Title: Penrose on what scientists know

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Abstract: This paper presents an analysis and critique of Roger Penrose's epistemological, methodological, and ontological positions. The analysis is relevant not only because Penrose is an influential scientist, but also because of the particular traits of his thought. These traits are directly connected with his background and approach to science: 1) ontological and epistemological realism, 2) mathematical Platonism, 3) emphasis on the continuities of science, 4) epistemological inclusiveness and essential openness of science, 5) the role of common sense, 6) emphasis on the connection between science, ethics, and philosophy. The paper articulates Penrose's position and criticizes some of its possible shortcomings. It contributes to the perception of science as an open activity, as illustrated in Penrose's particular approach, and provides an interesting case-study that can contribute to understanding how epistemological and ontological positions are connected with particular scientific practices.

Keywords: Roger Penrose, Realism, Common Sense, Scientific Method, Philosophical Openness.

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1. INTRODUCTION

In this paper and taking Penrose's work into account, I will argue that methodological and philosophical backgrounds are often intertwined in scientific practice; and that the objectivity of the methodological approach constrains what kind of philosophical backgrounds can be supported. Therefore, I distinguish between how the scientific method is used by scientists and the philosophical understanding that underlies the scientists' approach.

We consider some scientific features, such as the capacity for admiration, the flexibility to adopt new scientific discoveries, and the honesty to state the limits of one's own assumptions, as characteristics of any good scientist. However, sometimes there is an attempt to separate completely the scientific method from others aspects, such as the philosophical or ethical backgrounds that surround it.

Science both reveals aspects of the way things are and guides philosophical knowledge of reality, such that some philosophical stances cannot honestly be sustained by scientists. It would be analogous to what happens in ethics: not every kind of ethics can be underpinned by scientific methodology. For example, an ethical model that supports the falsification or doctoring of scientific data to dress an ideological goal "scientifically," is fundamentally incompatible with the characteristics of the scientific method, and an ethics inconsistent with science.

Hence, the consolidation of the scientific background leads to the consolidation of certain philosophical positions, provided that scientists are subjectively willing to accept them. That is, the consolidation of ideas is due to both the objectivity of the scientific method in general, and the subjective interpretation each scientist makes of the method and its results. Therefore, background ideas include a philosophy, conventionally understood as a personal understanding (subjective) of reality (objective)[1].

> "There is an objective physical world out there, and physicists correctly regard it as their job to find out its nature and to understand its behaviour. The apparent subjectivity that we see in the strong influences of fashion (…) are simply features of our groping for this understanding, where social pressures, funding pressures, and (understandable) human weaknesses and limitations play important parts in the somewhat chaotic and often mutually inconsistent pictures that we are presently confronted with." (Penrose 2005, 1024)

The nature of Penrose's work makes it especially suitable for studying this interaction between the scientific and philosophical domains. He is not a philosopher but, owing to the

[1] This is how Penrose uses the term philosophy. De Haro (2013), from a more detailed approach, also points out the existence and necessity of philosophy in relation to science.

breadth of his essays and his scientific experience, he definitely provides an interesting case-study. This paper can contribute to understanding how epistemological and ontological positions are connected with particular scientific practices. Specifically, we will study: ontological and epistemological realism, the epistemological inclusiveness and essential openness of science, the role of common sense, and the connection between science, ethics, and philosophy. However, some important features of the scientific method will not be taken into account because they are not addressed by Penrose. His special contribution to the Philosophy of Science is not limited to a particular aspect of the scientific method, but it principally shows how science and philosophy are intertwined, such that each contributes to the comprehension of the other.

In addition to this, I would like to clarify some details regarding certain concepts that will be used in this paper:

(i) On the one hand, the philosophical and the scientific methods are intertwined in their rationality. The first is characterized for *willingly* not leaving out anything that can be rationally studied; while the second has a similar but narrowed scope, because scientists commit themselves to *empirical or measurable evidence* subject to specific principles of reasoning.

(ii) On the other hand, the scientific method is more precise regarding what is subject to empirical contrast, while the philosophical method is wider in its access to reality. For instance, it enables us to carry out a Philosophy of Science.

(iii) Nevertheless, neither of them is founded in itself. Both require consciousness and free will as axioms of their approaches. As a consequence, unifying science and philosophy without naïvely mixing them is a task that has to be carried out.

(iv) Finally, in the words of Roger Penrose (1989, 291; 2005, 1024) there is something *out there*. This realism is understood as the conviction that some aspect of our reality is ontologically independent of our conceptual schemes, perceptions, linguistic practices, beliefs, etc.

Penrose takes into account, sometimes explicitly, sometimes implicitly, the former points[2] but at no point does he exhibit a normative aim for defining how science should be done. Nevertheless, he makes an undeniable contribution to the understanding of science as an open activity.

