

Essay

# Following the Footsteps of John Polkinghorne: In Search of Divine Action in the World

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**Abstract:** John Polkinghorne was, undoubtedly, one of the most influential authors in the dialogue between science and religion. His attitude is characterized by a focus on the concept of *kenosis* in response to the ontological orientation of process philosophy and theology. God's omnipotence implies the possibility that God created the universe as an evolutionary and autonomous world, which is not predetermined but has been created for openness. According to Polkinghorne, the position of this openness may be in the uncertainty associated with the world of quantum and chaotic phenomena. God's self-limitation of his own omnipotence can thus be understood as an effort to respect the autonomy of natural processes and human freedom. Such an image of God is compatible with the current state of scientific knowledge, which itself becomes the starting point for thinking about God and his relationship to the world. Thus, despite the problems of some parts of its concept, Polkinghorne creates a comprehensive integrative approach to the dialogue between science and religion.

**Keywords:** John Polkinghorne; divine action; quantum theory; chaos theory; universe; science and religion dialogue



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## 1. Introduction

John Charlton Polkinghorne (1930–2021) was, undoubtedly, one of the most influential authors in the field of the dialogue between science and religion. He was born in 1930 in a town called Weston in Somerset, England, into an Anglican family, which regularly attended religious services in a family atmosphere of deep, committed faith. Although his faith matured with the passing of the years, he never stopped practising the faith received from his parents. He first studied mathematics at Cambridge, however, and this encouraged him to continue his studies in theoretical physics and graduate in the field of quantum theory. Formed as a professional scientist who had devoted much of his life to mathematical physics, quantum mechanics, and elementary particles, he left the professorship of mathematical physics at Cambridge University in 1979 and began study at Westcott House (Cambridge), an Anglican theological college, with the support of his wife. His first idea was to dedicate himself to pastoral service in the Church of England. However, after a few years he came back to the field of science and religion and returned to university work. He was first called to occupy the deanship of Trinity Hall, and after three years, he was appointed President of Queens College at Cambridge University, a post he held until he retired in 1996. In 2002 Polkinghorne received the Templeton Prize for his career, but especially for his contributions over the last twenty years as scientist, philosopher, and theologian. Compared to other authors in this field, Polkinghorne's theological attitude is more traditional, which is, for example, reflected in his reserved relationship to process theology, although he has acquired some of its principles. In philosophy, his contribution to the study of the metaphysics of science is indisputable. Since his reflections are oriented from science to religion, theology, and the intelligibility of God, they move within the discourse of philosophical theology. Polkinghorne was a very prolific author and wrote a number of books on the subject of the interaction between science and theology, in

which many different, but interrelated, topics can be found. Let this text be a memory and appreciative retrospective of the recently deceased John Polkinghorne.

The claims that God constantly works creatively in the world through natural processes, that he works in history to redeem and save it, and that he shapes the course of an individual's life are all crucial to the Christian faith. Their very acceptability and intelligibility are now generally questioned on the basis of scientific aspects. This is one of the reasons why examining this issue is a central problem from the point of view of the Judeo-Christian tradition. One of the authors dealing with the issue of Divine action in the world is the British physicist and theologian John Polkinghorne. His concept is based on the contemporary image of the material world as brought to us by modern natural science, while reflecting elements of theistic faith, which is best reflected in three religious traditions (Judaism, Christianity, Islam) that are closely related, not just geographically and historically, but also by a common position on some important theological issues. Polkinghorne's basic starting point is a Christian perspective, but without claiming that it is the only point of view from which we can see everything that we are able to know about the mystery of God.

According to Polkinghorne, the idea of Divine action in the world is one of the central concepts of the Christian faith, because it gives meaning to Christian practice (e.g., pleading prayer) as well as religious experience. Polkinghorne emphasizes the importance of this topic for theology by agreeing with the German theologian W. Kasper, who says that "The God who no longer plays an active role in the world is in the final analysis a dead God." (Polkinghorne 2005, p. 8). Polkinghorne thus shows that one of the basic Christian beliefs is faith in a God, who is involved in a personal and caring relationship with all creation. Theology, therefore, cannot ignore the problem of Divine action in the world and must face the questions arising from the findings of modern science. On the other hand, Polkinghorne is aware, also based on his scientific background, of the explanatory power and achievements of modern science and the potential tensions that may arise when science meets the concept of Divine action.

Polkinghorne's approach can be explored from two basic perspectives, both of which have a long tradition in West Christian theology. One of them is known as "natural theology" and appears after the collapse of the medieval-Aristotelian view of the world and nature. Natural theology reached its peak in the 17th and 18th centuries, under the strong influence of Enlightenment. Representatives of this movement used reason and science, instead of revelation, as a means of achieving access to the realm of the divine. While considerations regarding natural theology have influenced many physicists, biologists are more opposed to theistic beliefs. There is a strong reductionist tendency there, which opposes the recognition of the intangible dimension of reality.

