged the notion of an objective physical reality and the claim that science provides knowledge of it.

George Berkeley, for example, famously asserted that "to be is to be perceived"[7] and argued that the belief in the existence of matter or any other mind-independent reality is incoherent. The regularity of perceptions, in Berkeley's view, are the result of divinely established laws. The success of science is then, in effect, a divine miracle. David Hume took the bold step of questioning general laws altogether. Hume argued that causality is merely the mental association of perceptions, and he challenged the validity of induction from a limited number of past experiences to a general law.[8] The regularity of experience, on this view, is comparable to a habit.

Immanuel Kant answered Hume's skepticism with his influential philosophy of transcendental idealism. Kant admitted that one can never know "the thing in itself" (i.e., objective reality).[9] Nevertheless, Kant argued that certain knowledge of causality and other fundamental principles of natural science can be grounded in subjective transcendental forms and categories that are necessary for the possibility of experience and understanding. Some of these principles of natural science, however, have subsequently been empirically falsified (e.g., it turns out that physical space is not, as Kant argued, Euclidean space but is curved, casting doubt upon a key feature of Kant's philosophy.

Logical positivism, founded by Rudolf Carnap and others in the early 20th century, was an influential philosophical movement that emphasized logic and empirical facts as the foundation upon which all meaningful propositions must be ultimately based. Concepts in scientific theories, on this view, only have meaning insofar they can be ultimately reduced to observational facts. [10]Consequently, asserting the existence of theoretical entities independent of such theories and facts is regarded as meaningless. More generally, logical positivism viewed metaphysical statements, as well as statements of value, as meaningless.

A number of philosophers raised serious arguments against logical positivism. Willard Van Orman Quine challenged its reductionism and the synthetic/analytic distinction.[11] The analytic/synthetic distinction contrasted analytic statements (which are true by virtue of logic and the meaning of the terms used) with synthetic statements (which are true by virtue of being facts of experience). Quine argued that this distinction in untenable because it is impossible to define the meaning of terms without somehow making reference to facts of experience. Quine also challenged the notion of reductionism in logical positivism. The truth of a synthetic statement, according to the logical positivists, ultimately is reduced to the truth of the empirical facts upon which it is based. However, the statement of such facts, Quine argued, requires the use of an unambiguous sense-datum language that itself is not given to us as a fact. This criticism is echoed in Norwood Hanson's challenge of the fact/theory distinction.[12] Hanson argued that the determination of any empirical fact implicitly requires interpretation in terms of some theory that is taken for granted. Consequently, all facts are theory-laden, and there is no such thing as a pure fact, independent of theory. This, together with Quine's criticism, further challenged the notion that theories in science are tested against "pure" empirical facts, which are somehow theory-independent. Consequently, when a theory is tested and disagrees with experimental data, the theory itself is not necessarily falsified. It may be that the error originates with the interpretation of the facts, the prediction from the theory, or the performing of the experiment.

Similar arguments regarding the nature of scientific knowledge had been made earlier by Pierre Duhem,[13] who also is credited with pointing out that theories are underdetermined by the facts. Because a given set of empirical facts is compatible with multiple distinct theories, the facts alone do not determine a single unique theory. In such situations scientists often appeal to principles such as Occam's razor to eliminate theories that involve unnecessary assumptions. However, its application may not result in just one unique theory. Moreover, because it is an aesthetic principle designed to help select a simple and elegant theory, it different scientists may apply it to arrive at different conclusions. The underdetermination of theory by the facts thus remains a challenge to scientific realism, because the same set of facts is compatible with different objective realities corresponding to different theories. Also, the same theory may admit several different interpretations. This is illustrated, for example, by the lack of consensus among physicists regarding how to interpret quantum theory as describing an objective reality. Moreover, according to Karl Popper's influential criterion, scientific theories are by definition falsifiable (i.e., they must be capable of being refuted by experimental observations).[14] As a result, every scientific theory is necessarily provisional, and there is always the possibility that a new experiment can falsify it. Thus, science can never provide any final, definitive theory of the world.

Moreover, as emphasized by Thomas Kuhn, science has undergone many paradigm shifts that have significantly changed fundamental scientific conceptions of the physical world.[15] For example, Aristotelian physics provided the foundation for understanding the physical world for almost two thousand years. With the rise of modern science, the Aristotelian paradigm was supplanted by the Newtonian paradigm of classical physics, and in the 20th century another revolution established quantum physics and relativity as fundamental cornerstones of the scientific paradigm. Eventually, there no doubt will be yet another revolution in physics that shifts the foundations of scientific understanding. For example, it is a goal of contemporary physics to develop a new theory that unifies quantum physics with general relativity, necessarily revising fundamental concepts once again. These dramatic paradigm shifts pose challenges to scientific realism's claim that any given scientific theory or paradigm provides a true or final description of an objective physical reality.

