

Creatio ex Nihilo, Number Theory, Quantum Vacuum, and the Big Bang

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This informal paper is a continuation of a discussion I had with Dr. Tsvi (Victor) Saks, of blessed memory, about using Peano's axiomatic approach in arithmetic as an analogy to illustrate the principle of *yesh m'ayin*, or the creation of something from nothing (*creatio ex nihilo*). Can we find at least a rough example or a coarse illustration of *creatio ex nihilo* in the world of mathematics and physics? The function of an empty set in set theory, the behavior of a quantum vacuum, and big bang theory are explored as illustrations—not parallels—to G-d's creation of something (everything, actually) from literally absolutely nothing. In the examples given below, the starting point is of course never the absolute nothing that preceded the six days of Creation.

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Accused of Jewish nationalist dissident activity, Poltorak was stripped of his academic degrees. In 1982 he emigrated to the USA. From 1982 to 1985 he served as an assistant professor of biomathematics at Cornell University Medical College. He is now chairman and CEO of General Patent Corporation. He has coauthored several papers on intellectual property.

While still in Russia, Dr. Poltorak and his wife became interested in Torah Judaism. He has written on Judaism for the Russian press, cofounded and edited the Yevreyski Mir Russian Jewish weekly newspaper, hosted weekly Jewish radio programs, and taught Jewish studies at Touro College. A popular lecturer on Jewish mysticism, religion, and science, he and his wife live in Monsey, New York, with their five children.

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Introduction

The kabbalistic principle of *yesh m'ayin* or *creatio ex nihilo*—creation of something from nothing, is difficult to fully understand because we have no experience of creating something from nothing. Although many human creative activities seem to create something new, in fact, they merely change the form or nature of things. Never do we create something from nothing.

A sculptor takes a preexisting slab of marble and shapes it according to his imagination. So does a potter, who molds pottery out of clay; a glassblower, who forms liquid glass into beautiful shapes; and a smith, who strikes iron into functional shapes. Phenomenal transformations may be observed in the chemistry lab, as substances react to produce new unexpected compounds. Yet, no one believes

that a chemist can create something from nothing. Even medieval alchemists who tried to transform lead into gold did not dream of creating gold from nothing. Although a chemical reaction may change the molecular structure of the compounds involved in the reaction, the atoms that make up these compounds preceded the chemical reaction.

Physics takes us to a deeper level. Solid ice melts into liquid water, which, in turn, evaporates into a gas. None of these transformations, however, involve a new creation. Whether solid, liquid, or gaseous, water is still water. Going further, we observe atomic decay, nuclear fission, transformation of subatomic particles, and even the transformation of mass into energy, as formulated by Einstein a century ago. None of these mind-bending phenomena, however, creates something new. They are reshapings of preexisting matter, no matter how profound.

Only the Creator can truly create something (indeed, everything) from nothing. How do we know this? It is a matter of simple logic. It is impossible to define G-d as He truly is for Himself because to *define* means to *limit*, and an Infinite Being cannot be limited by any definition. However, as far as we are concerned, to the extent we can relate to G-d, He relates to us as the Creator. He introduces Himself in the beginning of the Torah as the Creator of Heaven and Earth. G-d, therefore, by His own definition, is the Creator of all, or everything is a creation of G-d. Obviously, nothing existed besides G-d Himself, of course, before the primordial act of creation. If there was *nothing*, from where, then, did everything come? The only possible answer is, from *nothing*. This is what is meant by *creatio ex nihilo*, or, in Hebrew, *yesh m'ayin*.*

The created universe has myriads of levels, or “worlds” in the terminology of Kabbalah. In fact, there are an infi-

nite number of worlds. each of these worlds being further divided into an infinite number of levels—*heavens*, in kabbalistic terminology. The Kabbalah further teaches us that our physical world is merely the tip of the iceberg—an infinitely large upside down iceberg—because our world is at the bottom of creation. The creative process unfolds on all levels of the inverted pyramid. Therefore, the process of *yesh m'ayin* is manifested on many levels. This is elaborated more in depth by Rabbi Schneur Zalman of Liadi, the Alter Rebbe of Lubavitch, in the *Shaar Yihud v'eha'Emunah* in the *Tanya*.