The second of these aspects is known as the "theology of nature" and can be characterized as an approach that does not begin with science, as some versions of natural theology do, but instead begins with a religious tradition based on religious experience and revelation at some point in history. However, it emphasizes that some traditional parts of the doctrine need to be reformulated in the light of contemporary science. Those who try to construct the theology of nature do not draw conclusions from reason or science in such a way as to prove the existence of God or his attributes. They use reason and science more to adapt, improve, or even reject already established theological doctrines. According to Barbour, both natural theology and the theology of nature are two attempts to integrate science and theology, albeit in different ways (Barbour 1997, pp. 98–105).

Polkinghorne himself admits that both approaches are present in his thinking. As for natural theology, he is convinced that our universe not only contains, but also creates evidence of the presence of God's mind and purpose in it. The presence of such a mind can be inferred from what Polkinghorne calls the "rational beauty of the universe". This beauty is reflected in the fact that mathematics is a highly effective instrument for describing the world. Polkinghorne sees the proof of the presence of purpose in the fact of the evolution of the universe from its beginnings in the Big Bang to the fact that we as rational beings are

here. In connection with the theology of nature, Polkinghorne states that “we are not now looking to the physical world for hints of God’s existence but to God’s existence as an aid for understanding why things have developed in the physical world in the manner that they have.” (Polkinghorne 1998, p. 13). Furthermore, referring to Lonergan, he concludes: “Theism is concerned with making total sense of the world. The force of its claims depends upon the degree to which belief in God affords the best explanation of the varieties, not just of religious experience, but all human experience.” (Polkinghorne 1998, p. 24).

Polkinghorne perceives natural theology, as well as the theology of nature, as attempts to integrate science and religion. The effort to integrate science and religion is supported by the idea of the unity of all knowledge. Our knowledge always relates to something in this world. Since the world has been created by God, according to natural theology, it reflects some Divine attributes. Polkinghorne seems to infer, from the fact that God is one, the fact that the world must ultimately be a unity. He argues that both science and theology are attempts to gain knowledge about the world. Each of these areas seeks to obtain an image of the world by its own means and methods, but this image can only be complete if the scientific and theological images are integrated into one image. Polkinghorne thus strives for the integration of science and theology in a simple perspective, and the unity of all knowledge becomes the leitmotif of all his efforts.

## 2. Scientific Rationality and Realistic Starting Point

In the process of examining science and religion, all the results of this study will depend on our epistemological basis. Polkinghorne’s conception of science respects Popper and Lakatos (in some aspects) but is convinced that they fall short in describing what science really is. Science begins with facts and strives for an idea of reality, and thus creates knowledge based on facts. However, scientific knowledge is always only an approximation, and not definitive knowledge without any signs of cracks. Polkinghorne also often refers to Michael Polanyi, especially his work *Personal Knowledge*, in order to insist on the fact that science is even a personal commitment. Science is thus an interactive balance between the empirical and theory, modulated by personal commitment.

However, with such a conception of science, the question arises: What do we really know and are able to know about reality? Polkinghorne answers this fundamental question in the spirit of his epistemology of critical realism. Science creates knowledge that, with some probability, correctly describes and depicts the real physical world. If science did not have this realistic dimension, our impressive technological adaptation to the world would not be possible. The enormous number of technical conveniences is rightly considered to be a consequence of the ability of the natural sciences to form theories that can not only explain the world, but also gradually transform it. It is natural that this success is justified by the claim that what scientific theories describe is actually present. “The natural convincing explanation of the success of science is that it is gaining a tightening grasp of an actual reality. The true goal of scientific endeavour is understanding of the structure of the physical world, an understanding which is never complete but ever capable of further improvement. The terms of that understanding are dictated by the way things are.” (Polkinghorne [1986] 2007, p. 27).

The simplest explanation of the fact that theories are true is that they are consistent with how things actually exist. For Polkinghorne “the realist view, it seems to me, is the only one adequate to scientific experience, carefully considered” (Polkinghorne [1986] 2007, p. 28), because there is a confidential connection between our knowledge of reality and reality itself. However, a sustainable, realistic position must be a critical attitude, recognizing that all scientific knowledge is “only” close to the truth and—as shown by quantum theory for example—our common notions of objectivity may prove insufficient. In his publications, Polkinghorne uses a slogan that briefly expresses his characteristic view of critical realism—“epistemology models ontology”. However, the connection between our knowledge and the structure of reality is not a simple depiction of the relationship between knowledge and reality (naïve realism). Polkinghorne’s epistemology is thus critical in the

Popperian sense of criticizing the already acquired knowledge and re-evaluating concepts, linguistic formulations, theories, and mathematical formalisms, in an effort to promote progress toward the truth (Polkinghorne 1996, p. 79). Through this attitude, one knows reality, but not in an absolute, closed, definitive, and irreversible way. Only within the scope of this critical realism is a connection or coherence between the scientific and theological approach possible for Polkinghorne.