In view of these serious philosophical challenges to scientific realism, it is questionable whether it is essential to science at all. Indeed, the scientific method itself makes no reference to an observer-independent reality, and it continues to guide scientific progress despite major changes and increasing uncertainty regarding the objective reality that, according to scientific realism, science is supposed to describe. Thus, scientific realism may be discarded, and empirical science, in essence, may be viewed as a method involving formulating empirically falsifiable hypotheses, testing the hypotheses in controlled experiments, and revising the hypotheses accordingly. This essential method of scientific investigation, moreover, is similar in many respects to the method mystics use to investigate reality.[16] Both have teachings (doctrines/theories) that are tested in experience (contemplative practices/scientific experiments) by trained practitioners, and these two aspects feed back on each other to refine and deepen understanding.

These similarities suggest that, if science can be coherently understood without the belief in an external world independent of the perceiving subject, then a major barrier is removed to tracing science back to a non-dual core in common with the mystical core of religion.

Non-dual Science

This section begins by showing that it is unnecessary to posit an objective reality behind the objects of scientific theories or the empirical measurements of their properties. Due to the widespread tendency to reify both empirical measurements and the objects of scientific theories, it is useful to critically examine both scientific measurement and scientific theory. Specifically, it can be seen that 1) scientific theories can be understood without assuming that they describe an objectively existing substance, 2) scientific measurement can be understood without assuming that properties exist independent of observation, and 3) even the language of scientific theory and measurement, mathematics, can be understood in terms of distinctions formed in non-dual reality.

A. Theory

Scientific theories are understood in scientific realism as describing physical objects that have an objective existence. When the scientific description of objects is closely examined, however, no objectively existing entity is found. The following illustration is inspired by an analysis found in the Buddhist madhyamika philosophy.[17] Consider the scientific description of a wooden chair. If the chair is disassembled into a collection of wooden pieces, no objectively existing substance has been destroyed. Yet the chair no longer exists. Thus, the existence of the chair, as chair, is not based on any objective substance: it is an aggregation of parts in a particular form that is defined by convention. Scientific realism responds to this analysis by using material reductionism to claim that the objective substance resides not in the chair but in its constituent parts. The same analysis, however, applies also to the parts of the chair: If the wooden pieces of the chair are ground to sawdust, no substance has been destroyed. Yet the wooden pieces no longer exist. They, too, exist as conventional forms.

