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Reality in Science and Reality in Philosophy: Importance of the Concept of Reality by Postulation

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Abstract

Zubiri introduced the concept of reality by postulation in order to explain the reality of mathematical objects and literary characters. But the idea flows naturally from his view of reality as formality rather than a zone of things. It can readily be extended to other areas, including political reality. In this study, we will examine how science postulates reality, and how this new understanding of science can resolve longstanding issues and provide new insights into: (1) the scientific method; (2) paradigm shifts in science; (3) science fiction; and (4) expression of scientific laws. With respect to the laws, we noted that reality is postulated in two senses: direct and emergent. The emergent sense is associated with the notion of probability and stochastic processes, now an integral part of many areas of science. We observed that the emergent reality may be related to the reality field, instead of individual objects, since probability refers to aggregates of things and not individuals. Finally, we note that Zubiri's approach resolves the longstanding problem faced by realist philosophers, of why scientific theories can be used to describe reality at all.

Resumen

Zubiri introdujo el concepto de realidad por postulación para explicar la realidad de objetos matemáticos y los caracteres literarios. Pero la idea fluye naturalmente de su vista de realidad como formalidad en lugar de una zona de cosas. Puede extenderse fácilmente a otras áreas, incluyendo la realidad política. En este estudio, examinaremos cómo la ciencia postula realidad, y cómo este nuevo entendimiento de la ciencia pueden resolverse problemas antiguos y pueden proporcionar nuevas visiones en: (1) el método científico; (2) el cambio de paradigma en la ciencia; (3) la ciencia ficción; y (4) la expresión de leyes científicas. Con respecto a las leyes, notamos que esa realidad es postulada en dos sentidos: directo y emergente. El sentido emergente es asociado con la noción de la probabilidad y los procesos estocásticos, ahora una parte íntegra de muchas áreas de ciencia. Observamos que la realidad emergente puede relacionarse al campo de realidad, en lugar de los objetos individuales, desde que la probabilidad se refiere a los agregados de cosas y no los individuos. Finalmente, notamos que ese el acercamiento de Zubiri puede resolver el problema antiguo enfrentado por los filósofos realistas, de por qué pueden usarse teorías científicas para describir realidad en absoluto.

Introduction

Zubiri introduced the concept of reality by postulation in order to explain the reality of mathematical objects and literary characters. But the idea flows naturally from his view of reality as formality rather than a zone of things. To understand reality by postulation, it is essential to understand how Zubiri has rethought the entire notion of reality. Postulation of reality makes no sense under the traditional no-

tion of reality as a zone of things, typically envisioned as somewhere outside the mind. Reality, in that scheme, cannot be *postulated*; it can only be *discovered*. But there are many problems associated with such a view of reality, especially insofar as it cannot convincingly account for the reality of dreams or mathematical objects, to say nothing of literary figures, historical realities, or scientific theories, which often utilize simplifying assumptions known to be incorrect. It is also very confused about the reality of political entities. For Zubiri, the matter can be clarified by recognizing that reality in the primary or fundamental sense is a *formality*, not a zone of things. Our sensing is a sensing of reality (sentient intelligence), and in that sensing is both content and formality. That is, both content and formality (reality) are sensed in a unified process; content cannot be sensed without formality. By recognizing the dual but unified nature of all human sensing, Zubiri can formulate a radically new way to understand the nature of mathematics and literature; and the idea can be extended to other realms.

In mathematics we postulate the existence of objects such as lines or spaces, specify certain characteristics of the object(s) thus postulated, and then explore the consequences by proving theorems and carrying out other forms of investigation. These objects are, indeed, real, not ideal; they have the formality of reality. They differ from rocks, chairs, and tables in that their content has been *constructed* according to concepts. We sense the *reality* of mathematical objects just like sensible objects such as chairs; but their *content* is not sensible; rather, it is intelligible, the result of postulation. Zubiri also points out that reality by postulation is the mode of creation of literature, where for example characters such as Hamlet are postulated, and then their characteristics—their personality—is drawn out by the author. In an earlier article,[1] I pointed out that political entities are also real by postulation, though in a different way than characters in literature or the objects of mathematics.

I. Reality as Formality

For Zubiri, the reality of literary characters and mathematical objects can be clarified by recognizing that reality in the primary or fundamental sense is a *formality*, not a zone of things. What exactly does this mean? What is 'formality'?[2]

'Formality' is used to describe an essential characteristic of all perception. When we sense, we sense specific and very concrete things, such as particular colors, sounds, tastes, and so forth. But, sensing is not exhausted with this *content*, as previous philosophy thought—this, indeed, is one of the great errors which have plagued Western thought since the time of the Greeks. Rather, we sense not just *content* (that would probably be impossible), but necessarily something more. We sense the content in a determinate form, as something *other*; and this form of otherness, *which completes the content but is not reducible to it*, is *formality*. In the case of human beings, the formality is the *formality of reality*, which means that what is sensed is *real*. That is, we directly perceive reality at some level, and perceive real things as *other*. The formality is always given together with the content, and perceived (i.e., sensed in an impression of reality) just as directly:

> In the first place, the idea of reality does not formally designate a zone or class of things, but only a formality, reity or "thingness". It is that formality by which what is sentiently apprehended is presented to me not as the effect of something beyond what is apprehended, but as being in itself something "in its own right", something *de suyo*; for example, not only "warming" but "being" warm. This formality is the physical and real character of the otherness of what is sentiently apprehended in my sentient intellection.[3]