Polkinghorne called himself a bottom-up thinker (Polkinghorne 1994, p. 4) which has its undeniable basis in the English empirical tradition, which is now (even with post-Popperian nuances) generally accepted in natural science. It is a science explaining man, the evolution of his psyche, and his knowledge as a consequence of the evolutionary process of inclusion of organisms in the external environment. Everything that can be known in this way has a bottom-up development, always starting with the facts. Constructing theories, physical, or metaphysical explanations is always an attempt to explain the facts, or more precisely why the world appears to us as science captures it. In this sense, Polkinghorne insisted on a natural scientific stance in terms of philosophical, metaphysical and theological claims, to find empirical evidence and to draw consistently rational explanations from it. "Scientists know that reality can have many surprises for us and consequently do not hold a high view of human powers of rational prevision. They believe that the question, "Is it reasonable?" is not to be answered in a priori terms but by asking the further question, "What is the evidence that makes you think it might be the case?" (Polkinghorne 2000b, p. 958).

In the case of top-down causality, higher level structures exert a causal effect on the interactions between lower-level elements. The properties of the system appearing as a consequence of the bottom-up processes have a specific character and cannot be deduced from the interacting elements themselves (nor reduced to these elements). The bottom-up and top-down approaches describe, so to speak, two separate and non-reducible types of processes. Therefore, the most appropriate approach will be to consider them as separate, yet complementary descriptions of a single system. The place where God's activity is combined with natural causality is commonly referred to as the "causal joint" (Farrer 1967, p. 65). Polkinghorne admits that our search for a "causal joint" is difficult because we seek to delve into the mystery of the divine, and therefore the answers obtained will never be definitive. Nevertheless, we are able to give some degree of explanation of how the interaction between Divine action and natural causality occurs. "If holistic causality is present it must be there as a genuine novelty, and the structure of the relationship between the bits and pieces must be open enough to afford it room for manoeuvre. In some sense there must be gaps in the bottom-up account which this top-down action fills in, but those gaps must be intrinsic and ontological in character and not just contingent ignorances of the details of bottom-up process. They must be 'really there' if they are to provide the causal joint for which we are looking." (Polkinghorne 1998, p. 59). Polkinghorne therefore argues that, although the bottom-up action is responsible for the emergence of new system properties, these properties cannot be reduced to those of lower levels of interactions. It means that the bottom-up causal connection is not closed, but contains ontological slits, which ultimately establish the causal connection. This causal connection is the place where the top-down oriented activity of God meets the bottom-up oriented natural processes.

### 3. The Nature of the Material World

In the process of sketching the image of the world, as presented to us by contemporary science, Polkinghorne presents ten of its characteristics (Polkinghorne [1986] 2007, pp. 64–85). He begins by stating that, while the world is intelligible, it is not graspable without remnant. Although the intelligibility of the world is taken for granted in almost every situation, in its most developed form, it is represented by the use of mathematics as the basic form of expression of our understanding of the physical world. Mathematical elegance has become one of the strategies of searching for or, more precisely, evaluating theories. Nevertheless, we had to give up the image of the "intelligible and unchanging" world of Newtonian and

Maxwellian physics, and we are confronted with the obscure world of quantum theory. It is connected with the questionability and unexpectedness of the world, which is linked to our inability to reach consensus on what exactly is going on in the quantum world, even though we agree on the choice of mathematical tools and our solutions correspond to experimental results. An important factor in the evolution of the universe appears to be the combination of randomness and necessity, which ensures change and development on the one hand, and preservation and choice on the other (Polkinghorne 1994, p. 81). As a final sign, Polkinghorne cites the fact of the incompleteness of the scientific worldview, related to the fact that science is limited to a certain kind of research, and at the same time, it misses many (often important) things. Science is not able to include in its system all types of experience, for example aesthetic, social, historical, cultural, or religious experience.

Throughout its history, the universe has created life, consciousness, and humanity—these are empirical facts that science knows and seeks to explain through an interdisciplinary approach, seeking certain temporary conclusions, while not ignoring existing secrets. Polkinghorne begins with the evolution of the universe, because for billions of years there has been only the evolution of the material universe, roughly as described by modern cosmology. Only at a certain stage of this development did life appear. There is no doubt, then, that life, consciousness, and humanity emerge from this very world of matter. However, it is not yet clear how this happened, and which causes and circumstances accompanied this process. In this context, Polkinghorne points to two basic problems. First, it is the problem of the time necessary to form life in all its various forms by the action of chance and necessity in the genetic code. The second, and even more fundamental, problem is the question of why organisms become more complex in the process of development. The level of our current knowledge of the organization of matter in organisms will convince us that life should tend to the simplest and most stable forms possible. So where does that surprising impulse towards increasing complexity come from? According to Polkinghorne, these problems are even greater if we focus on the evolutionary process of the brain, from its simplest forms to humans.