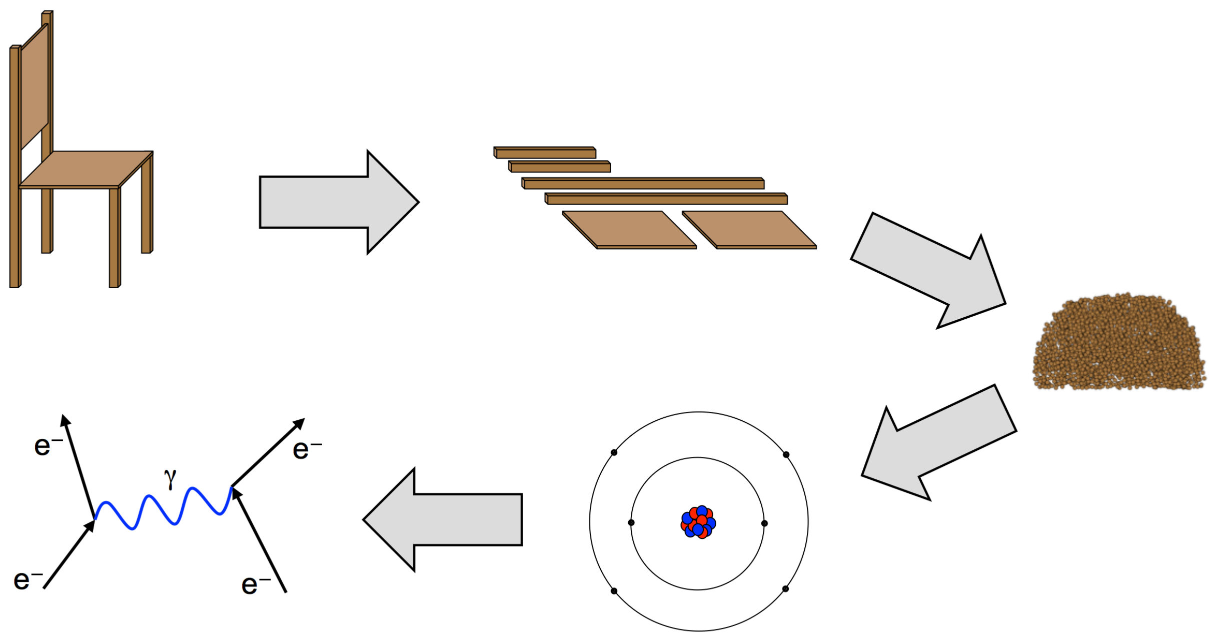

Fig. 2. Upon analysis, no substance can be found in a physical object such as a chair. Each step of decomposition only alters the form. No substance is ever found at any stage.

Does the objective substance reside in the particles of sawdust? They can be dissociated to their elementary atoms, and again no substance is destroyed. Yet the sawdust no longer exists after such dissociation. It, too, was mere form. Are the atoms an ultimate substance? Even atoms can be broken up into elementary subatomic particles without destroying any objective substance. So, even atoms exist as conventional forms. As for the subatomic particles, they can be transformed into other particles and into energy, so even these elementary particles can be transmuted and are not final immutable substances. They are described as excited states of a quantum field, i.e., as conventional forms. With the quantum field, we reach the most basic level of physical description. There are several problems attributing substance to the quantum field, however. First, because experiments measure only the attributes of the excitations of this field, and never measure the field itself, the field is not anything that directly corresponds to any empirical measurement. Second, the quantum field is mathematically a complex-valued probability function in an infinite dimensional Hilbert space. This abstraction, however, fails to correspond to any intuition of an objective physical substance. Finally, as discussed earlier, this description may fundamentally change when another theory supersedes the current theory, so the objective reality corresponding to the current theory would then be wrong. For all these reasons, the attempt to understand a chair (or any other object) as ultimately reducible to an objective substance is problematic. While the notions of a chair or atom are convenient concepts, they properly refer to recurring forms or patterns arising in the context of physical measurements and theories, and do not in themselves imply or require the existence of a corresponding objective substance.

The reification of objective substance associated with physical concepts in science is analogous to how fixed patterns are habitually seen in experience, e.g., when lines / – \ are joined to form the letter A or when stars are arranged to form the constellation of the big dipper. There is no real, objective A or big dipper. Yet, when these patterns are experienced, they are habitually experienced as being more than just a conventional arrangement or pattern.

The existence of objective substance in science may thus be dispensed with as both unnecessary and problematic, and science may be viewed instead as describing order. As Heisenberg, a leading developer of quantum theory, writes, "The ultimate root of appearances is therefore not matter but mathematical law, symmetry, mathematical form. ...Mathematical law, a mathematical symmetry, ultimately underlies the atomic structure of matter."[18] The cosmos as measured and described by science is thus more appropriately viewed as order rather than objective substance. This is consistent with the etymological meaning of *cosmos* (κόσμος), which in Greek means not only the universe, but also order, and beautiful adornment . Bohr expressed a similar idea this way: "Physics is to be regarded not so much as the study of something *a priori* given [i.e., an external world], but rather as the development of methods for ordering and surveying human experience."[19]

B. Measurement

Having shown that theories of science need not be seen as describing an objective reality, this section now examines empirical measurements. Do the observational data of science exist objectively? Among all theories of physics, quantum theory shows most clearly that properties do not exist independent of observation. As Heisenberg writes, "The measuring device has been constructed by the observer, and [so] we have to remember that what we observe is not nature in itself but nature exposed to our method of questioning. Our scientific work in physics consists in asking questions about nature in the language we possess and trying to get an answer from experiment by the means that are at our disposal."[20] For example, depending on the measuring device used for observation, an electron can exhibit particle-like or wave-like properties.