The unfolding of creation descends from *Atsilut* (the World of Emanation) to *Briyah* (the World of Creation), to *Yetsirah* (the World of Formation), to *Asiyah* (the World of Action). Divine light, the creative force, emanates from the highest world, *Atsilut*. Creation actually takes place in *Briyah*. In *Yetsirah* creation is formed and developed, although it exists there in a purely spiritual form. It is only in the lowest world of *Asiyah*, the world that we know, that physical matter appears. *Asiyah* is subdivided into spiritual and physical domains. The division of each of the four worlds into infinite worlds consisting of myriads of levels is called in Kabbalah *Seder Ha'hishtalshelut*—the Order of the Unfolding of Creation.

For most of us with dull spiritual senses, the worlds above the spiritual domain of the World of *Asiyah* are beyond our reach. Only the physical and spiritual domains of the world of *Asiyah* are within our grasp. Roughly speaking, the spiritual domain of the World of *Asiyah* is the realm of music, logic, and mathematics—the world of abstract ideas. This is an oversimplification because the spiritual domain of the World of *Asiyah* contains many levels, only the lowest of which, right on the “border” of our physical world, is associated with the world of music and mathematics. The physical domain of the world of *Asiyah* is the physical world which we inhabit.

How does the concept of creation from nothing filter down through the myriad levels of Seder Ha'Histolshelut to our World of *Asiyah*? Can we find illustrations—however coarse—of *creatio ex nihilo* in mathematics and physics? I shall endeavor to do this below.

Yesh Me'Ayin in Mathematics: Peano's Set Theory

Let us begin with mathematics—the queen of science. Where else should we look for creation from nothing if not in number theory, which itself is called the queen of mathematics. As it turns out, all of mathematics is based on (or “created from”) number theory. When mathematicians attempt to prove the consistency of a mathematical theory, they reduce it to number theory.

One would think that at least two numbers are necessary in order to build the full set of natural numbers: zero and one. Indeed, if we start with zero and add one to it, we obtain one. Adding one to this result, we obtain the number two, and so on. In fact, most textbooks on number theory do just that.

The Italian mathematician Guiseppe Peano took another approach. He built the first consistent system of axioms for number theory using set theory as the foundation. A set is a formal mathematical representation of the familiar notation of a collection of objects. A set of three elements $\{a, b, c\}$ is a collection of the three objects a , b , and c . Set theory can have some very interesting sets. First of all, sets do not have to have only a finite number of elements. There are sets containing an infinite number of elements, such as the set of all natural numbers $N = \{\emptyset, 1, 2, \dots, n, n+1, \dots\}$. Then, there is $\emptyset = \{\}$, an empty set that contains no elements at all; and there is U , a universal set that contains *all* elements. A set can contain other sets as its elements.

According to Peano, the natural numbers are constructed (or “created”) from the sets as follows. We begin with the empty set $\emptyset = \{\}$. An empty set $\{\}$ has no elements.

In fact, it has nothing. The number of elements in this set is obviously zero. Hence, we get our first natural number, *zero* (\emptyset). We then consider a set in which the sole element is the empty set $A = \{\emptyset\}$. The set A now has one element, the empty set, whereby we obtain our second natural number, *one* (1). The next set will contain two elements, the set A and the empty set $B = \{A, \emptyset\}$. Thus, we obtain the next natural number, *two* (2), and so on *ad infinitum*. This simple procedure allows us to create the entire infinite set of natural numbers by using only one concept—the empty set.

Peano's construction of the set of natural numbers from an empty set gives us an illustration, an analogy to the concept of *creatio ex nihilo*. Needless to say, the well-defined concept of an empty set is a far cry from the incomprehensible nothingness that preceded G-d's creation of the universe. It is a crude example at best. Yet, because the empty set contains...well, nothing, it is not such a bad example of nothingness after all and may be the best example of nothingness available to us in mathematics.