At this point it is necessary to provide an explanation of how Penrose relates the scientific method to different kinds of knowledge, and, following this, a description of the

[2] For instance, Penrose (1994, 38-39) explains: "My own use of these terms ["awareness, free will, consciousness…] (and, I maintain, common usage also) entails the implications: (a) 'intelligence' requires 'understanding', and (b) 'understanding' requires 'awareness'.

"Awareness, I take to be one aspect –the *passive* aspect– of the phenomenon of *consciousness*. Consciousness has an *active* aspect also, namely the feeling of *free will*. I shall not attempt a full definition of the word 'consciousness' here either (and certainly not of 'free will')."

initiation, development, openness, and limits of scientific activity according to Penrose's view and the author's critiques.

2. THE SCIENTIFIC METHOD IN PENROSE'S SCIENTIFIC PRACTICE

Proponents of the scientific method are often backed by its undeniable achievements. Penrose agrees with that tenet:

> "What science has so far achieved has been dramatic. We have only to look about us to witness the extraordinary power that our understandings of Nature have helped us to obtain. The technology of the modern world has derived, in good measure, from a great wealth of empirical experience. However, it is physical theory that underlies our technology in a much more fundamental way, and it is physical theory that we shall be concerned with here. The theories that are now available to us have an accuracy which is quite remarkable. But it is not just their accuracy that has been their strength. It is also the fact that they have been found to be extraordinarily amenable to a precise and detailed mathematical treatment. It is these facts together that have yielded us a science of truly impressive power." (Penrose 1989, 194)

Penrose concludes that these successes reveal a minimum of realism and causality *out there*, as do many other authors (Artigas 1999, 29-36). Such realism and causality not only support scientific activity and method, but are also conditions for other ways of knowing: alternative ways that would help to achieve a more complete view of the world; the scientific method being the most reliable one yet.

Penrose does not elaborate a list of different methods that could be helpful to comprehend reality but he addresses the issue in different places, for example when he writes about conscious judgements:

"Consciousness needed	*Consciousness not needed*
'common sense'	'automatic'
'judgement of truth'	'following rules mindlessly'
'understanding'	'programmed'
'artistic appraisal'	'algorithmic'

> "Perhaps these distinctions are not always very clear-cut, particularly since many unconscious factors enter into our conscious judgements: experience, intuition, prejudice, even our normal use of logic. But the judgements themselves, I would claim, are the manifestations of the action of consciousness. I therefore suggest that, whereas unconscious actions of the brain are ones that proceed according to algorithmic processes, the action of consciousness is quite different, and it proceeds in a way that cannot be described by any algorithm." (Penrose 1989, 531)

In any case, according to him, the experimental scientific method would still hold primacy over other methods. This primacy would be due to the fact that it gives measurable outcomes and allows one to master reality, what is not so obvious in philosophy.

However, we can advocate those methods which allow one to contemplate or to admire reality without our direct intervention. In this case, knowledge which is not intrinsically limited to experimental outcomes is more apt to obtain a wider understanding of reality. And this would imply the predominance of knowledge itself over practical purposes.

Penrose's position is intended to be an in-between. He advocates the importance of the scientific method for the effectiveness of science, but he does not reduce it to mere practical purposes (Penrose 2005, 803). In fact, the scientific method aids one to know reality. Hence, it should not stop at difficult questions, but should even seek and find answers to fundamental questions about the origin of the universe, the origin of consciousness, and the origin of life. For Penrose the only kind of questions to which experimental science cannot provide any answer are those about good and evil, because they are unique to a moral approach[3].

To my mind, Penrose's understanding of the scientific method seems to overburden it with responsibilities that should be tackled from the point of view of knowledge as a whole. In addition, he extols too strongly the particular merits of the scientific method over other ways of knowing. The entire field of knowledge should be valued over the more limiting scope of the scientific method. This method would then be a *player on a team*, the most talented *to score*, to get outcomes, but every method plays on the whole field of knowledge, and each one has its role (Herce 2014, 40). Each method would provide complementary answers and, therefore, a greater variety of methods could provide a more complete understanding.

Yet, as Penrose points out, these contributions might impede research rather than contribute to it. For instance, you might give up posing some difficult but fundamental scientific questions, in one scientific field, because they already have a satisfactory answer in other fields[4]. This, to Penrose, would be a mistake. An example of this type of error might be that faith in a creator God could limit scientific research on the origin of the universe (Penrose 1994, 144-145; 2005, 758)[5].

This concern seems legitimate, but you can also read it in the opposite direction: to know the intricacies of the physical origin of the universe carries out no claim that God did not create the universe. An *aut-aut* approach between scientific explanation and divine explanation means a very poor understanding of God, as if He were one more cause among other similar causes and not the cause of all creation[6].

To summarize my critiques, the net priority Penrose gives to the scientific method should be more nuanced and better integrated among other avenues of knowledge, although I

[3] What it is not clear is if this moral knowledge is relative or could be equivalent to the scientific one.