This qualitative wave-particle duality has a quantitative expression in the form of Heisenberg's famous uncertainty principle (or principle of indeterminacy), which prohibits the simultaneous determination of exact values for any two complementary variables. For example, the uncertainty principle implies that the position x and momentum p in the x-direction (p_x) of an electron do not simultaneously have exact values. More specifically, denoting the uncertainties in x and p_x by Δx and Δp_x, respectively, then Heisenberg's uncertainty principle states that $(\Delta x)(\Delta p_x) \geq h/4\pi$, where h is Planck's constant. Consequently, a very precise determination of a particle's position (i.e., small Δx), corresponds to a less precise determination of its momentum (i.e., large Δp_x), and conversely. (Because of the extremely small magnitude of Planck's constant, $h \approx 6.626 \times 10^{-34}$ m^2kg/s, these constraints are not noticeable for relatively large objects in everyday life. Nevertheless, the uncertainty principle is fundamental and ubiquitous, and it has profound consequences at the quantum level.) Significantly, because the indeterminacy of the position (Δx) and the indeterminacy of momentum (Δp_x) are never zero, the position and momentum of an electron are always to some extent inherently indeterminate. It is not that the scientist simply lacks knowledge of a true, exact value for position and momentum due to an imperfect measurement apparatus or due to disturbances of the measurement process (the so-called "observer effect"); instead, the position and momentum have no definite values. How the scientist decides to observe the electron determines whether the indeterminacy of position is made small (as in a position measurement) or the indeterminacy of the momentum is made small (as in a momentum measurement). The position and momentum properties thus do not have an exact objective existence, and the extent to which they are made precise depends on a specification of the manner of observation.

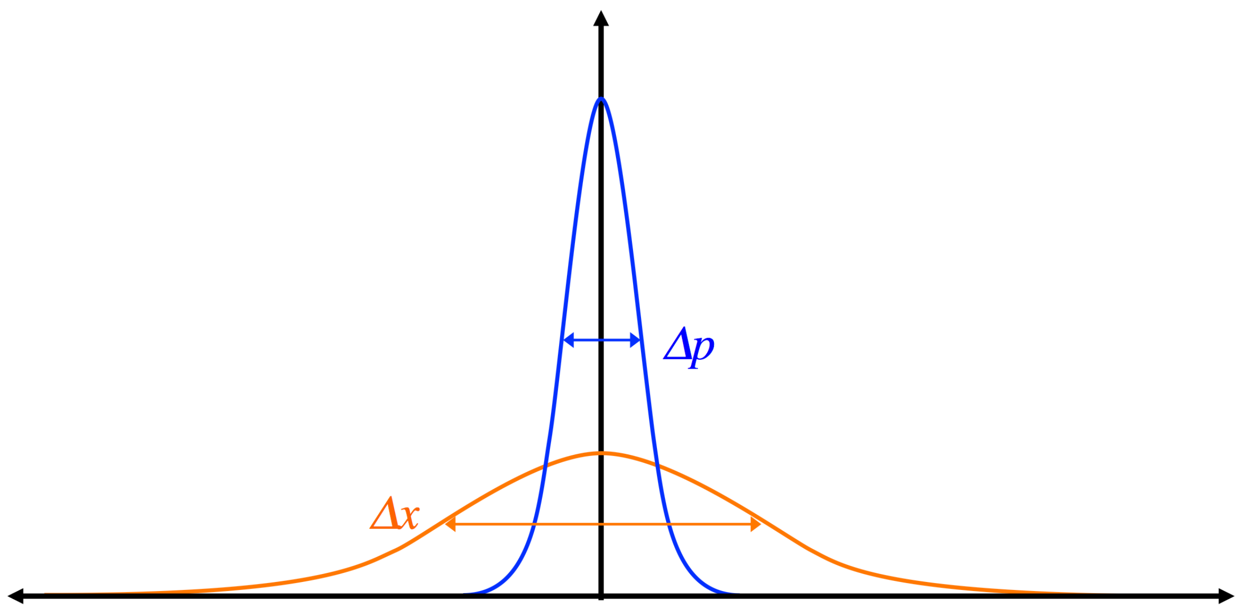

Fig. 3. An illustration of Heisenberg's principle of indeterminacy showing that if we choose to measure the momentum of a particle precisely (small Δp), its position becomes uncertain (large Δx).

Similarly, in Einstein's theory of special relativity, physical properties such as length and mass exist only in relation to a choice of reference frame. They do not have well-defined values independent of the specification of the observational reference frame. For example, consider a boxcar sitting still on railroad tracks. Suppose someone standing at a train station measures its length to be 50 feet and its mass to be 30 tons. If the boxcar is then observed by someone moving along the tracks at 80% the speed of light, it will have a length of 30 feet and mass of 50 tons, i.e., its length will be shorter and its mass larger. Because the length and mass measured from one reference frame are different from the length and mass measured from another reference frame, it is meaningless to attribute definite values for length and mass to the boxcar without first specifying the reference frame of the observation. Thus, these properties of the system have meaningful existence only in relation to a choice of reference frame.