#### 4. Metaphysics of Open Universe

The Christian religion is based on free human activity and the experience of human activity in the world. The language we use to describe God is undoubtedly not entirely adequate, but the concept of a personal God implies that God does specific things in specific circumstances. In the biblical tradition, the idea of God acting in the world is central. Since the call of Abraham, through the exodus from Egypt, the birth, ministry, death, and resurrection of Jesus Christ, to the foundation of the Church on Pentecost, God has been presented as the one who acts in the lives of individuals and entire nations and communities. Through these “great deeds,” God creates and saves, so that the themes of creation and redemption are closely linked in biblical theology. Neither in the Hebrew nor in the early Christian tradition was God’s activity understood as occasional interventions in otherwise spontaneously running natural and historical processes, but as God’s creative and maintaining activity, which is a kind of basis for everything that happens in nature and in history.

The biblical God is not a god of deists, but he is a God who acts in the world, answering the prayers and intercessions of individuals and entire nations. However, if the material world has been constructed as a strictly mechanistic and deterministic system, then every future state of the system is determined by a previous state. In such a clockwork universe, any change to an already-determined procedure would have catastrophic consequences. Everything in this system happens with certainty and there is no point in interfering with it, for example, in the form of free human will or by specific action of God. Polkinghorne’s attempt is to show that the world is not such a system. His efforts here do not primarily relate to the basic activity of creation, or *creatio continua*, but to the problem of God’s personal interventions in human history.

In analysing the possibility of Divine action in the world, Polkinghorne assumes that this activity is analogous to the activity which is characteristic for a human being. A human being is a person who is able to act freely in the world, so if God is also a person, it is possible for him to act freely in our world. Thus, with regard to both divine and human activity, Polkinghorne focuses on the freedom to act and on the idea of personality. His analysis of human and divine activity is a great example of reasoning through analogy. Two components need to be considered when reviewing human activity. On the one hand, human activity depends on our mental abilities, especially on consciousness and intentionality. On the other hand, there is a physical element present, i.e., the human body, as an “instrument” of activity in the sense that our activities are bodily activities. The human body is also limited by our activities in at least two ways. First, there is a limitation due to “perspective”, i.e., the fact that we perceive the world “from within” our body, and we are not able to look at it from the position of “God’s eye.” Second, our bodies are vulnerable to the external effects, e.g., the brain can be destroyed by mechanical destruction or by some neurodegenerative disorder (Alzheimer’s disease). The problem with the analogy between human and Divine activity is that the physical and mental aspects of our activity are very closely linked.

According to Polkinghorne, every analogy between human and Divine activity fails on both of these problems, namely the problem of the perspective of perception as well as the vulnerability of the human body, because if we apply them to God, they bring theologically unacceptable results. It would mean limiting God to one perspective. However, the doctrine of God’s omnipotence and omnipresence expresses, among other things, the conviction that God is able to accept any perspective based on his own choice. Unlike these involuntary restrictions of God’s power, Polkinghorne uses the concept of kenosis, which points to the possibility of self-limitation of God’s power (Clayton 2012). The categories of the process, as developed by Whitehead, have been used by many theologians to reformulate Christian beliefs in the context of contemporary world. John Cobb and David Griffin expressed the bipolar nature of process theism through the understanding of God as creative-responsive love. The creative aspect of God is the primary source of order and novelty, which can be identified with the biblical concept of Logos. The responsive aspect of God expresses his temporality and influence by the development of the world. In such a view, no event is exclusively an act of God. There is a certain structural similarity between God’s work in the non-human sphere and in human life, but there are also significant differences. Thus, it can be said that God’s basic *modus operandi* is the same everywhere, but its consequences vary according to the level of being. “Process theism is sometimes called ‘dipolar theism,’ in contrast to traditional theism with its doctrine of divine simplicity. For Charles Hartshorne, the two ‘poles’ or aspects of God are the abstract essence of God, on the one hand, and God’s concrete actuality on the other. The abstract essence is eternal, absolute, independent, unchangeable. It includes those abstract attributes of deity which characterize the divine existence at every moment. For example, to say that God is omniscient means that in every moment of the divine life God knows everything which is knowable at that time. The concrete actuality is temporal, relative, dependent, and constantly changing. In each moment of God’s life there are new, unforeseen happenings in the world which only then have become knowable. Hence, God’s concrete knowledge is dependent upon the decisions made by the worldly actualities.” (Cobb and Griffin 1948, p. 47).

According to Cobb and Griffin, God builds on the past, so he always takes into account existing cultural traditions and expects free answers from individuals and communities. God loves everything equally, but this love can be revealed in a more obvious way in the tradition of one community or person than in another one. God calls everyone, but people respond in different ways. Process theologians combine Divine action in nature, in religious experience, and in Christ by using a common set of concepts. Cobb and Griffin speak of Christ as God’s supreme act (Cobb and Griffin 1948, p. 96). We have already found a tradition of God’s initiative and human response in Israel. Christ’s legacy and life are rooted in this tradition and refer to God’s purpose and love, which Christ so convincingly

manifested. Thus, in Christ, we see a specific and key case of Divine action. However, Jesus' free choice and answer in faith was needed to carry out this plan, so his humanity was not a compromise. Jesus was subject to the same conditions and limitations as other persons, but he was unique in knowing and realizing God's purposes. However, according to Cobb and Griffin, this was not caused by any external pressure. If we understand Christ's life and his vision of God as Divine revelation of the essence of reality, it can open us for God's power in our own lives.

