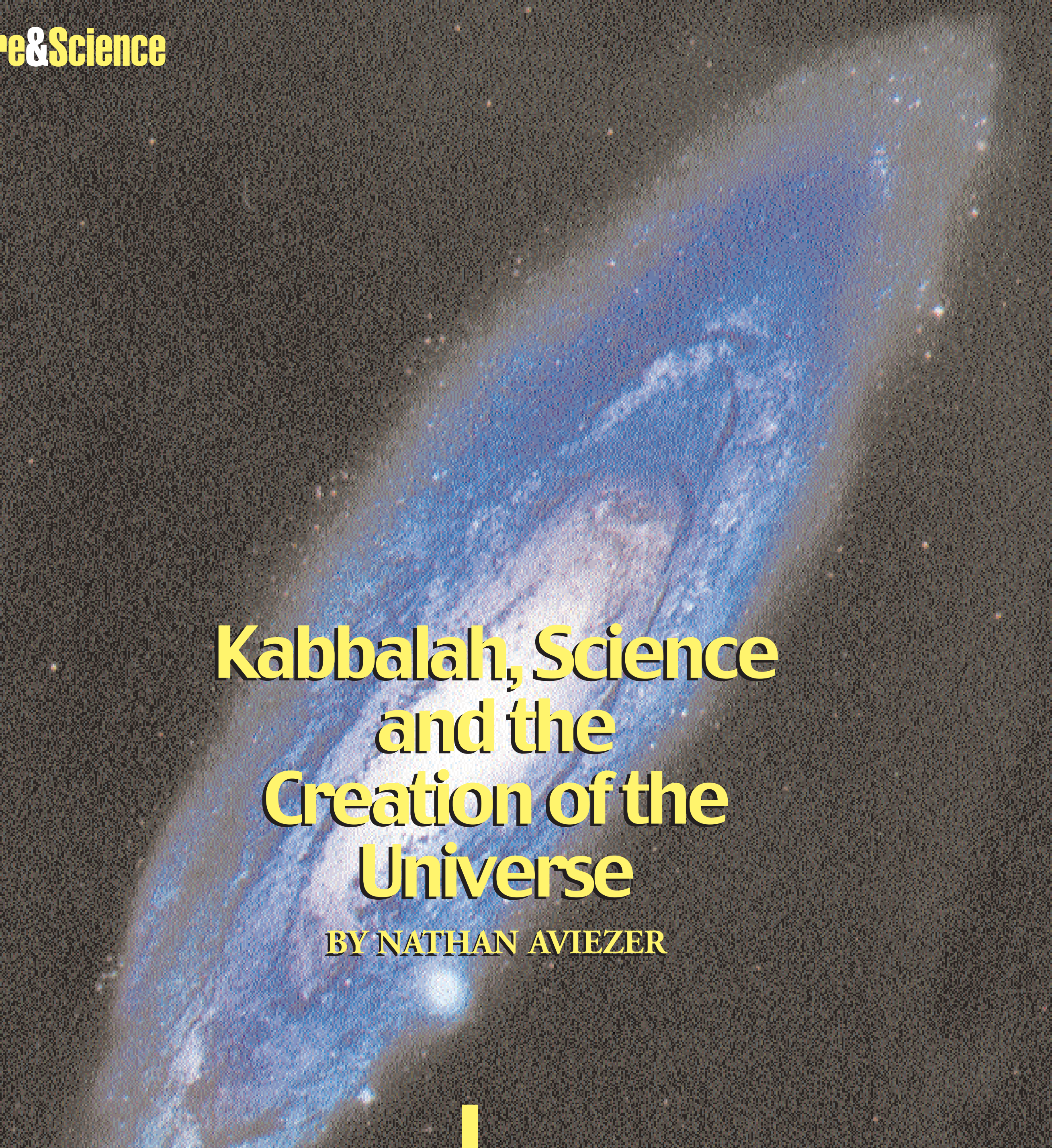


Kabbalah, Science and the Creation of the Universe

BY NATHAN AVIEZER

In recent years, many religious scientists, I among them, have written at length about the emerging harmony between the discoveries of modern science and the Torah account of Creation.[1] In particular, the big bang theory of cosmology provides a scientific explanation[2,3] for every word and phrase that appears in the first five verses of Bereishit—the First Day of Creation. In view of these remarkable correlations between Torah and science, it is tempting to explore the other traditional source that discusses the creation of the universe, namely, kabbalah.

Kabbalah presents a description of Creation that is very different from the description that appears in the first chapter of Bereishit. This does not imply any contradiction between these two accounts of the same event. Rather, the two versions emphasize different features. The Torah description deals with the actual sequence of events (First Day, Second Day, et cetera), whereas kabbalah stresses the role of God in the process of Creation and His interactions with the universe.

Is it possible that the account of Creation given by kabbalah can be correlated with the findings of modern science? One might object to this question on the grounds that kabbalah deals with the spiritual realm, whereas science is restricted to the physical realm. Nevertheless, one of the principles of kabbalah is that the spiritual realm of the world above descends, suitably garbed, to create a physical counterpart in the world below. Therefore, it is indeed in place to ask: Can one find features of the physical world that appear related to kabbalah? As we shall see, the answer to this question is "yes."