Even in classical physics, a simple measurement of length only has a meaningful value relative to the choice of a measurement device and measurement procedure. For example, a number cannot be unambiguously assigned to the length of the boxcar unless the units of measurement, such as feet or meters, are also specified. In addition, the measured value for length has a clear and definite meaning only if the measurement device is calibrated to a universal standard and a standard measurement procedure is followed. For example, imagine two measurements of the length of the boxcar using two rulers that do not use the same units (one uses feet, another meters), or using two rulers that are not both properly calibrated (both use meters, but one is actually longer than a the standard meter), or using different measurement procedures (measuring between the axles vs. measuring between front and back walls). Under these circumstances, the meaning of the measured values is ambiguous. This demonstrates that the values of empirical measurement results arise in dependence upon conventions chosen for measurement and do not have an independent objective existence independent of those choices. Moreover, nature does not dictate particular units of measurement, or particular measurement procedures. These are all free choices made by scientists, and the results of measurements depend on these choices. Only if it is forgotten that these conventions were adopted does it seem as if the measured values have objective existence.

The dependence of measurement results upon conventions, however, does not imply that the data can be made to conform to any arbitrary law. For example, consider an object falling in a vacuum under the influence of a uniform gravitational field. As long as uniform standards and conventions are adhered to, the measured height of the object will always vary with the square of the measured time irrespective of whether distance is measured in feet or in meters, or whether time is measured in seconds or minutes. The necessary precondition for the possibility of identifying regularities in the measured data is that the choice of conventions for making observations is uniform. It is by imposing upon the method of making scientific observations the condition that they be standardized and uniform that it becomes possible to coherently relate diverse measurement data to each other and describe them in terms of patterns of order that are invariant with changes in time and place. By making observational choices consistently and uniformly, it is then possible to understand the measurements as expressions of an order that is independent of those particular observational choices. As physicist Wolfgang Pauli stated, “The instrument of observation (subject) must possess a higher degree of stability than the system observed (object).”[21]

Although the order identified by science is invariant with changes in time and place, such order arises by design in dependence upon these general preconditions for conducting meaningful science.[22] Science is, in this view, a way of investigating reality to seek out order that is invariant with time and place. The necessary preconditions for conducting science may be viewed as defining a fundamental “reference frame” or “lens” for observing reality. Stated differently, the very definition of science imposes conditions on how observations are made and related to each other so that it becomes possible to describe observations in terms of such order. The invariance in the order, therefore, is a natural consequence of investigating reality through the lens of science, and the laws of nature arise relative to the framework of science itself and do not have objective meaning independent of that framework.

A fundamental barrier between the core of science and the core of religion is thus resolved by recognizing that science, at its core, need not be understood as measuring or describing an objective reality. Instead, it measures and describes an order that arises when investigating reality through the lens of science (which seeks to identify and isolate order). This significant revolution in perspective makes science, and its success, comprehensible without appeal to scientific realism. By liberating science from scientific realism, this vision helps makes possible a deep reconciliation of science and the mystical core of religion at their very roots. But to entirely complete the task, it is necessary to see explicitly how science can be traced back to its roots in non-duality. To do this, the next section examines the language used by science to describe both theoretical laws and empirical measurements: mathematics.

C. Mathematics

Galileo declared that the universe "cannot be understood unless one first learns to comprehend the language in which it is written. It is written in the language of mathematics."[23] This view has its origins in ancient Greece, with Pythagoras declaring that everything is made of number,[24] and Plato describing in the *Timaeus* how physical elements are made of basic geometrical shapes.[25]

The fundamental role of mathematics in modern science applies both to the formulation of theories with mathematical equations and to the expression of empirical measurement results with mathematical quantities. Using mathematics, the relationship between empirical observations and conceptual theories can be made rigorous and precise by relating the numerical measurement results to the theoretical equations. For example, the equation $h=(^1/_2)gt^2$ relating the height, h, of a falling object to the square of time, t, and the empirically determined value of the acceleration due to gravity, g, can be used to deduce a precise numerical prediction of how long it will take an object to hit the ground when dropped from a particular height. The general equation can thus be tested empirically by making a precise measurement of the height and the falling time and examining whether the measured numbers satisfy the equation. The empirical measurements then either confirm or falsify the theory. This illustrates how the use of mathematical language by both theory and experiment allows theories to be related to experiment with precision and rigor.