The motive for the development of this concept is also the effort to avoid pantheism, which claims that the world is the body of God. Polkinghorne points to a model in which God represents the soul of the world, as we find it in Spinoza or Einstein, and rejects it as unacceptable from the Christian point of view. The Christian God is much more than the basis of all cosmic processes. In fact, there are differences between God and the world that Christian theology cannot ignore. Their basis lies in the basic Christian belief that contact with God is essentially a personal encounter, and not just a communication with the cosmos (Polkinghorne 2005, p. 20). It was the emphasis of the relative autonomy and integrity of the natural order that led Polkinghorne to lean towards the kenotic concept (Silva 2015, p. 108). This concept has its origins in the Christological context and is currently popular in the context of the doctrine of creation as well as the doctrine of God's nature.

The idea that God is personally involved in the "life" of the universe led Polkinghorne to reject both extreme positions—the concept of "one act of God" on the one hand and interventionism on the other. It proves that the model of the "one act of God" as presented by, for example, Maurice Wiles (1986) and Gordon Kaufman (1972) leads to a deistic position, incompatible with the concept of a personal and caring God. He rejects interventionism both from the position of science and theology. Although science is essentially based on causal explanations, Polkinghorne rejects its complete self-sufficiency because it would imply determinism that precludes any personal intervention by God. Polkinghorne chooses the middle path of God's continuous action. In his approach, we can identify the elements leading to the characteristic model of Divine action in the world. (1) Polkinghorne takes science and the scientific worldview seriously. (2) This means that the idea of God's intervention involving the disruption of the natural order is unacceptable. (3) However, this order is not strictly closed and deterministic, but—as indicated by free human activity for instance—it shows a certain amount of flexibility and openness. The ontological requirement placed on our world is causal openness to God's continuous activity. Modern science offers two ways to construct an "open" and largely undetermined universe—quantum theory and chaotic processes (Smedes 2004, pp. 37–38).

At the beginning of the 20th century, the results of many measurements and experiments appeared in the natural sciences, which were dissimilar to the common human experience and the natural science had to be reviewed. Starting with Planck, quantum theory began to be built; its first phase culminated in brilliant and independent formulations of matrix mechanics and wave quantum mechanics. Polkinghorne's statements are based on the belief of a majority group in the community of physicists: "They have freely (and in my view rightly) made the metaphysical decision to interpret quantum theory as indicating an intrinsic indeterminacy in physical reality." (Polkinghorne 1995, p. 148). Through such quantum indeterminacies, God could interfere with the world he had constructed in the original act of creation without being compelled to disrupt its original construction.

Polkinghorne points to two basic difficulties of such an approach (Polkinghorne 2000c, p. 933). First, in quantum mechanics we speak of indeterminism only if the measurement in the macro-world was performed, while, without measurement, the quantum world behaves deterministically—in accordance with the Schrödinger equation, which is the basic differential equation determining development of a physical system by formalism of wave mechanics. "There is a particular difficulty in using quantum indeterminacy to describe divine action. Conventional quantum theory contains much continuity and determinism in addition to its well-known discontinuities and indeterminacies. The latter refer, not to all quantum behaviour, but only to those particular events which qualify,

by the irreversible registration of their effects in the macro-world, to be described as measurement.” (Polkinghorne 1995, p. 152). The second difficulty is that a convincing interpretation of how quantum-mechanical effects are displayed in the macro-world has not yet been developed. In this regard, Polkinghorne takes the views of the neo-Copenhagen school, represented by interpretations by Ghirardi, Rimini, and Weber (GRW theory), with Penrose’s noticeable influence through quantum gravity, Bohm’s concept, and the reference to the role of consciousness in the wave function collapse (Polkinghorne 2001, pp. 183–85). It can be assumed that indeterministic quantum effects could be a microphysical initiator of certain chaotic processes, the effects of which may be amplified to the macro-physical level.

The second possibility is the interpretation of hypersensitive systems, which has been called “the chaos theory”. Deterministic equations of the classical chaos theory should be understood as approximate solutions of systems completely isolated from the environment. However, this is not the case with real systems that are open to many forms of action from their surroundings. Equations describing a chaotic system are mathematically reflexive (effects can have a retroactive impact on their causes) and nonlinear (the effect is not directly proportional to the cause). The geometric expression of their solution does not correspond to uniform, regular curves of massive systems, but to the fragmented geometry of fractals. The hypersensitivity of these systems gives them (from our point of view) an internally unpredictable and unique character. Although chaotic systems are perfectly deterministic based on mathematical definitions, Polkinghorne’s interpretation of these systems is different because he believes that the unpredictability of chaotic systems indicates the presence of cracks in the causal structure of the world.