Formality is not something added to the *content* of an impression; rather, it is just another aspect of the *same* impression. Nor is it the result of any sort of complicated reasoning process, or conceptual elaboration. It is, as Zubiri emphasizes, the "in its own right" character of impression, the *de suyo*, as he expresses it. Many things traditionally disqualified as "real", but which everyone still thinks of as real, such as dreams or even colors, regain their status. Of course, real in this sense does not necessarily imply intersubjectivity, for example; but that is a later question, which comes after the basic definition is established, that of reality as formality. Anything which is "in its own right" is real in this primary sense. This *de suyo*, the formality of reality, is how the content is delivered to us. Our brains—Zubiri refers to them as organs of formalization—are wired to perceive reality, to perceive directly the "in its own right" character. It does *not* emerge as the result of some reasoning process working on the *content*—another longstanding error of the Western philosophical tradition—it is delivered *together with the content* in primordial apprehension.

This includes reality *in* apprehension, as well as reality *beyond* apprehension. Zubiri agrees that there is a distinction between these two; however, he notes that reality in perception or apprehension not only comes first, but is the ultimate foundation for intellectively knowing reality beyond perception.[4] Thus, reality in perception *is* real—the point often disputed by earlier philosophies.[5] But always, the character of reality is the same: *de suyo*. It is therefore something *physical* as opposed to something *conceptual*. And this is true whether one is speaking of things perceived at the level of primordial apprehension, such as colors, or things perceived in subsequent modes of apprehension such as reason, where examples might be historical realities such as the Ottoman Empire, or mathematical objects such as circles and lines: both are *real* in the same sense, though they differ in other respects (mathematical objects are real by postulation, whereas historical entities are not). Moreover, reality is independent of the subject, not a subjective projection, but something *imposed* upon the subject, something which is *here-and-now* before the subject. Logos and reason do not have to go to reality or create it; they are born in it and remain in it. But this does not mean, of course, that subsequent questions of reality are unimportant; obviously, they are. Questions such as whether the Loch Ness monster is real, or whether quarks are real, remain to be answered.

To make a very crude analogy, consider a play by Shakespeare, for example, *Hamlet*. This play may or may not exist as an abstract entity of some sort; but there is no doubt that for us to experience it—to experience its *content*—there must be a vehicle. I can read the play from the printed pages in a book, or I can watch the play on a stage, or I can listen to the play on an audiotape. In each case, the *content* is the same—Shakepeare's text—but the form, the *formality*, is different. And there must be a formality; I cannot have the play miraculously delivered into my mind without some form, which is given together with the content.

Moreover, content is always specific, whereas formality is always nonspecific, and this has two consequences: (1) it is identical for impressions arising from different sensory organs (for a rough analogy, consider a shell, which can have different contents); and (2), it is *open* and *transcendental*. This is especially significant for Zubiri, since he believes that things such as mathematical entities are also sensed, though the impression we have of them is different than that which we have of, say, colors and sounds. But the formality of reality remains the same in all cases, however. The formality of reality Zubiri sometimes terms 'reity' [*reidad*]. The formality of human perception, i.e., the formality of reality, is in contrast to the (hypothetical) formality of animal perception, the *formality of stimulation* [*formalidad de estimulidad*], in which the content of sensation is

delivered in a form which is such that the things perceived are perceived as other *but not as real*, merely as objective *signs* of a response.

This conception of reality is, so to speak, a radical "paradigm shift". Among its consequences is the fact that there are multiple *types of reality*, though they share the *de suyo*, the formality of reality. Zubiri notes that

> [t]he reality of a material thing is not identical with the reality of a person, the reality of society, the reality of the moral, etc.; nor is the reality of my own inner life identical to that of other realities. But on the other hand, however different these modes of reality may be, they are always reity, i.e., formality *de suyo*.[6]

Zubiri's observation is all the more interesting viewed in the context of the Western philosophical tradition, which has tended to equate "reality" with material reality, and thus has had difficulty with the ontological status of moral reality, of society, of mathematical entities, of fictional characters, and even of colors as perceived.

When a thing is known sentiently, at the same time it is known to be a reality. The impression of reality puts us in contact with reality, but not with *all* reality. Rather, it leaves us open to all reality. This is *openness* to the world. All things have a unity with respect to each other which is what constitutes the *world.* Zubiri believes that reality is fundamentally open, and therefore not capturable in any human formula. This openness is intimately related to transcendentality:

> ...reality as reality is constitutively open, is transcendentally open. By virtue of this openness, reality is a formality in accordance with which nothing is real except as open to other realities and even to the reality of itself. That is, every reality is constitutively respective *qua* reality. [7]

Reality must not be considered as some transcendental *concept*, or even as a concept which is somehow realized in all real things:

> ...rather, it is a *real and physical moment*, i.e., transcendentality is just the openness of the real *qua* real....The world is open not only because we do not know what things there are or can be in it; it is open above all because no thing, however precise and detailed its constitution, is reality itself as such.[8]

Sentient intellection is transcendental impression, in which the *trans* does not draw us out of what is apprehended, toward some other reality (as Plato thought), but submerges us in reality itself. The impression of reality transcends all its content. This is the object of philosophy, whereas the world as such-and-such is the object of science.