[4] Ruse (2010) distinguishes between only two types of approach: the scientific and the religious, both as valid and complementary, as far as no dialogue between them is concerned. Polkinghorne (2005; 2007) also distinguishes between theological and scientific issues. God would have written two books: the book of Scripture and the book of Nature. Plus, Polkinghorne advocates a kind of *God-of-the-gaps* that can provide information, not energy, in the chaotic processes of nature. Penrose, neither seems to fall into a dualism between scientific reasoning and philosophical-religious reasoning, nor seems to deny the value of the latter, as there are scientific questions, moral questions, and common questions that can and should be answered with these two approaches as the fundamental ones.

[5] In this particular case, Penrose poses a false dilemma when he questions if the Big Bang is an act of God or if we have to seek a mathematical-scientific theory to explain it.

[6] There is too much to say on this argument about divine causality. See Silva (2013; 2014).

think his approach has several positive aspects. One that I wish to emphasize now is how the confidence that Penrose lays on the scientific method implies a trust in the whole human capacity for knowledge.

3. PENROSE AND THE EPISTEMOLOGY OF SCIENCE

Thinking, according to Penrose, is a human prerogative which has allowed us to transcend our physical limitations. The creation of tools and machines that have afforded accomplishments hardly achievable for humans is just one example of that. And the apparent superiority of machines in certain fields neither hurts human pride, nor seems to threaten human hegemony. On the contrary, it promotes our pride seeing what we can achieve and manifests our superiority: it is the consequence of our ability to think.

> "Computers are able to perform numerous tasks that had previously been the exclusive province of human thinking, with a speed and accuracy which far outstrip anything that a human being can achieve. We have long been accustomed to machinery which easily out-performs us in *physical* ways. *That* causes us no distress. On the contrary, we are only too pleased to have devices which regularly propel us at great speeds across the ground – a good five times as fast as the swiftest human athlete - or that can dig holes or demolish unwanted structures at rates which would put teams of dozens of men to shame. We are even more delighted to have machines that can enable us physically to do things we have never been able to do before: they can lift us into the sky and deposit us at the other side of an ocean in a matter of hours. These achievements do not worry our pride. But to be able to think - that has been a very human prerogative. It has, after all, been that ability to think which, when translated to physical terms, has enabled us to transcend our physical limitations and which has seemed to set us above our fellow creatures in achievement." (Penrose 1989, 3)

This ability is based on the fact that man is a conscious being capable of understanding, an activity that according to Penrose is totally absent in computers.

> "The supporters of strong AI would claim that whenever the algorithm were run it would, in itself: experience feelings; have a consciousness; be a mind.
>
> "By no means everyone would be in agreement that mental states and algorithms can be identified with one another in this kind of way. In particular, the American philosopher John Searle (1980, 1987) has strongly disputed that view. He has cited examples where simplified versions of the Turing test have actually already been passed by an appropriately programmed computer, but he gives strong arguments to support the view that the relevant mental attribute of 'understanding' is, nevertheless, entirely absent". (Penrose 1989, 22-23)

Machines may have some kind of superiority because they are able to handle more data than human beings, but it is and will remain an unconscious 'knowledge'. It is therefore essential to understand what it means to be aware, what a conscious being is, and how consciousness shows up in humans. These questions are a real challenge about which physics has something to say. Penrose affirms - without further considerations because it is

not the aim of this paper - that machines cannot be conscious because they are made of a different kind of physics than humans.

Thus we are faced with a reality that is *out there* and which can be known because there is a causality in it that can be consciously unravelled through different kinds of judgements.

> "For how else do we normally form our judgements that people other than ourselves possess just such qualities, except by conversation? Actually there are other criteria, such as facial expressions, movements of the body, and actions generally, which can influence us very significantly when we are making such judgements". (Penrose 1989, 11)

> "The relationship between consciousness and the forming of judgements will be central to my later arguments" (Penrose 1989, 17)

These judgements are consistent with Penrose's metaphysical and epistemological realism and refer to progress in knowledge. Such knowledge can always achieve a higher degree of reality, which, in the case of experimental science, allows a greater control, contains part of the reality known, and opens up new research areas.

A classic example of this development is established by the theories of relativity of Einstein concerning Newtonian mechanics. In this case, knowledge of reality has been clarified, refined and deepened, while new fields of research have been opened. Therefore, reality is known more extensively and intensively[7].

To summarize briefly, for Penrose (1) the scientific method is not the only valid way of knowing and (2) there is a human capacity to understand reality, which goes beyond the functional or pragmatic approach and its ability to obtain valid outcomes. Now, taking this into account, where should the scientist start from? For Penrose this starting point is twofold. It is constituted by both the consolidated theories that have been accepted by the scientific community (Penrose 1989, 194-202) and the results provided by new experiments (Penrose 2005, 500).