Polkinghorne interprets chaotic systems from the point of view of physics, i.e., he does not clearly distinguish between mathematical and empirical chaos. Therefore, according to him, chaos theory is not only an area of study of mathematics, but in fact it describes the behaviour of many physical systems. Polkinghorne believes that mathematics is a natural language for formulating physical theory. To say that does not mean, according to him, to place a sign of equality between theoretical physics and pure mathematics, because an irreplaceable element of a model or theory in theoretical physics is a set of interpretive rules by which mathematical formalism and observed phenomena are harmonized (Polkinghorne 1991, p. 29). Polkinghorne thus describes the relationship between mathematical and physical models as isomorphic, which is very similar to Wittgenstein’s approach in his *Tractatus*, where our language is attributed an isomorphic relationship with the reality to which it refers. At the heart of this approach is the belief that nature is inherently rational, i.e., mathematical. Polkinghorne thus belongs to the long philosophical tradition of Pythagoras, Plato, Galileo, Gödel, and Penrose, who perceived nature as a book written in the language of mathematics. For Polkinghorne, this idea has strong theological implications, as he believes that the rational beauty of the universe really reflects the Mind that keeps it in existence (Polkinghorne 1998, pp. 125–30). In line with the motto “epistemology models ontology” is epistemological unpredictability, related to the limitations of our cognitive capacities, transformed into an ontological claim about the world, leading to a belief in the openness of our world (Saunders 2012, p. 62).

The future development of chaotic systems depends on very small fluctuations, so in the end it appears as a kind of incalculable future possibilities, represented by a “strange attractor”. The best-known example of a strange attractor is the Lorenz attractor—a nonlinear, three-dimensional, dynamic system, derived from simplified equations of convection in the atmosphere. The phase trajectory of the strange attractor is not closed, does not deviate from a certain limited part of space, is not periodic, and does not intersect itself, because in that case it would return to the point where it once was, and from then on, its movement would be cyclical. It is an infinitely long line in a confined space. Such curves show a significant regularity, but also a considerable disorder. The term attractor refers, in science, to the final state of the system, i.e., the state to which the dynamic system in time is directed. For example, the attractor of a pendulum is its steady state, in which it no longer oscillates, and the suspended body (or point-like particle) remains at the



lowest point of its path. This means that as the system approaches (or is attracted to) the attractor, the possibilities for its further development decrease. Some attractors are points, which means that the development of the respective system is finally completed by an equilibrium state when the body is in relative peace. However, we also know periodic attractors, which means that the development of the system does not stop but fluctuates between two or more states. In the case of a pendulum, we know that its periodic motion stops after a certain time. In a chaotic system, which is characterized by great sensitivity to initial conditions and external influences, even the smallest movement can affect the overall behaviour of the system, in a completely unexpected way. "The infinitely variable paths of exploration of this strange attractor are not discriminated from each other by differences of energy. They represent different patterns of behaviour, different unfolding of temporal development. In a conventional interpretation of classical chaos theory, these different patterns of possibility are brought about by sensitive responses to infinitesimal disturbances of the system." (Polkinghorne 1995, p. 153).

As trajectories following a "strange attractor" differ in their behaviour rather than energy, the new principles will apply more to the structure of future behaviour than to the input energy. According to Polkinghorne, this dependence on initial conditions has a diagnostic function because it points to the fact that the systems in our universe are never isolated. Based on this approach, Polkinghorne argues that a critical-realistic interpretation of the unpredictability of these influences suggests internal unpredictability, and thus openness. Since chaotic systems cannot be isolated, the new causal principles will have holistic character. The term "active information" has been introduced for this new type of causality because it is causally effective and involves shaping the structures of future behaviour (Polkinghorne 2002, p. 53). Polkinghorne expects that further knowledge will emerge from the synthesis of chaos dynamics with quantum theory, as the behaviour of chaotic systems appears to be dependent on fluctuations at the level of Heisenberg uncertainty and at even lower levels.

The reason Polkinghorne rejects the idea of God interfering with the initial conditions is that any deliberate change of the initial conditions would mean God's intervention in specific states of earthly events and would in fact be an interventionist position. What would be much worse, however, is that such interventionism would reduce God's effect on (albeit invisible) cause among the causes. Due to the ontological difference between God and the world, God's work will always have a specific character, so Polkinghorne is not looking for a way out in the initial conditions of a chaotic system at the quantum level. Polkinghorne's model of Divine action in the world can be summarized in the following points (Smedes 2004, pp. 54–55):

1. The infinite number of possible trajectories of the strange attractor reflects the infinite number of possible initial conditions. These possible pathways are diagnostic in the sense that they indicate the degree of sensitivity of the chaotic system. Small causes can cause large and global effects, manifested in the development of the whole system.
2. For this reason, no system in the universe can be completely isolated. Every change in a certain part of the universe will affect the behaviour of everything else in the universe. The universe can thus be understood as a whole, comprising a set of innumerable, interconnected systems that show a sensitive dependence on the initial conditions.
3. The unpredictability of chaotic systems interpreted in accordance with a critical-realistic position results in ontological openness. This leads us to the conclusion that the universe is not a deterministic clockwork, but a system open to top-down causal influences.
4. God's activity should therefore not be understood as operating at the micro-level of quantum mechanics but at the level of the whole. Polkinghorne describes this view as contextualism. Because the whole has a top-down impact on the lower subsystems, influencing the whole may result in a change of situation at certain levels within a particular hierarchy of subsystems.