For Zubiri, the fundamental or constitutive openness of reality means that the search for it is a never-ending quest; he believes that the development of quantum mechanics in the twentieth century has been an example of how our concept of reality has broadened. In particular, it has been broadened to include the concept of person as a fundamentally *different* kind of reality:

> That was the measure of reality: progress beyond the field was brought about by thinking that reality as measuring is "thing". An intellection much more difficult than that of quantum physics was needed in order to understand that the real can be real and still not be a thing. Such, for example, is the case of person. Then not only was the field of real things broadened, but that which we might term 'the modes of reality' were also broadened. Being a thing is only one of those modes; being a person is another.[9]

Now of course, not everything which we perceive in impression has reality beyond impression; but the fact that something is real only in impression does not

mean that it is not real. It is, because it is *de suyo*. And what is real in impression forms the basis for all subsequent knowing, including science. Still, we are quite interested in what is real beyond impression, which may be something else, or the same thing understood in a deeper manner. For example, electromagnetic theory tells us that colors are the result of photons of a particular energy affecting us. But, according to Zubiri there are not two realities (the photons and the colors), but *the colors are the photons as perceived*. Reason is the effort to know what things are "in reality" which are known in primordial apprehension.

II. Reality by Postulation

Given this new concept of reality, how does postulation of reality work? What, exactly, is postulated? And how does it acquire the status of reality? Zubiri discusses reality by postulation in two contexts: mathematics and literature

A. The nature of reality in mathematics

Let us begin with mathematics. Mathematicians speak of mathematical objects as if they were real, though fully aware that they are not real in the same sense as rocks, chairs and tables. When doing mathematics, we postulate mathematical entities, e.g., we say, "Let *A* be a circle of radius 1", or "Let *X* be a Hilbert space", or "let $\mathbf{P}_n$ be the set of all polynomials of degree *n*". In other cases, the existence is simply asserted, as in Euclid's postulates:[10]

> Postulate 1. To draw a straight line from any point to any point.
>
> Postulate 2. To produce a finite straight line continuously in a straight line.
>
> Postulate 3. To describe a circle with any center and radius.
>
> Postulate 4. That all right angles equal one another.
>
> Postulate 5. That, if a straight line falling on two straight lines makes the interior angles on the same side less than two right angles, the two straight lines, if produced indefinitely, meet on that side on which are the angles less than the two right angles.

Regardless of form, it is upon this act of postulation that Zubiri focuses. Mathematicians typically go on to specify certain characteristics of the object(s) thus postulated, and then explore the consequences by proving theorems and carrying out other forms of investigation. These objects are, indeed, real, not ideal; they have the formality of reality. They differ from rocks, chairs, and tables in that their content has been *constructed* according to concepts:

> The objects of mathematics are "real objects", objects in reality, in this same reality with rocks and stars; the difference is that mathematical objects are constructed by being postulated in their content. A rock is a reality in and by itself; a geometric space or irrational number is a reality freely postulated. It is common to refer to mathematical objects as "ideal objects". But there are no ideal objects; mathematical objects are real. This does not mean —and I must reiterate it—that mathematical objects exist like rocks exist; but the difference between the former and the latter concerns only content, a content given in the one case, freely postulated in reality in the second. Therefore mathematical objects do not have ideal existence but only postulated existence, postulated but in "the" reality. What happens is that their content (1) is constructed, and (2) is constructed according to concepts.[11]

The difference between objects real by postulation and objects such as rocks is that the content of the former is constructed, whereas that of the latter comes through

sensible impression:

> What is so inappropriately labeled "ideal" is the real constructed according to concepts. Both existence and properties are constructed by postulation in "the" reality. Therefore a mathematical object is not real just because of its definition or because it is carried out; but neither is it a real object in and by itself like things apprehended in sensible impression. It is something real by a postulate which puts into action or makes real a content (notes and existence) freely determined thanks to the postulation.[12]

But does this mean that mathematical objects have a status that is somehow inferior to that of objects such as rocks and tables? The latter, after all, are sensible and at some level are apprehended in primordial apprehension. The answer to the question, however, is definitely "no". The key is the difference between *sentient* and *sensible*. What is important is the *mode* of intellection:

> …a geometric space or irrational number is [not] sensed like color is sensed; the former objects are clearly not *sensible*. Rather, it means that the mode of intellection of an irrational number or a geometric space is *sentient*. And this is so (1) because they are intellectively known by being postulated in a field of reality, i.e. in the formality given in the impression of reality, and (2) because their construction itself is not just conceptuation but realization, i.e. something brought about sentiently. Without sensing the mathematical, one could not construct mathematics…Sensible intelligence is based on the senses; sentient intelligence intellectively knows everything sentiently, both the sensible and the non-sensible. A mathematical object is real with a content which is freely constructed in the physical reality given in impression, and its construction is postulation.[13]

Is there any reason to believe Zubiri's interpretation? Yes—a very strong one, discovered in the twentieth century. Up until the 1930s, it was generally believed that the process of discovering mathematical truths could be complete, at least in a "theoretical" sense. This belief was one motivation for the development of mathematical systems such as Whitehead and Russell's *Principia Mathematica*, and it certainly animated the thought of David Hilbert. It also allowed for nominalistic interpretations of mathematics, i.e., the regarding of mathematics as a symbol manipulation process only. There is no reason, under these interpretations, to doubt that all truths about mathematical objects can be known, at least in principle. In this sense, they would be exhausted through the act of postulating them, just as one would expect for ideal objects. For Zubiri, the incompleteness theorem of Gödel means that the mathematical object, once created, has a reality, and a reality with properties *de suyo*; and this reality is *not* exhausted by the postulation, indeed, just the opposite.[14] In other words, the reality of these objects goes far beyond the construction used, somewhat analogously to the fact that the reality of a building goes far beyond the architect's blueprints. As this reality includes what can be deduced about the object, the interpretation of Gödel's theorem is that it shows rigorously that they are not exhausted through logical deduction, or in other words, they have a reality which exceeds what we put into them by postulation:

> Mathematical objects have their properties *de suyo*, i.e., they are real. The fact is that the real object made real by being postulated according to concepts has, by being made real, more notes or properties than those defined in its postulation. On account of this and only on account of it are problems posed which may not be solvable with the finite system of axioms and postulates which defined its realization. What is constructed in reality itself is,

> by being made real or put into action, something more than what was postulated at the outset. This, as I see it, is the thrust of Gödel's theorem. It does not refer to a limitation intrinsic to affirmations based on axioms and postulates *qua* affirmations—that is the usual interpretation of the theorem—; rather, it leaves the character of reality of what is constructed according to the axioms and postulates in question to be revealed before the intelligence. It is not, then, the intrinsic inadequacy of a system of postulates, but the radical originality of what is constructed by being real, a reality which is not exhausted in what has been postulated about it.[15]

The mathematician postulates not the *truth*, but the *reality* of the mathematical object, so that it acquires both its content and its reality in the same operation. This is possible only because the act of postulation, as a creative act, endows it with the characteristic of being "in its own right", that is, the *de suyo*:

> What are these postulates? I.e., what is it that the postulates postulate? That is the question. As I see it, the postulates do not postulate "truth", i.e., they do not ask that we admit their truth. If they did, mathematics would be purely and simply a combination of truths, ultimately just a phase of logic. Many have thought this, including mathematical thinkers of genius. But that does not prevent it from being false. Mathematics is not a system of necessary truths, merely coherent among themselves with respect to the "principles" of logic; rather, it is a system of necessary truths about an object which, in its way, has reality before the intelligence. What the postulates postulate is not "truth" but "reality"; what is postulated is the reality of that about which one postulates. If one wishes to go on speaking about truths, it will be necessary to say that the postulates enunciate the "real truth" about what is postulated. That is, the postulates are not mere logical statements but statements of the characteristics which the "content" of the "reality" of what is postulated has.[16]

Because reality is formality, and not a "zone of things", mathematical entities are real in the same sense as ordinary physical objects, though they do not exist in the same world as these objects since their content comes not from primordial apprehension, but from postulation. So it makes no sense to look for them in the physical world—how would one look for a Hilbert space there anyway? The vast expansion of the entities investigated by mathematicians, most of which have nothing to do with the world of our day-to-day life, meant that the Greek view had to be abandoned or radically modified.

This sensing of the mathematical has to do with sensing the transcendental moment of reality itself. We sense the *reality* of mathematical objects just like sensible objects such as chairs; but their *content* is not sensible; rather, it is intelligible, the result of postulation. As Zubiri explains, reality is formality, not a zone of things; objects of mathematics have the same formality as ordinary objects. Thus, when a mathematician (or anyone else) speaks about the number π or *e*, he is speaking about something which really exists, though neither he nor anyone else grasps the content of these transcendental irrational numbers through ordinary sense perception.

The fact that postulation yields reality goes to the heart of Zubiri's philosophy, because it shows the essential nature of sentient intelligence, namely, its direct contact with reality. Only a reality conscious animal can postulate reality, because only such an animal is aware of reality as such, as *de suyo*. The radically creative nature of sentient intelligence, as revealed through reality postulation, is perhaps the most striking characteristic of what Zubiri terms 'human reality'. The

fact that what is postulated actually becomes something about which further discoveries can be made, which cannot be exhausted by analysis, and which leads man to learn about and control *other* types of reality, is surely a remarkable fact which has heretofore been little emphasized in Zubiri studies.

It is necessary to be clear about just what is postulated, and it is not truth, but real content. As Zubiri puts it, to emphasize this point, "It is not postulation of reality, but reality in postulation".[17] By postulating content, one postulates how things are related, and all of this, of course, with respect to in-depth reality, not primordial apprehension. Postulation is not a mode or type of affirmation, but rather a mode of content realization:[18]

> One postulates what belongs to something [*suyo*] but not the *de suyo* itself. Postulation is the mode by which in-depth reality is endowed with a freely constructed content. Reality is actualized in my free construction, which latter is thus converted into the content of the real; a content however free one may wish, but always the content of the real…That which is freely constructed and made real by postulation can remain on its own; it is creation by creation. This is proper, for example, to a novel. But that which is freely constructed can be made real in the "ground-reality" as grounding the content of a field thing. Then that which is freely constructed is "grounded" content; it is theoretical postulation.[19]

Postulation actually involves two other modes of free rational creation, and all three rely upon aspects of a reality field as experienced: notes, structure, and construction, yielding free experience, free systematization, and free construction or postulation. Free experience endows in-depth reality with what Zubiri terms "model-like" content. "Modelizing" is endowing in-depth reality with a content which is consistent through modification of certain field notes. Free systematization endows it with a basic structure, one which relies upon the field (also called "homologizing"). And free construction endows it with a completely created content, albeit one which may utilize elements of ordinary experience, as we have discussed. This latter is, formally, postulating. Zubiri notes:

> These three are the three modes of rational creation. They are but modes of moving ourselves intellectively in a primary, identical, and ineluctable formality of reality. And as this formality is intrinsically and formally given in the impression of reality, it follows that the three modes of rational creation are three creative modes of sentient reason.[20]

It is important to note that the reality postulated is not inferior in any sense to field reality, or reality in depth. As Zubiri puts it, the postulated reality is a "reality numerically identical with field reality *qua* reality." [21] Also, postulated reality in some cases—Zubiri observes it for works of fiction—is self-verifying, in that these realities have internal coherence, and are apprehended.[22]

B. Verification: the mode of experience of postulated reality

Moreover, every postulated reality has a mode of experience that pertains to it, called "verification".[23] Verification is, indeed, one of the four fundamental modes of experience (the others being experimentation, compenetration, and appropriation).[24] For mathematics, it consists of unity of two moments, the moment of truth and that of apprehension of reality:

> It is what I call *testing-together* [*comprobar*] or *verifying*…verification does not consist in verifying if my affirmation is verified; that does not need to be verified in mathematics. What is verified is not the truth of my affirmation but the very presence of reality apprehended through a way of logical

> deduction. It is the testing or verifying of reality through the "together" of truth. Truth is not verified, but rather reality in its truth; we apprehend "reality in truth".[25]

Zubiri goes on to point out that it is the physical testing of reality which completes mathematics:

> The physical testing [*probación*] of reality is now verification [*comprobación*]. Here we have the essence of what, paradoxically, but very exactly, should be called the 'experience of the mathematical'. The mathematical is the terminus of a physical testing of reality, of experience.[26]

III. Postulation in Science

Next we wish to discuss the role of postulation in science. In his work, the scientist *postulates* reality, and then *explores* that reality to draw out its consequences and to see how well it corresponds to reality beyond apprehension. This is the true meaning of the so-called "model building" to which many writers on science refer. As in the case of all reality by postulation, the reality created is richer than the simple postulations which create it. Thus the necessity and difficulty of exploring it and seeing what it entails. Examples of this postulation are: genes as bearers of heredity, relationships such as $F = ma$, symmetry and symmetry breaking. Often mathematical realities are utilized in the scientist's quest to describe reality beyond apprehension. This does not change the status of the mathematical realities, but may endow them with a new type of postulated reality, beyond-apprehension-reality. Thus we have quarks, relativistic mass, genetics, and quasars. But phlogiston, the aether, caloric, and absolute space and time are all postulated realities, intended to tell us about reality beyond apprehension, which failed the crucial test of verification. As a result the reality they postulate is now like the reality of a literary work, or an imaginary world. Successful theories correspond to postulation of reality which, while not identical to or complete as a description of reality beyond apprehension, is congruent with it. Such postulated reality helps us to understand reality beyond apprehension; and indeed our society relies extensively upon it for medicine and engineering. But as Zubiri has pointed out, because of the openness of reality, no theory scientific or otherwise can exhaust reality beyond apprehension; and art and poetry represent other rational ways of seeking to understand that reality.

There are four areas of interest in connection with postulation of reality in science:

- The scientific method
- "Paradigm shifts" in science
- Science fiction
- Postulation of reality by scientific laws

We shall examine each of these in turn.

A. The Scientific Method

Exactly what comprises the "scientific method" has been a contentious subject for nearly a century. This may be due to the fact that philosophers have been mistaken about reality and the connection of science with it. By formulating the scientific method in terms of reality by postulation, matters are notably clarified. In this approach science involves 5 steps:

1. *Start with some knowledge of reality* (at all three levels). All science is based on observations which ultimately derive from primordial apprehension, and all rational explanations are intended to tell us about reality beyond apprehension which may account for our observations. Typically the scientist starts from knowledge at least at the logos level, and more often at the level of reason. For example, the Special Theory of Relativity starts with observations about Galilean (non-accelerated) frames, and the speed of light. Both of these are already concepts at the rational

level, though they clearly use the logos level because things are named. Likewise quantum mechanics starts with the observed distribution of light frequencies from atoms, and Maxwell's theory starts with observations about electric and magnetic fields. In the theory of evolution, as promulgated by Darwin, one starts with observations about similarities in physiological function and also historical sequences of organisms, the existence of random changes in genetic material, and the existence of the process of natural selection.

2. *Postulate reality*. This may involve postulation of new realities such as atoms or quarks, and their characteristics stemming from their essences; or it may involve postulation of new relationships among things already known, such as the Universal Gas Law. There may be a combination of the two. In the case of the Special Theory of Relativity, the reality postulated is that the speed of light is a universal constant, and that all Galilean frames are equivalent, i.e., there is no absolute space or time. Quantum mechanics postulates that energy is quantized and that the position of particles is described by a probability density function—which is equivalent to saying that they do not have absolute position and momentum. Maxwell's theory postulates a set of relationships among electric and magnetic fields, as expressed in his famous four equations. Darwin's theory postulates that random mutations operated on by natural selection can account entirely for the history of life on earth.

3. *Explore the postulated reality*. At this stage the scientist explores the new reality which has been postulated by the tools at his disposal. Typically this involves deduction or other inference of consequences about the new reality.

4. *Verify*. At this stage the scientist seeks to determine if what has been learned through the exploration of postulated reality is in accord with our experience of reality beyond apprehension. This is done by finding things in the postulated reality which have not yet been observed in reality beyond apprehension, and then searching for them in that reality, usually by experimentation. Verification in this case takes the form of congruence.