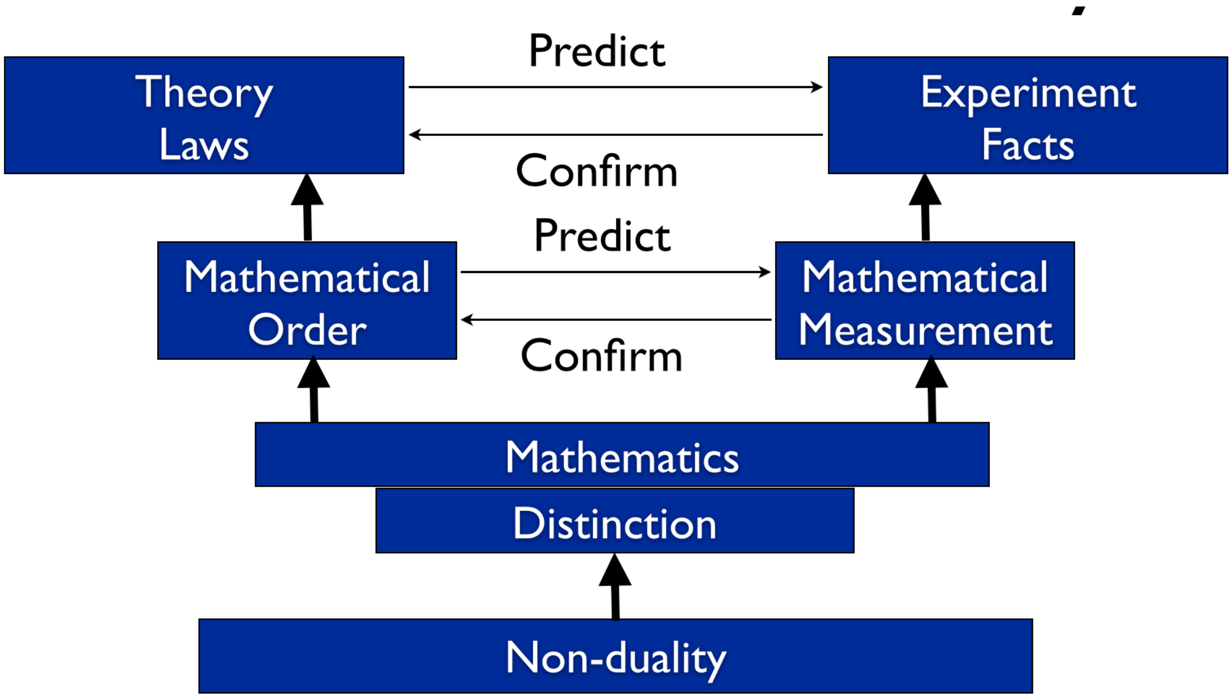

Fig. 4. The language of mathematics is used in science to represent both theoretical laws and empirical measurements, and provides a rigorous and precise link between the two. Mathematics, in turn, has distinctions as its basic elements.

Mathematics, like all language, is based on distinction and duality. Indeed, the beauty and power of mathematics derives from the fact that the distinctions in mathematics are made as clear and precise as possible. So, it might seem impossible to reconcile these precise distinctions with non-duality. But, as will be shown below, the clarity of mathematical distinction actually helps trace the root of all mathematics back to distinction itself. All that remains then is the single problem of reconciling distinction with non-duality, and this is exactly the root problem that the mystics address in their teachings and claim to overcome by direct realization.

One of the great accomplishments of 20th century mathematics is the development of set theory as a foundational language for unifying all of mathematics. The mathematical notion of a *set* is simply the idea of taking a collection of things together into a single group. As Cantor stated, "A set is a Many that allows itself to be thought of as a One."[26] In other words, a set is simply the act of drawing a distinction. This distinction is denoted using a pair of brackets, e.g., {X, Y} refers to the set whose elements are X and Y. Sets can be used to construct and express everything in mathematics, from the natural numbers to the most abstract mathematical equations. For example, the natural numbers can be constructed sequentially as follows: Start by forming the set that does not contain anything { }, and call that set *zero*. Next, form the set of that set { {} }, and call that *one*. Next, form the set of those previous two sets { {},{{}} } and call that *two*. Repeating this, all the natural numbers can be represented as sets, and arithmetic operations can be expressed as relationships between these sets. Note that numbers defined in this way do not presuppose any more fundamental substance or thing, but are constructed from nothing except the act of making a distinction. Distinction can also be used to express the laws of logic in terms of making distinctions.[27] Extending this, one can show that all of arithmetic (including arithmetic operations, the laws of arithmetic, and the numbers themselves) can be expressed as distinctions and, in fact, can be seen as naturally arising from a single distinction.[28] This suggests that all of mathematics can be expressed as distinctions that grow organically from a single seed, the first distinction. Consequently, both the numerical quantities expressing empirical measurement results and the equations expressing theoretical laws and patterns of order can be expressed in terms of distinctions, all of which ultimately unfold from a single distinction. As long as the first distinction is not reified, all of mathematics, and thus all scientific measurements and mathematical equations relating them, can be seen as rooted in non-duality.