An important but delicate question remains: How does God affect the whole? Polkinghorne seeks to avoid thinking about God's action in terms of energetic causality, because, as we have said, such a concept reduces God to a cause among causes and assumes an interventionist concept of God's activity. But how can God work in a world where every change takes place through energy? Although God's action has a specific character, which is a reflection of his ontological difference, he must still be able to act physically in the world. Therefore, Polkinghorne understands God's activity as directed at the universe as a whole, while through top-down causality every particular subsystem of the universe can be affected.

### 5. Divine Action through Active Information

In Polkinghorne's conception, therefore, the world can be characterized as open and whole. Its openness lies in the fact that bottom-up causality does not determine a "closed future". Such an open world provides an opportunity to act for other causal principles as well, such as top-down causality with a holistic character, which is inherent in living beings and on the basis of which man is able to generate free, open, and undetermined decisions. Thus, human activity on the environment is oscillating, which means that it does not follow any necessary pattern, and in addition, it is able to transform natural structures. It is a sign of the open and integrated nature of the psychical word. Top-down psychic causation is holistic and different from bottom-up causation described by physics. Such influences will not cause tension only in nature, which is open and able to include them in the range of its possibilities within indeterministic systems (Monserrat 2008, pp. 239–40).

It is ironic that Polkinghorne uses his efforts to elaborate, in detail, the model of Divine action in the world, the concept of active information in the context of open space metaphysics, although the original context of this concept was Bohm's theory of hidden variables, an attempt to reintroduce determinism into quantum theory. Bohmian mechanics is a form of quantum theory proposed by Louis de Broglie in 1927 and rediscovered by David Bohm in 1952. It is the simplest example of what is commonly called the quantum mechanics of hidden variables. In Bohm mechanics, a system of particles is partly described by a wave function, evolving (as usual) according to the Schrödinger equation. However, the wave function provides only a partial description of the system, which must be supplemented by a specification of the actual position of the particle, which develops according to an "accompanying equation" expressing the velocities of the particles in terms of the wave function. According to this interpretation, the arrangement of the particle system develops by means of a deterministic motion arranged by a wave function.

The concept of active information is the result of the collaboration of two quantum physicists—David Bohm and Basil Hiley, who came up with a new ontological interpretation of quantum theory (Bohm and Hiley 1993). According to them, the uncertainty in quantum mechanics is not an ontological state (as explained by the Copenhagen interpretation), but, in fact, only reflects our epistemological limitations. They seek to prove the existence of hidden variables and mechanisms which, if we knew them well enough, would reveal to us the deterministic ontology that forms the basis of the quantum world. According to them, one such mechanism could be active information. In 1954, David Bohm published a new formulation of quantum theory that was fully deterministic while giving the same predictions as standard quantum mechanics. Bohm achieved success by separating the waves and particles that the former Copenhagen way of thinking connected through the principle of complementarity. In Bohm's theory, particles are unproblematically classical. If their position or momentum is measured, it is a matter of determining an objective and unambiguous state. However, in addition to the particles, there is also a wave, the shape of which carries information at all times about the entire environment that surrounds the system. Although this wave is not directly visible, it has measurable consequences, as it additionally affects the motion of the particle beyond normal force fields. The presence of this hidden wave (also called a "pilot wave" or "quantum potential") deflects the particle in a double-slit experiment in such a way that an interference

pattern and associated probability relations are created on the detection screen. However, this acting is strictly deterministic. In Bohm's theory, the positions of individual particles represent the searched hidden parameters of quantum theory.