5. *Modify the canon of reality*. Successful theories remain as beyond-reality-postulations and the reality they postulate usually enlarges our canon of reality; unsuccessful theories become essentially literary postulations; indeed, "science fiction" as a literary genre is closely related to failed scientific theories. Thus the Theory of Relativity gave us relative space and time, and the speed of light as a universal constant, as well as the equivalence of mass and energy, made famous by $E = mc^2$ and of course nuclear weapons.

By utilizing Zubirian concepts and ideas, the nature of the scientific enterprise can be notably clarified. This understanding of the scientific method also helps to position science with respect to philosophy as a type of human knowledge.

B. "Paradigm Shifts" in Science

This analysis of the scientific method can explain Thomas Kuhn's "paradigm shifts" as cases where a radically new form of reality is postulated, rather than one similar to what is already known. This often results in a significant enlargement of our canon of reality, as it did in the case of quantum mechanics.

Since the postulated reality is intended as an accurate description of reality beyond apprehension, it is necessary to be on guard against a serious temptation: taking the postulated reality as a complete description of reality beyond apprehension and then rejecting any evidence which contradicts it. This state of affairs occurs periodically in science—usually when philosophical or other doctrines take precedence over purely scientific considerations—and as a result all empirical evidence is interpreted as somehow verifying the postulated reality. This occurred in the case of the geocentric theory of the universe for example. Typically this state

of affairs leads to great tensions and eventually some type of paradigm shift.

C. Science Fiction

Science fiction is actually a special case of literature, one in which characters are postulated, as usual, but also scientific developments (e.g., exotic spacecraft and modes of travel) as well as the reality of other "worlds" (e.g., aliens), or special characteristics of matter, space, or time. The scientific developments may or not accord with true scientific laws; for example, travel at speeds greater than light may be postulated, even though this contradicts scientific laws as we know them.

D. Postulation of reality by promulgation of scientific laws

Perhaps the most important aspect of the postulation of reality in science occurs in connection with the promulgation of scientific laws, since this is really the heart of any scientific enterprise. The nature of the postulation of reality in scientific laws falls into two categories, *direct* and *emergent*. We shall discuss the direct postulation first as it is the simplest. Emergent reality is more complex and points us to the notion of field reality.

Direct postulation of reality. This can perhaps best be understood by some examples. First, let us examine a simple case, Newton's Second Law, $F = ma$. This law postulates that there are these three real things in the world, *force, mass,* and *acceleration*, and that they have certain characteristics such that there is a relationship between these real things expressible by this mathematical formula, an algebraic equation. That is, both the reality and the characteristics of the things related by the law are postulated. This is an example of a broad class of scientific laws which can be expressed by simple algebraic equations. Such laws postulate the reality of directly observable (measurable) things in the world, and some relationship among them. Another example is the Universal Gas Law, $PV = nRT$. Here there is an explicit postulation of the reality of pressure (*P*), volume (*V*), moles (*n*), and temperature (*T*), related algebraically by the Universal Gas Constant *R*. Of course, people may have been speaking of one or more of these things before the law was ever conceived; but that does not change the fact that the act of expressing the law amounts to explicitly postulating the corresponding reality of the things related, and their characteristics (or some of them at least). After postulation, the job of the scientist is to determine what the postulated reality entails, and then verify that reality is this way. For example, Newton's law above entails that bodies will fall to earth in a certain time which can be calculated using the version of the law expressed in terms of distance and time: $F = m\frac{d^2 s}{dt^2}$. This law also entails that if objects such as the moon are moving fast enough, their "falling" toward the earth will be balanced and they will orbit the earth rather than crashing into it.

The nature of scientific postulation of reality may be clarified by considering theories which have been proven wrong. Consider the case of caloric, imagined as a fluid corresponding to heat, which flowed from one object (usually a hotter one) to another (usually a cooler one). The reality of caloric was definitely postulated, as a measurable quantity. However later work, notably Count Rumford's famous cannon boring experiment, showed that no such fluid corresponding to heat existed.

In some cases the postulation of reality by means of laws immediately entails the reality of something new, something unexpected. This is of course quite similar to the case of mathematics, where Zubiri pointed out that postulation of reality always entails more than just the things postulated. Consider Maxwell's Equations:

$$DivD = \rho$$
$$DivB = 0$$
$$CurlE = -\mu \frac{\partial H}{\partial t}$$
$$CurlH = \varepsilon \frac{\partial E}{\partial t}$$

From these equations Maxwell was able to deduce that electric and magnetic waves would propagate through space—what we now term electromagnetic waves—and thus predicted a new reality, radio waves, later confirmed by Hertz.

Emergent postulation of reality. We next turn to theories which are based not on deterministic laws and equations, but on statistical laws. These laws postulate reality in a rather different way. Let us begin by considering an example from economics, Pareto's Law, which asserts that income is distributed in accordance with the formula[27]

$$N = Ax^m$$

where N is the number (fraction or probability) of workers earning more than x, A and $m<0$ are constants. Amount of money earned per year is of course a directly measurable quantity, but probability is not. Any given worker may earn more or less than x; only in the aggregate (when many workers are considered) does the above relationship emerge. This number may have to be quite large. This suggests that probability-based laws postulate reality in an *emergent*, not a *direct* sense. Another example of this type of postulation occurs with Schrödinger's equation,

$$-\frac{\hbar^2}{2m}\frac{d^2\psi(x)}{dx^2} + U(x)\psi(x) = E\psi(x)$$

Now what is interesting about this equation is that the basic functional entity here, $\psi(x)$, is a *probability distribution function*; it gives the probability of finding an electron, say, at some position x. Schrödinger's equation clearly postulates the reality of this function, which does have measurable consequences in the observable world, but is not itself something in the world, as are trees, water, atoms, or molecules. Once again observations must be aggregated to manifest this probability function, so we are dealing with a postulation of reality in an emergent sense, as before.