Our analogy does not stop here. A careful reader may notice that Peano's method presupposes the existence of an empty set. In fact, this assumption of the existence of at least one set—an empty set—is the first axiom of set theory in Zermelo-Frenkel's axiomatic set theory. This axiom is appropriately called the *Axiom of Existence*. An axiom in mathematics is a self-evident truth that does not require proof. Why is the existence of an empty set considered self-evident? Can we imagine a forest with no trees? Can we imagine a novel with no words, a symphony with no sounds? Yet, we must postulate the existence of the empty set before we can proceed building number theory. The "belief" in the Axiom of Existence as a self-evident truth in a way parallels the belief in the existence of G-d, Whose creative powers are the "building blocks" of creation.

Let us now turn to physics. On the surface, the physical world appears solid and tangible. Who would think that behind this appearance is utter nothingness?! In physics this nothingness is called quantum vacuum. Although it is not the primordial nothingness that preceded Creation, a vacuum is a good example of “nothingness” because there is nothing there. Quantum vacuum, however, is not a static dull nothingness. On the contrary, quantum vacuum is abuzz with activity. It is here that virtual particles like virtual electrons and positrons appear out of nothing for a fleeting moment to disappear back into nothingness.

How is this possible? Werner Heisenberg’s Uncertainty Principle gives us a clue. According to the Uncertainty Principle, the energy state of a particle and its time duration cannot be measured simultaneously with precision. The product of an uncertainty of the energy (ΔE) and the time during which it is measured (Δt) must always be equal to or greater than the Planck constant (\hbar): $\Delta E \times \Delta t \geq \hbar$. This means that for a short period of time energy can be “borrowed” from the vacuum without violating the law of energy conservation. This is how virtual particles are born. The shorter the life span, the more energy such a particle could have. These virtual particles, albeit short-lived, behave very violently, colliding with each other and annihilating each other in a burst of energy when particle and antiparticle collide. This is an example in quantum physics of how matter can arise out of a vacuum.

Yesh Me’Ayin in Cosmology: The Big Bang

Cosmology provides us with a no less dramatic example. Most cosmologists today consider the existence of the entire universe to be the result of a big bang. The big bang was an explosion of unthinkable proportions through which time, space, and matter all came into existence. But where did the explosion come from? From nothingness! Before the big bang, there was no matter, not even space or time. Before the big bang, there was not merely an empty

space; there was no space at all. It is hard to find a better example of the utter nothingness out of which G-d created the universe.

Conclusion

Needless to say, these parallels in mathematics and physics to the concept of *yesh m'ayin* are not meant to be a scientific “proof” of this concept, but merely approximate illustrations. It may be surprising that we find such parallels at all. However, on second thought, it should not be surprising. Recall that Kabbalah and Hasidism view our world as existing on many parallel planes of reality, most of which are spiritual and the lowest of which are physical. Consequently, *yesh m'ayin*—the creation of something from nothing which takes place in the World of Creation (*Briyah*)—ripples through all the worlds and levels and descends into our world, the lowest world of *Asiyah*. In the World of *Asiyah* *yesh m'ayin* filters into the spiritual domains of ideas and mathematics and the physical domain that we are cognizant of. (This ripple process works the other way as well. Everything we do down here reverberates up through all the higher spiritual realms, eventually returning to us in a never-ending universal feedback loop.)

Rabbi Eliyahu of Vilna (the Gra) once said that it is impossible to understand Torah without understanding science. At the very least, science and mathematics can provide vivid illustrations of highly abstract Torah concepts. Our ability to see supernal spiritual concepts reflected in this lowest of worlds is in itself a testimony to the fact that the physical world is but a small part of a greater universe composed of innumerable parallel levels of reality which all reflect the same unifying principle of creation.

Note

“This, of course, is an oversimplification. Maimonides maintains that *creatio ex nihilo* cannot be proved logically or scientifically (*Guide to the Perplexed* 2:15).