Bohm and Hiley embraced the idea of a "pilot wave" described as a field with a certain intensity and potential (quantum potential). The effect of this potential does not depend on the intensity of the field, it only depends on its form. This contrasts with the behaviour of the wave in classical mechanics, in which the effect of the field is more or less proportional to the intensity of the wave. To make it clear, Bohm and Hiley give the example of a ship with autopilot controlled by radio waves. "The essential point is that the ship is moving with its own energy, and that the form of the radio waves is taken up to direct the much greater energy of the ship. We may therefore propose that an electron too moves under its own energy, and that the form of the quantum wave directs the energy of the electron." (Bohm and Hiley 1993, p. 32). Thus, a quantum wave does not push or pull a particle in any particular direction, because such an action would result in a change in its energy. The quantum wave acts analogously to the radio waves in the example and directs the particle without affecting its total energy. The quantum field contains information about the surroundings of the particle and this information is associated with the motion of the particle. The basis of the concept of active information is the fact that, despite its very low energy (negligible compared to the energy of the particle), it is able to direct much bigger energy. The consequence of such an understanding is that if a particle suddenly changes direction during its movement along the trajectory, it may not be the result of some force, but the result of capturing changes in the environment by the pilot wave and their further "communication" to the particle. As a result, a particle reaction is observed, which occurs through a change in trajectory. As further analogous examples of active information, Bohm and Hiley cite, for example, radio, computer, or DNA. All of them are examples of the ability to inform, i.e., "give form" to a relatively large amount of energy through active information (Bohm and Hiley 1993, p. 36).

Polkinghorne interprets the concept of active information in the context of Divine action in the world as "God's acting through pure information input" (Polkinghorne 2000a, p. 124). Theologically said, God's activity can be described as an immanent activity of a pure spirit. Polkinghorne considers input through active information to be a kind of non-energy input, although nowhere does he explain exactly the mechanism of this action. However, he seems to have in mind something similar to Pannenberg, who compares the action of the Holy Spirit with the action of physical fields (Pannenberg 1993, pp. 13–14). Just as radio waves contain information about position, speed, direction, etc., of the guided ship and at the same time information about the nature of the environment in which it is situated. Similarly, we can say that the Spirit "knows" the whole system, i.e., all its elements and all their interrelationships, in short, everything that happens in the universe. This field of the Spirit covers and permeates the entire universe in the sense that the immanent God as the Spirit is omnipresent and equally omniscient, without being identical with him. The spiritual pilot wave contains information about God's intentions with the world, just as radio waves contain information about the future trajectory of the ship. The crucial element in this proposal is the fact that the universe is, analogously as an autopilot, capable of processing the information of the Spirit of God. In other words, the universe is a structure capable of processing information, a structure capable of transforming potentially active information into current changes in the arrangement of the universe. On the other hand, Polkinghorne avoids detailed explanations of the "mechanism" of Divine action, because such an interpretation threatens to reduce God's action to purely causal action. However, a total rejection of the attempt to explain Divine action can only end in silence or fideism. "The more explicit the talk becomes about the causal joint by which God acts in the world, the more danger there is that providence becomes just one form of causality among others. Without some such attempt at explication, the idea of providence remains too mysterious for any discussion beyond fideistic assertion." (Polkinghorne 2000a, p. 125).

## 6. Conclusions

As we have said, Polkinghorne emphasizes the integrity and autonomy of the universe and of all creation, and does not perceive it as a completely self-sufficient and self-sustaining system, as this could then imply deism. In his view, it can be expected that a world created by a loving and faithful God will be characterized by both an openness of chance and a regularity of necessity. The openness of chance in this universe is expressed through quantum indeterminism, chaos theory, and the role of the mind in human activity. The necessity, in turn, can be indicated, for example, in the regularity of natural laws. Because God is absolutely free, He can interfere with the natural order. However, according to Polkinghorne, God is intrinsically bound by the consistency of his own nature (Knight 1994, p. 535). This inner consistency, therefore, in a sense limits the scope of Divine action.

Although Polkinghorne's formulation of solving problems concerning Divine action in the world is primarily based on a scientific context, it contains places where it becomes precarious. The interpretation of chaotic behaviour, in terms of ontological indeterminism, in connection with Divine action, depends on two metaphysical components—critical realism and the idea of isomorphism between mathematical models and the reality which they depict. However, these metaphysical elements in Polkinghorne's model are problematic in some respects (Smedes 2004, pp. 104–5):

- Polkinghorne's critical realism unexpectedly rejects the isomorphic notion in cases where the problem of determinism appears. Such a procedure seems like an ad hoc adaptation.
- All elements of chaotic behaviour to which Polkinghorne refers are derived from mathematical determinism. For Polkinghorne, these elements indicate the indeterminism of chaotic physical systems. In effect, he uses elements entailed by a deterministic ontology to back up his claim for indeterminism.
- There is a tension between Polkinghorne's critical realism and his idea of isomorphism, which he seeks to resolve by arguing that mathematical determinism is a "downwards emergent" feature of indeterministic chaotic behaviour.
- Another weakness of Polkinghorne's critical realism is that the "correspondence" between our concepts and the reality is based solely on the religious conviction that human rationality partakes in the Divine rationality inherent in the universe.
- Polkinghorne's assertion that God's action has causal effects even without the presence of the energy component is also problematic. Such an approach seems to be a modification of the "God-of-the-gaps" approach.

These problematic elements of Polkinghorne's system are the result of his efforts to prove the plausibility of Divine action in the world from a scientific perspective. Despite the problematic points of this approach, Polkinghorne's concept shows us how science can become the starting point for thinking about God and his relationship to the world.

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