In turn, this twofold point is not an unchangeable bedrock, but has the strength of tectonic plates: theories are reviewed by the development of new experiments and experimental data, and thus are subject to reinterpretation. There is a continuous flow of theories, experiments and interpretation, where man plays the key role: he makes the theories, prepares the experiments, interprets the data, and judges what is to be changed when something does not fit: theory, experiments, or interpretation. So theories and experiments are not only the starting point, but points of continual return through interpretation and judgement. The re-examination of a theory depends on the scientific judgement about how important are the data provided by experiments.

With this approach, Penrose consistently formulates his theories, associating them to experiments. In his most recent publications on quantum mechanics, on the origin of the universe, and on the physical basis of consciousness, he proposes experiments that in some cases may be carried out in a few years, while in others will have to wait for technical progress (Penrose 2005, 856-860, 1032; 2010, 216). And for this reason too, Penrose rejects

[7] Artigas (1999), at the end of the second chapter, develops these ideas. See also Mancini (2014, 68-70).

some theories that are not experimentally testable, such as the multiverse, and evaluates others as interesting speculations that do not postulate any experiment.

> "I do not see how these arguments can be regarded as providing any significant observational support for supersymmetry, except for perhaps to those already committed." (Penrose 2005, 877)

He also points out that not all experimental data back a theory with the same strength and recognizes that, while some of his experiments serve to substantiate or discredit a theory, others only give some hints about its viability (Penrose 2005, 1020-1024).

So far we could describe what has been explained, in kuhnian terminology, such as the period of normal science, in which the researcher moves within an agreed paradigm that serves as a model which is tweaked or consolidated with new experiments[8]. In addition, Penrose notes the presence of anomalies in the current paradigm, anomalies that are becoming bigger because there is also a proliferation of new theories and that is a sign of weakness in the existing paradigm. But, noting the current paradigm's crisis and pointing towards a new stage of physics, Penrose neither implies the necessity of a scientific revolution, nor a period of kuhnian extraordinary science. Similarly, his proposal neither fits with the popperian scheme of refutation, nor underlies the existence of crucial experiments. He rather suggests an improvement on the paradigm by a reinterpretation of known data and an integration of the latest advances in physical science (Penrose 2005, 782-785).

> "We shall need powerful new ideas, which will take us in directions significantly different from those currently being pursued. Perhaps what we mainly need is some subtle change in perspective – something that we all have missed…" (Penrose 2005, 1045)

Our author suggests a shift in focus to reinterpret the experiments and to study what has been overlooked, integrating everything according to the scientific method. To achieve this shift in focus Penrose highlights the importance of the scientist's heuristic knowledge, common sense, and mathematical intuition (Penrose 2005, 1024-1027). We will see some of these issues later, but first we will study what Penrose means when he talks about reality.

4. PENROSE'S ONTOLOGY: THREE WORLDS, THREE MYSTERIES

For some authors the question of realism in science is not relevant[9] while for Penrose it is essential:

[8] Although Penrose's approach is different from the Kuhnian scheme, there are common grounds and it seems interesting to use his terminology in a flexible way.

[9] As Stephen Hawking (Hawking and Penrose 2010, 81) says: "I don't demand that a theory correspond to reality because I don't know what it is. Reality is not a quality you can test with litmus paper. All I'm concerned with is that the theory should predict the results of measurements. Quantum theory does this very successfully".

"I hope, at least that I have been able to persuade the reader of the fundamental importance of having a quantum mechanics with a viable ontology (…) The importance of having an ontologically coherent (improved) quantum mechanics cannot, in my view, be over-estimated." (Penrose 2005, 865)

"My own position, on the other hand, is that the issue of ontology is crucial to quantum mechanics, though it raises some matters that are far from being resolved at the present time." (Penrose 2005, 785)

Therefore, it is appropriate to clarify what he means by reality:

"I speak of the reality of physical objects: this table, this pen, the Earth (...) [and] distinguish three worlds of reality. On one hand, the physical reality; secondly, the mental experience; and finally the Platonic world of mathematical absolutes. So I conceive three different realities" (Alfieri 2007, 125).

This three-world scheme is inspired by Plato's world of ideas, Berkeley's mental world, and Popper´s three-world scheme (Penrose 1997, 1-4, 93-98; Lombo and Russo 2005, 220-223) and it is presented by Penrose himself in three successive books (Penrose 1994, 411-420; 1997, 93-99; 2005, 17-21). However, he does not adhere to a clear terminology and introduces minor changes in the books to deepen the scheme. Therefore, I will focus on his latest explanation, which is found in *The Road to Reality*.

First, before explaining the three worlds, Penrose asks the reader to expand their concept of "real existence". According to him, this concept should fit not only to physical things but also to mathematical structures which seem to exist before being discovered. Even if they do not possess spatiotemporal existence, as physical objects do, they are timeless, and they *were there* before man discovered them (Penrose 1989, xii).