Emergent reality postulation and the reality field

The nature of emergent postulation of reality suggests that it is postulation about the reality field, rather than about individual realities themselves. This would imply that all probability-based assertions are statements about the field, which makes sense since reality is open and the reality field is something which affects all real things. Zubiri's comments on the reality field are applicable here:

> The field, we said, is "something more" than each real thing and therefore something more than their simple *sum*. It is a proper unity of real things, a unity which exceeds what each thing is individually, so to speak.[28]

In particular, the field is determined by individual things (suggesting why probability gives a measure of the field, since it is a measure of things in an averaged sense):

> …in the field determined by the reality of *each* thing all the others are there as well. This is a structural and formal moment of the field; the field determines the reality of each thing as a reality "among" others. The "among" is grounded in the field nature and not the other way around; it is not the case that there is a field because there are some things situated among others, but rather some things are situated among others only because each and every one of them is in a field.[29]

Of course, deterministic postulation about the reality field can also be made.

One can argue that the Special Principle of Relativity, that nothing can exceed the speed of light (*c*), is also a statement about the reality field. What is especially interesting about this general line of thought is that the tools we have developed to describe reality, such as probability and stochastic differential equations such as that of Schrödinger, indicate that we cannot fully capture reality—by their very nature they only give us partial information. Indeed, reality is fundamentally open, and therefore not fully capturable in any human formula. This openness is intimately related to transcendentality:

> ...reality as reality is constitutively open....Reality is not a transcendental concept, nor is it a concept realized transcendentally in each real thing; rather, it is a real and physical moment, i.e., transcendentality is just the openness of the real *qua* real....The world is open not only because we do not know what things there are or can be in it; it is open above all because no thing, however precise and detailed its constitution, is "the" reality as such.[30]

The fundamental or constitutive openness of reality means that the search for it is a never-ending quest, as is the exploration of the postulated reality in mathematics or literature.

Zubiri believes that one of the principal errors of past philosophers was their excessively static view of knowledge—a conquer it "once and for all" approach. Typical of this mentality are the repeated attempts to devise a definitive list of "categories", such as those of Aristotle and Kant, and Kant's integration of Newtonian physics and Euclidean geometry into the fabric of his philosophy. Rather, knowledge as a human enterprise is both dynamic and limited. It is limited because the canon of reality, like reality itself, can never be completely fathomed. It is limited because as human beings we are limited and must constantly search for knowledge. The phrase "exhaustive knowledge" is an oxymoron:

> The limitation of knowledge is certainly real, but this limitation is something derived from the intrinsic and formal nature of rational intellection, from knowing as such, since it is inquiring intellection. Only because rational intellection is formally inquiring, only because of this must one always seek more and, finding what was sought, have it become the principle of the next search. Knowledge is limited by being knowledge. *An exhaustive knowledge of the real would not be knowledge; it would be intellection of the real without necessity of knowledge.* Knowledge is only intellection in search. Not having recognized the intrinsic and formal character of rational intellection as inquiry is what led to...subsuming all truth under the truth of affirmation.[31] [Italics added]

Once again we see that Zubiri's ideas permit a significant clarification of questions about what science does, and its scope and limitations. A summary of the types of postulation is given in Table 1.

Zubiri and the Conventional Approach to Understanding Science

The fundamental concern of most realist philosophers is how to establish a relation between mathematical formulations of scientific laws and theories and the real world. They must establish this relationship because for them, there are two distinct things: the real world or reality, and the scientific laws and theories about them. So why can we describe reality with our scientific theories? Why does mathematics work as a description language for nature? This is of course similar to the question Kant asked about causality and knowledge.

For Zubiri, of course, reality is formality, and not a zone of things. Hence the realists' fundamental problem is not an issue because any scientific theory itself *postulates* reality. Thus the real issue—for both science and philosophy—is not why

we can describe reality with our theories, but *how well postulated reality corresponds to reality beyond apprehension*. We can describe reality with our theories because they *postulate* it. For example, phlogiston was postulated to account for observed transformations in combustion.[32] But further research disclosed that there is no such entity—it did not correspond well with reality beyond apprehension. However the postulation of subatomic particles such as electrons, photons, and quarks has proved useful. The integration of postulated reality and apprehension is very tight in Zubiri's philosophy. This is illustrated by his famous example of photons and color: the photons are postulated reality, but there are not two realities, photons and color; rather, color is the photons as sensed.

Because human formulations can never encompass all of reality, and therefore human postulations of reality can never cover all of reality, the question is not one of a scientific "theory of everything". We can never have such a theory; reality is much richer than we can encompass in any rational description of it. The postulated reality will always break down at some point, but postulated reality through science remains one of the best ways we have to gain knowledge of reality beyond apprehension.