D. Physical concepts of time and space

In addition to mathematical concepts, the framework of empirical science also involves certain basic physical concepts such as time and space. These fundamental scientific concepts are implicit in what it means to make measurements at different times and places, and relate those measurements to each other to find an order that is invariant with respect to changes in time and place. These basic concepts can also be seen to arise naturally from non-duality through the act of making a distinction.

Consider time. When any appearance is regarded as arising, a distinction is implicitly made between the appearing thing and the absence of the thing (i.e., nothing). Thus, any thing implicitly entails nothing, i.e., something and nothing arise together in mutual dependence upon one another through the act of making a distinction. Note that the distinction, the thing, and nothing need not be reified. If the distinction is reified, however, the thing is regarded as present while the nothing is regarded as not being present. The nothing, consequently, is regarded as existing but without being present. Its existence is thus posited as an absent existence, which is called the *past*. When the thing passes away, it then is regarded as having an absent existence in the past, and a nothing (i.e., the absence of the thing) is present. This nothing is considered as having arisen in the present from another absent existence, which is called the *future*. Thus, the present and future arise from making and reifying a distinction between something and its absence, nothing. This simple proto-time is the seed of the view of objects as existing in time. By further developing it and making this proto-time rigorous with measurements using standardized clocks and numerical systems, scientific quantifiable time emerges.

Similarly, consider space. When any appearance is regarded as arising, a distinction is implicitly made between the presence of the thing in one place, called *here*, and the absence of the thing everywhere else, called *there*. Thus, a thing here implicitly entails absence of the thing there, i.e., here and there arise together in mutual dependence upon one another though the act of making a distinction. The distinction, the thing, and nothing, need not be reified. If the distinction is reified, however, the thing is regarded as separate from its absence, which is reified as a space. Consequently, any thing implicitly entails a kind of primitive localization in a containing space. This simple proto-space is the seed of the view of objects as existing in space. By further developing it and making this proto-space rigorous with measurements using standardized rulers and numerical systems, scientific quantifiable space emerges.

Thus, these basic concepts of time and space also arise naturally from making a distinction. Combined with the distinctions that unfold into the mathematics of measurements and laws, it becomes clear how science arises from within non-dual reality as a way of drawing distinctions so that order appears.

The Root

Science can be viewed as mathematics combined with basic concepts of time and space, which all can be seen as arising from a single distinction. This is also how the mystics have described the apparent arising of a world within non-dual reality: through the creation of distinctions.[29] Most mystics, of course, did not use the language of mathematics to express this insight. Instead, they spoke in terms such as the division of heaven and earth, light and dark, or subject and object. The principle, however, is the same. Their testimony is that, although distinctions appear and unfold in amazing variety and complexity, they do not represent real division or separation.