This being admitted, there would be three different types of existence: Platonic-mathematical, physical and mental ones. The existence of a mathematical concept would be based on mathematical consistency; the existence of physical elements and space-time would imply some kind of sense perception; and the mental existence would be that of ideas or thoughts[10]. These three types of existence, characteristics of each one of the three worlds, would constitute reality. Therefore, although the worlds are separated, they somehow would interconnect; and these interconnections are three *mysteries* to be investigated:

1. The mystery that links the physical world with a small portion of the Platonic mathematical world that works as its foundation.

2. The mystery that links the mental world with a small part of the physical structures that works as its physical substrate.

3. Finally, the mystery that links the Platonic mathematical world with a small fraction of mental activity.

[10] In this context the terms of the spatiotemporal existence and mental existence are not well defined, while the concept of mathematical consistency is a syntactic notion with a precise content. The notion of mathematical consistency is one of the central elements of mathematical proofs. See Shapiro 2000.

> "These are deep issues and we are yet very far from explanations. I would argue that no clear answers will come forward unless the interrelating features of all these worlds are seen to come into play. No one of these issues will be resolved in isolation from the others. I have referred to three worlds [Platonic world, Physical world, and Mental world] and the mysteries that relate them one to another. No doubt, there are not really three worlds but one, the true nature of which we do not even glimpse at present." (Penrose 1994, 420)

These mysteries interconnect precisely and uniquely the different worlds, such that: the physical world would be ruled by a small part of mathematics; the mental world would be rooted in a small part of physics; and mathematical world would be achievable by our mental activity, although not every mental activity is oriented to it. Furthermore, each world would emerge from the world which precedes it.

But this scheme requires clarification: It is too dark; it does not seem apt to understand reality as a whole; and this way the only reality is *causa sui*. This latter problem manifests an obvious difficulty, however, Penrose does not shed more light on his scheme, but he insists on saying that the scheme is only intended to express his *prejudices*[11].

Penrose admitted some changes after receiving some criticisms. He accepted the possibility of a physical action that is not governed by mathematics, or a mental activity that is not rooted in physical structures, or the existence of true mathematical statements whose truth is, in principle, inaccessible by reason or intuition. However, Penrose believes these amendments are superfluous since his first scheme would be able to express well the three mysteries: the mystery of how mathematical laws can be applied to the physical world with precision, beauty and sophistication; the mystery that a properly organized physical matter, like human brains, can evoke conscious awareness; and the mystery of the human mind's ability to capture complex or simple mathematical intuitions.

Understanding these three worlds without neglecting the three mysteries is a task for the scientist:

> "Just because there is something very puzzling going on does not mean that we shall never be able to understand it" (Penrose 1997, 139).

In this ambitious and difficult road to reality, scientists must ask themselves *what* the object they are investigating is, focusing not only on *how it is* or how it behaves. Moreover, the question about *what it is* should lead them to the question about *why it is,* (Penrose 2005, 1028) opening the doors to philosophy. However, as Penrose points out, so far there has been little progress in the attempts to unravel even the easiest of these mysteries.

[11] It is likely that the term "prejudice" contains a semantic relation to Bacon's *Idola*. Francis Bacon in Novum Organum argued the need to abandon all prejudices and preconceived attitudes, *Idola*, to do science. Bacon thought that if any preconceived notion of the world was eliminated, reality could be studied by controlled observations. Scientists therefore should be skeptics and should validate hypotheses by observation and sensory experience. However, Penrose doesn't seem to accept Bacon's thesis, because in that case he would have rejected his prejudices rather than show them.

5. PENROSE ON THE RELATIONSHIP BETWEEN SCIENTIFIC KNOWLEDGE AND OTHER KINDS OF HUMAN KNOWLEDGE

Having faced the question of what is reality for Roger Penrose, I wish to recover the main argument. I return therefore to the deepening of knowledge as a *move towards a higher content of reality through a variety of methods and approaches*. The scientist from her starting point looks for a higher content of reality and her task is not limited to experimental, but requires an openness to other ways of knowing and ultimately to philosophical questions. A higher content of reality demands other ways of approaching reality, among which Penrose includes common sense, morality, and philosophy. Before studying each one, a metaphor about knowledge as light may be useful.

According to this metaphor, which is not present in Penrose's work, variety in the way of knowledge is analogous to variety in the light spectrum. A way of knowing is more focused on some aspects of reality than others, as some bulbs emit light more strongly in some colours than others. This means that with a kind of light or way of knowing, a particular hue prevails.

Let's suppose now that a scientific approach to reality can be pictured as artificial lighting with incandescent bulbs. In that case, if the amount of illumination is increased without changing the type of bulb; the hue is retained. We could also use different types of bulbs (methods) to increase illumination (knowledge). In this case, a broader spectrum of light would be covered and the predominance of a hue would be dim. If the metaphor is still carried further, what really would be interesting is to know daylight reality. Or even, as the light spectrum is much broader than the visible spectrum, this *visible* reality could be reinforced with the help of infrared or ultraviolet.