Characteristic	***Type of Reality***				
	Mathematics	**Literature**	**Political/Legal Systems**	**Science**	**Meaning things [cosa sentida]**
Construction according to…	Concepts	Percepts, items of fiction	Concepts, percepts	Concepts, percepts	Sensible reality and logos
Postulation by	Individual	Individual	Group	Individual	Not postulated
Extraction of new reality	Theorem proving	Literary analysis	Judicial system; deduction	Logical deduction	Not applicable
Mode of intellection	Sentient	Sentient	Sentient	Sentient	Sensible
Are real "in their own right" [de suyo]	Yes	Yes	Yes	Yes	No
Method of verification	Testing together: apprehending reality in truth	Internal coherence of the fictional vision, and of apprehension of its reality	Realization through power	Same as mathematics + empirical observation	Not applicable
Have starting and ending points in time	No	No	Yes	No	Yes
Vehicle	Axioms, statements of form "Let …"	Novel, poem, story, etc.	Charters, constitutions, incorporations, regulations	Any type of scientific law or principle	Not applicable

Table 1. Types of postulation

IV. Conclusion

Reality by postulation flows from Zubiri's new concept of reality as formality, not a zone of things existing somewhere. In particular, Zubiri noted that we postulate reality in literature and mathematics, and that we sense the reality of postulated objects such as mathematical objects, though not their content. Elsewhere I have indicated that reality is also postulated in political and legal systems, and that the notion of postulated reality can also be applied to meaning things, though this case is significantly different than the others. Here we have discussed the case of science, and have noted that reality is postulated in science and this postulation can clarify several areas of scientific and related thought: (1) the scientific method; (2) paradigm shifts in science; (3) science fiction; and (4) expression of scientific laws. With respect to the laws, we noted that reality is postulated in two senses: direct and emergent. The emergent sense is associated with the notion of probability and stochastic processes, now an integral part of many areas of science. We observed that the emergent reality may be related to the reality field, instead of individual objects, since probability refers to aggregates of things and not individuals. Finally, we noted that Zubiri's approach resolves the longstanding problem faced by realist philosophers, of why scientific theories can be used to describe reality at all. This is because any theory postulates reality, and thus is automatically able to describe it. The real question is always whether (or how well) postulated reality corresponds to reality beyond apprehension.

Notes

[1] Thomas Fowler, "A Framework for Political Theory Based on Zubiri's Concept of Reality," *The Xavier Zubiri Review*, vol. 4 (2002), pp. 109-132.

[2] See also the discussion of formality in the article "Formalidad, 'de suyo', y 'prius'" by Ricardo Espinoza Lolas in *The Xavier Zubiri Review*, vol. 4 (2002), pp. 67-99.

[3] Xavier Zubiri, *Inteligencia y realidad*, Madrid: Sociedad de Estudios y Publicaciones, 1980, p. 172. (Volume I of trilogy *Inteligencia sentiente*; this volume designated hereafter as IRE). English version from *Sentient Intelligence*, tr. by Thomas Fowler, Washington, DC: Xavier Zubiri Foundation of North America, 1999, p. 63.

[4] Zubiri also discusses what he terms "in depth reality", which is reality with a grounding function; cf. Zubiri, *Inteligencia y razón*, Madrid: Sociedad de Estudios y Publicaciones, 1983, p. 108 [hereafter, IRA].

[5] IRE, p. 182-183 (English version, p. 66].

[6] IRE, p. 173; English version, p. 63.

[7] IRA, p. 19; English version, p. 247-248.

[8] *Ibid.*.

[9] IRA, p. 56; English version, p. 261.

[10] Euclid, *Elements*, Book I. Taken from the online edition prepared by D. E. Joyce, Clark University, http://aleph0.clarku.edu/~djoyce/java/elements/bookI/bookI.html#posts.

[11] Zubiri, Xavier, *Inteligencia y logos*, (Second volume of trilogy, *Inteligencia sentiente*), Madrid: Alianza Editorial/Fundación Xavier Zubiri, 1982, p. 144. (Hereafter, IL); English version, p. 156.

[12] *Ibid.*

[13] IL, p. 145; English version, p. 157.

[14] Díaz Muñoz, G., Zubiri, "Lakatos y la crisis gödeliana del fundamento matemático", *The Xavier Zubiri Review*, Vol. 2, 1999, p. 57-66.

[15] IL, p. 138-139; English version, p. 155.

[16] IL, p. 128-129; English version, p. 151.

[17] IRA, p. 131; English version, p. 285.

[18] IRA, p. 251-252; English version, p. 332.

[19] IRA, p. 130; English version, p. 285-286.

[20] IRA, p. 133; English version, p. 286.

[21] IRA, p. 251; English version, p. 332.

[22] IRA, p. 252-254; English version, p. 332-333.

[23] IRA, p. 254; English version, p. 333.

[24] IRA, p. 257; English version, p. 334.

[25] IRA, p. 253-254; English version, p. 332-333.

[26] *Ibid.*

[27] *Vilfredo Pareto, 1848-1923*, http://cepa.newschool.edu/het/profiles/pareto.htm.

[28] SI, p. 115 Eng. ed.; *Inteligencia y logos*, p. 28.

[29] SI, p. 117 Eng. ed. *Inteligencia y logos,* p. 34.

[30] SI, p. 488-489 Eng. ed.; *Inteligencia y razón*, p. 19-20.

[31] *Ibid.,* pp. 261-262.

[32] Jim Loy, *Phlogiston Theory*, http://www. jimloy. com/physics/phlogstn.htm.