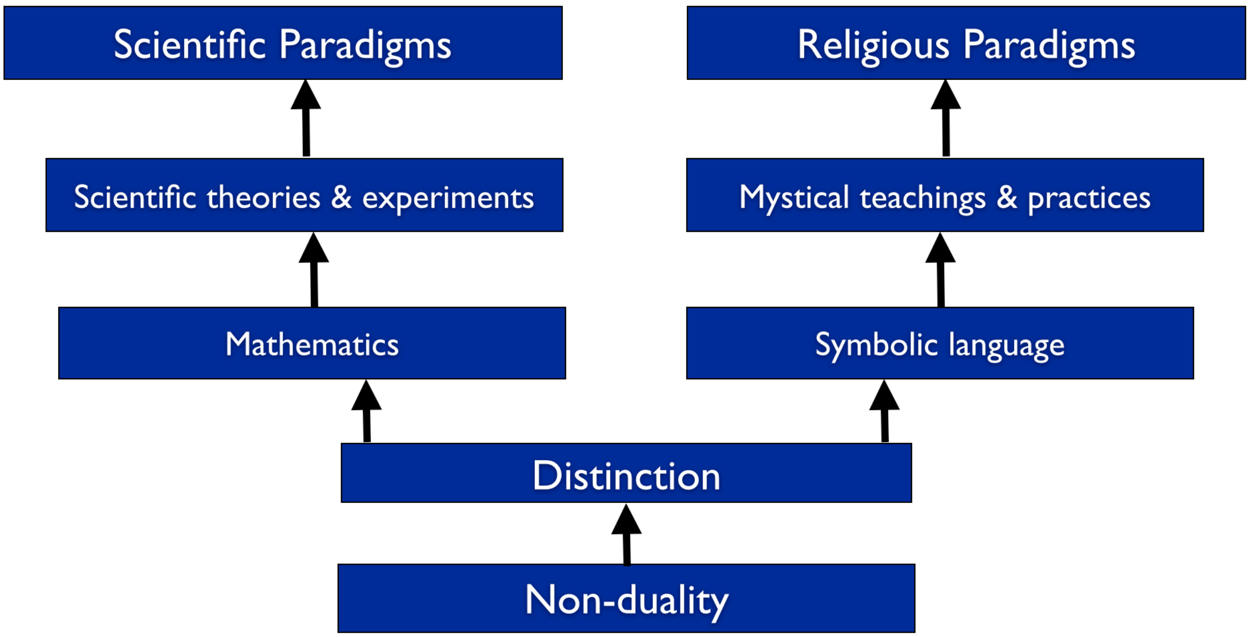

Fig. 5. Specific paradigms of science may have parallels with specific religious paradigms, but a deep and durable connection between science and religion is found by tracing them both back to their common roots in non-duality.

A common metaphor to describe the appearance of the world within non-dual reality is that of waves on the surface of the ocean: the waves may be viewed as distinct forms arising and passing but there is no real division between one wave and another, or between a wave and the ocean itself. Similarly, if any distinction at all is examined, whether empirical or conceptual, it is found to have no objective existence. For example, although the colors of a rainbow may be distinguished, nature does not dictate where exactly the distinctions between specific colors are drawn, or that they are drawn at all. The same is true of all empirical distinctions. As for conceptual distinctions, they are fundamentally free and unconstrained creations of the mind. Once certain primary distinctions are adopted, of course, they may be allowed to constrain secondary distinctions (as, for example, when a set of axioms and laws of logic is adopted as a foundation for exploring the concepts that are logical consequences of those axioms). Such constraints, however, are not imposed by some objective reality.

Conclusion

From non-duality, distinction is imagined. From imagined distinction arises number and form, time and space. These, in turn, provide the basis for empirical measurements and the formulation of scientific theories. Science is thus rooted in non-duality. This provides a profound and durable reconciliation between science and the mystical core of religion. In such a view, science is transformed into a way in which non-dual reality knows itself through and as order, or cosmos. As Franklin Merrell-Wolff would agree, science is thus not only a mode of revelation but a path to realization.[30]

Science, in this view, is not a way of knowing an objective physical reality, but a lens through which order can be known. Empirical science, by design, provides mathematical relationships between empirical data that are expressed as mathematical quantities, both of which are, by design, invariant with time and place. The mystery of why mathematics is so effective in science[31] is then comprehensible: it is the necessary means for expressing general relationships between quantitative measurements. These general relationships are intersubjectively valid knowledge insofar as scientists all agree on the methods by which they obtain quantitative empirical measurements (e.g., definition of the system being measured, calibration of measurement devices, measurement procedures, units of measurement, and so on). As a result of adopting these conventions, there will be intersubjective agreement about experimental results (to the extent that the accuracy and precision allow). Just as mathematical knowledge is intersubjectively valid insofar as mathematicians all agree on the definitions and logic that are being used, empirical data are intersubjectively valid insofar as scientists agree on the same methods of measurement.

If a mathematical relationship expressing how measured data relate to each accurately fits the data, it is confirmed. If it does not fit the data, then it is falsified (or there may be a problem with the measurement). In either case, the relationship is preferably tested repeatedly, and if it continues to be confirmed in a wide variety of circumstances with great accuracy, scientists treat it as a well-established scientific theory. In this way, the resulting scientific theories provide highly reliable knowledge of empirical measurements. Such theories, however, are never completely certain, since they are always in principle subject to falsification by some new data. Normally, however, such new data only falsifies the extrapolation of the general mathematical relationship beyond a specified empirical domain, so that the theory remains a valid approximation for special cases. With both facts and theories rooted in mathematics that unfolds from a single distinction, this view of science does not require that objectively real entities be posited as referents of scientific theories. Instead, The cosmos described by science is a characterization of that aspect of reality which is revealed through the lens of mathematical relationships between mathematically expressed measurements, all arising in the context of conventions implicit in the very definition of empirical science.[32]

Because this view of science is expressed using dualistic words and concepts, it is subject to all the inherent limitations of any teaching. Nonetheless, this view helps to integrate and heal the apparent divisions between the cores of the scientific and religious views of reality, thereby opening up greater possibilities for mystical realization and for its fruits to flow into this world for the benefit of all beings.

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