5.1. Common sense

Following the metaphor, for Penrose common sense is the first light by which we see reality. And as a consequence, (1) it should always be present in all human activities, science included; (2) and it should lead us to trust what we have received, that the reality is there, that we are not deceived when we know, that we can make mistakes but also can make up our minds... This confidence in our initial perception of things is essential for doing science. Our starting point is not a Cartesian doubt.

Indeed Penrose likes to put scientific knowledge in contact with common sense. He normally rejects what is overly abstract and is suspicious of those physicists who develop theories that are far from ordinary and experimental perception:

> "At this point I must again declare my bias, and provide the required statutory warning to the reader. I have found myself to be totally unconvinced of the physical relevance of the scheme of supersymmetry, at least in the form employed in particle physics and underlying theories today. As of now, observations certainly do not provide much support –and probably none at all– for the claims of supersymmetry." (Penrose 2005, 873)

While common sense could lead one to accept well-founded theories that initially seemed *distant*, in no case should these theories be *strange*. The scientific activity should have a harmonic continuity with common sense, with different but not dissonant notes.

Penrose states something similar regarding aesthetic criteria, simplicity and the beauty of mathematical theories. These criteria cannot replace the scientific method, but are present in valid theories. Valid theories have a certain intrinsic beauty and cannot go against reasonable common sense.

As a counterpoint to this view, some authors advocate the need to go against common sense to get rid of stereotypes and prejudices that hinder doing real science. For instance, Hofstadter argues that the concept of "I" is ultimately a social convention, a fictional illusion on which we have agreed and from which it is almost impossible to free ourselves. The "I" would refer to a “strange loop”, a mere consequence of physical laws, which is associated with the greatness of feelings and which we know as consciousness (Hofstadter 2007, 316, 357-364).

This would be an example of a *strange* theory, very remote from ordinary experience[12]. For Penrose, and according to common sense, I not only perceive my "I" but I can also perceive the aware "I" of other people. I could be wrong in denying that others are aware, but I will be almost always right about saying that someone is conscious.

> “Thus there must indeed be some mode of behaviour which is characteristic of consciousness (even though not *always* evidenced by consciousness), which we are sensitive to through our ‘common-sense intuitions’” (Penrose 1989, 527).

Rosenblum and Kuttner also advocate putting into brackets three common-sense intuitions in order to understand what physics states. First, we should stop assuming that two objects cannot both be in the same place at the same time. According to them, this would be tantamount to questioning the principle of non-contradiction. Second, we should also stop thinking that what happens here cannot influence immediately what is happening in some faraway place. And finally, we should not believe that there is a real world, regardless of whether we contemplate it, because observation in quantum mechanics creates the physical reality observed (Rosenblum and Kuttner 2012, ch. 1).

It might be arguable to say that some of these positions really go against common sense, but it is not the subject of this paper. What I would stress is the importance of interpreting experimental data in the light of common sense. According to Penrose, we should avoid creating theories where anything is possible except to admit that there may be an error in the theory or in its interpretation. Common sense is the first light in which we see things and should be trusted. That light is essentially right and should never be turned off, even if it occasionally misleads in the initial assessment of reality.

[12] Penrose (1989, 27-29) criticizes another of Hofstadter’s theories: “Hofstadter envisages a book, of absurdly monstrous proportions, which is supposed to contain a complete description of the brain of Albert Einstein. Any question that one might care to put to Einstein can be answered, just as the living Einstein would have, simply by leafing through the book and carefully following all the detailed instructions it provides (…) I do not regard the idea as intrinsically an absurd one — mainly just wrong!”

This trust in common sense and the fact that quantum mechanics has so far failed to achieve an elegant solution leads Penrose to conclude that:

> "Present-day quantum mechanics has not credible ontology, so that it must be modified in order for the physics of the world to make sense" (Penrose 2005, 860).

5.2. Morality

After addressing common sense, let us focus on morality as a valid way to approach reality. To do this, I would take into consideration a further modification of the three-world original scheme. In this case Penrose's Platonic world would be enriched with the Platonic absolutes of beauty and morality (Penrose 2005, 1029).

Given Penrose's geometrical bias, it is quite reasonable to assume that he wants to express his philosophical *prejudices* in a scheme. So every detail of this scheme would be significant: doing it one way or another involves a very different impact on the subjectivity-objectivity of morality, on the goodness of the physical world... Anyway, I do not discuss them in detail because our author does not stop to clarify them. But Penrose's absolutes imply a reference to the classical doctrine of the transcendental, which has been developed over many centuries and describes reality with a philosophical richness and precision (Aertsen 1996).

Penrose also argues that "it is more important than ever, in today's technological culture, that the scientific questions should not be divorced from their moral implications" (Penrose 2005, 22). However, apart from this consideration and a few others that reflect a certain openness to transcendence, I don't find more explicit reflections on the value that both morality and religion may have for scientific activity.

Therefore, while in Penrose's approach to science both ontological and epistemological foundations are observed, it would be inaccurate to claim that Penrose takes into consideration any kind of ethical foundations[13]. Furthermore, though he neither separates moral from scientific activity, nor considers the moral as a limit to the scientific, but as something necessary, he does not reflect on the fruitful guidance ethics offers to scientific activity.

5.3. Philosophy

To conclude this section, I will reflect on Penrose's concept of philosophy. He often emphasizes that he is only competent to give scientific answers and always avoids any kind of religious allusion. But somewhere between science and theology is philosophy, and Penrose makes some forays in relation to this field of knowledge.

[13] See Artigas (2001, ch. 2) for a more detailed explanation of the ontological, epistemological and ethical foundations of science.

Given a philosophical question like "Why is there something rather than nothing?" Penrose replies:

> "I don't know. In a mathematical sense you can answer this question to some extent, because a mathematical concept exists if it is consistent. So if the rules are consistent and coherent, then we say that such an entity exists. But of course, this is the mathematical meaning of existence. You might think that physical existence is more or less similar, but the truth is I'm not sure. We need to know more about what is existence in the physical sense. My suspicion is that it has to do with conscious perception, because the question of whether there is a universe is possible because we know." (Alfieri 2007)

Penrose neither rejects the question nor is enclosed in a physical reductionism, but admits that there is no clear answer.

> "Biology is a good deal further from being reducible to physical laws, but we have no reason to believe (consciousness apart) that biological behaviour is not, at root, purely dependent upon physical actions that we now basically understand" (Penrose 2005, 1043)

Something similar happens in other contexts when he classifies as "works of God" some realities from which we obtain much more than had been presented:

> "There are things in mathematics for which the term 'discovery' is indeed much more appropriate than 'invention' (…). These are the cases where much more comes out of the structure than is put into it in the first place. One may take the view that in such cases the mathematicians have stumbled upon 'works of God'." (Penrose 1989, 126)

He tries not to give answers which overstep his limits, and when asked about the contingency or necessity of the universe, he answered that this question took him to the limits of physics and led into philosophy, but that he preferred not to answer. (Alfieri 2007)

In this difficult balance of saying no more than a scientist can say, Penrose cannot avoid questioning himself on the meaning of life, showing in this way a necessary openness to a philosophical attitude:

> "It seems to me to be clear that the musings and mutterings that we indulge in, when we (perhaps temporarily) become philosophers (...) are the necessary 'baggage' that must be carried by beings who indeed *are* conscious (...). It is when one sees others behaving in this strange philosophical way that one becomes *convinced* that one is dealing with individuals, other than oneself, who indeed also have minds." (Penrose 1989, 528-529)

In summary, I would qualify Penrose's scientific approach as "inclusive". First, because he does not want to give up when difficulties arise. Second, because his approach underlines a historical continuity of knowledge, where there are no breaks with the past though there may be full stops. Third, because, according to Penrose, there are some mysterious connections between the three worlds. And finally, because he sustains the integration of scientific epistemology with common sense, as precursor and adviser, and philosophy, as the continuation and catalyst of science to answer the questions science cannot.

6. *PENROSE ON SCIENTIFIC LIMITS*

The first conscious limitation that a scientist discovers in his work may be accuracy. This is an important limit because the explanatory power of science lies precisely in its accuracy (Penrose 1989, 194, 198). However, there are some more significant limits: those of which scientists are unaware. So far some limits of the scientific method have been explored, but, without being exhaustive, we can add some more identified by Penrose. To facilitate their being understood I'll divide them into the essential and the circumstantial. The former will always be present, while the latter can partially be solved with time.

Among the essential constraints there may be included: those questions that the scientific method cannot answer; the different kinds of valid answers that it cannot give, such as philosophical or religious ones; and also the increasing amount of unanswered questions posed by the progress of science.

On the other hand, among the circumstantial constraints Penrose identifies that: scientists usually do not care about the fundamental questions; or that current research does not allow for the existence of individual researchers and is driven by theories that attract more investment; or that technical and economic difficulties delay the realization of important experiments (Penrose 2005, 1026). Some of these circumstantial constraints may be improved in the future, but as a whole all of them will increase as the borders of scientific activity are expanded.

Therefore, there are some constraints in the method, due to its particular way of knowing reality, constraints that will always be present and that it is important to know, so as not to fall into any kind of reductionism. Along with these, there are also some circumstantial constraints that will open a wider field of new constraints as they are solved. This may be why Penrose, rather than pointing out the limits of the scientific method, prefers to emphasize its ability to deepen and expand our knowledge, pushing forward the current borders.

7. *CONCLUSIONS*

Although Penrose does not present great philosophical conclusions, he is still a scientist who transcends the boundaries of science, seeking the ultimate meaning of things, and thus he behaves like a philosopher. His philosophical background is mainly realist: for him, the scientific approach to reality generates an increasingly stable and real knowledge. In addition, he is a platonic mathematician; and sustains that scientific activity can help to get to know how reality is. He leans towards positions such as that of Einstein, Schrödinger and Dirac, as he departs from those of Bohr and Hawking (Penrose 2010, 185).

His philosophical background is based primarily on his scientific training, which not only leads him to be realist but sometimes to overstate the essential role played by the scientific

method, overburdening it with the responsibility of answering some questions which should be answered with the help of the whole scope of human knowledge. However, he still maintains the existence of other ways of approaching and knowing reality, such as common sense, morality and philosophy. His epistemology can be therefore labelled as integrative.

Regarding scientific knowledge, Penrose highlights the importance of starting from consolidated ideas to complete them flexibly with the new data collected from the experiments and their interpretation. So, experimental testability is erected as a criterion when it comes to developing and substantiating theories. However, these theories are open to a great deal of heuristic creativity both in their formulation and in their development and interpretation, without letting them slip too far from common sense.

Finally, science would lead us to achieve true knowledge of a reality composed by three worlds, as has been presented in Penrose's scheme. However this scheme fails in explaining how knowledge is produced and is insufficiently critical to realize that, on the whole, the scheme is *causa sui*, not having a bedrock upon which to lie. Consequently, it is a scheme which shows Penrose's positions, but which, as a philosophical proposal, is inadequate because of its lack of foundations. As Penrose himself says:

> "Be that as it may, there is the further mystery, or paradox, of the cyclic aspect of these worlds, where each seems to be able to encompass the succeeding one in its entirety, while itself seeming to depend only upon a small part of its predecessor". (Penrose 2005, 1029)

From my point of view, the key idea which can break the chains of Penrose's scheme is precisely the fact that scientific activity is open to common sense, morality, beauty, philosophy… and therefore to interdisciplinary or trans-disciplinary studies.

This openness is manifested in scientific activity itself because the scientific method is open to the world, through experimental testability, and to the contributions which come from the scientific community through creativity. So scientific activity has its own roots outside science, and thus has to seek its foundations outside itself. Penrose's approach to science points to both ontological and epistemological foundations but fails to reflect on the ethical foundations of the scientific activity.

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9. REFERENCES

Alfieri, C. 2007. Roger Penrose: "creo en un universo de ciclos sucesivos", *Revista de occidente* 319: 118-131.

Aertsen, J. 1996. *Medieval Philosophy and the Transcendentals: The Case of Thomas Aquinas*, Leiden, Brill.

Artigas, M. 1999. *Filosofía de la ciencia experimental: la objetividad y la verdad en las ciencias*, Pamplona, Eunsa.

—. 2001. *The Mind of the Universe: Understanding Science and Religion*, West Conshohocken, PA, Templeton Press.

De Haro, S. 2013. *Science and Philosophy: A Love-Hate Relationship*. Arxiv.org http://arxiv.org/abs/1307.1244. Accessed 12 February 2015.

Hawking, S. W. and Penrose, R. 2010. *The Nature of Space and Time*, Princeton, Princeton University Press.

Herce, R. 2014. *De la física a la mente. El proyecto filosófico de Roger Penrose*, Madrid, Biblioteca Nueva.

Hofstadter, D. R. 2007. *I am a strange loop*, New York, Basic Books.

Lombo, J. Á. y Russo, F. 2005. *Antropologia filosofica: una introduzione*, Roma, Edusc.

Mancini, H. 2014. Comentarios sobre la cosmovisión científica en Mariano Artigas, *Scientia et Fides* 2 (1): 59-80.

Penrose, R. 1989. *The emperor's new mind: concerning computers, minds, and the laws of physics*, Oxford, Oxford University Press.

—. 1994. *Shadows of the mind: a search for the missing science of consciousness*, Oxford, Oxford University Press.

—. 1997. *The large, the small and the human mind*, Cambridge, Cambridge University Press.

—. 2005. *The Road to Reality: A Complete Guide to the Laws of the Universe*, New York, Knopf.

—. 2010. *Cycles of Time: An Extraordinary New View of the Universe,* London, Bodley Head.

Polkinghorne, J. C. 2005. *Quarks, chaos & Christianity: questions to science and religion*, New York, Crossroad.

—. 2007. *Quantum physics and theology: an unexpected kinship*, New Haven, Yale University Press.

Rosenblum, B. and Kuttner, F. 2012. *Quantum Enigma: Physics Encounters Consciousness*, Kindle Edition.

Ruse, M. 2010. *Science and spirituality: making room for faith in the age of science*, Cambridge, Cambridge University Press.

Searle, J. R. 1980. Minds, brains and programs. *Behavioral and brain sciences*, 3 (3): 417-457.

Shapiro, S. 2000. *Thinking about mathematics: the Philosophy of Mathematics*, Oxford, Oxford University Press.

Silva, I. 2014. Revisiting Aquinas on Providence and Rising to the Challenge of Divine Action in Nature*, The Journal of Religion* 94 (3), 277-291.

—. 2013. Indeterminismo y providencia divina. *Anuario Filosófico*, 46 (2): 405-422.