In the past few decades, the physical universe has been revealed to be a far richer, stranger and more wonderful place than anyone could have imagined. It is precisely this subtlety and intricacy of the physical world that provide the framework for the various correlations with the spiritual world of kabbalah.

Kabbalah

There are learned scholars who have spent their entire lives studying the mysteries of kabbalah. It is therefore obvious that this essay will not contain a comprehensive account of the subject. For our purposes, it is sufficient to concentrate on a few basic principles.

It should be noted that there are different traditions in kabbalah. Our presentation will follow the ideas of the Ari (Rav Isaac Luria, sixteenth century), whose approach to kabbalah was foreshadowed in the writings of earlier *mekubalim* (kabbalists). The views of the Ari were written down by his most important disciple, Rav Chaim Vital.[4]

One of the basic concepts in kabbalah is the *sefirot*. The origin of the term has been understood in various ways: it is either *sefirot*, that is, "spheres," or *sapirim*, relating to God's "radiating and sparkling," or *mesaprim,* alluding to the Divine cosmos "relating" the glory of God. The essence of God cannot be known; we know of God only through His manifestations. Central to His manifestations are the ten *sefirot*, which represent Divine emanations or dimensions. The idea of exploring the ten *sefirot* is discussed in *Sefer Yetzirah* 1:4:

> *Ten* sefirot *from nothingness. Ten and not nine; ten and not eleven.*
> *Understand with wisdom; be wise with understanding.*
> *Probe with them and explore with them. Establish a thing in its essence.*
> *And return the Creator to His rightful place.*

The Kabbalistic Account of Creation

Kabbalah characterizes God as the *Ein-Sof* ("without end"), a limitless and unknowable infinite realm. The ten *sefirot* are configurations of Divine powers within the Godhead, containing the principles whereby God manifests Himself to us, and constituting the vehicle through which God interacts with the universe.

In the beginning, the universe did not exist. The existence of an entity in addition to the *Ein-Sof* would have been impossible, because this would constitute a limitation on His infinity. To enable the universe to exist required an act of *tzimtzum* on the part of God. The literal meaning of *tzimtzum* is "contraction," which the Ari understood as "withdrawal." Although the Midrash also speaks of the presence of God undergoing *tzimtzum*, the idea there is that His presence contracts and *concentrates into* a point. The Ari understood *tzimtzum* to mean contracting and *withdrawing away from* a point. This Divine withdrawal made possible the creative processes leading to an entity—the universe—that could exist in parallel with the *Ein-Sof.*[5]

God's withdrawal provided a space into which flowed a ray (*kav*) of Divine light. The nature and development of this light is dealt with in kabbalah literature. What is relevant to our discussion is the effect of the light on the *sefirot* or, more accurately, on the vessels (*kelim*) associated with each of the ten *sefirot*.

The vessels of the first three *sefirot* managed to contain the ray of light that flowed into them. However, as the light struck the following seven *sefirot*, it was too powerful to be held by their vessels, which cracked and shattered, one after another. This kabbalistic concept is known as "the breaking of the vessels" (*shevirat hakelim*).

In the future, through human fulfillment of Torah and *mitzvot*, the seven broken *sefirot* may regain their perfection, a process known as *tikkun*. However, until the era of *tikkun*, the universe will consist of three intact and seven broken *sefirot*.

The Scientific Account of Creation

The branch of science that deals with the origin of the universe is known as cosmology. In every age and in every culture, people would look up at the sky and wonder: What was the origin of the heavenly bodies—the sun, the moon and the stars? The concept of Creation was considered an impossibility, because science asserted that something cannot come from nothing. Therefore, scientists viewed the universe as eternal, thus neatly avoiding questions regarding its origin. The Bereishit statement that the universe was *created* became an arena of conflict between science and Torah. That is how matters stood for many years.

But this situation has now changed. The twentieth century has witnessed an unprecedented explosion of scientific knowledge that was nowhere more dramatic than in cosmology. Astronomers had been studying the heavenly bodies for thousands of years, but their studies dealt almost exclusively with charting the paths of the stars, planets and comets, and determining their composition, spectrum and other properties. The *origin* of the heavenly bodies remained a complete mystery. Important advances in cosmology during the past few decades have, for the first time, permitted scientists to construct a coherent history of the origin of the universe. Today, an overwhelming body of scientific evidence supports the big bang theory of cosmology.[6]

The current scientific status of the big bang theory was summarized as follows: "The big bang theory works better than ever."[7] Similar views were expressed in 1999 by cosmologist Brian Greene of Columbia University:

> *The modern theory of cosmic origins [asserts] that the universe erupted from an enormously energetic event...the big bang theory of creation is referred to as the standard model of cosmology.*[8]

The most important assertion of the big bang theory is that *the universe was literally created.* It is instructive to quote some of the world's foremost authorities.

Nobel laureate Paul Dirac, a major architect of twentieth-century physics, writes: "It seems certain that there was a definite time of creation."[9] Leading cosmologist Stephen Hawking writes: "The creation lies outside the scope of the presently known laws of physics."[10]

When cosmologists use the term "creation," to what are they referring? Precisely what object was created? Scientists have discovered that the universe began with the sudden appearance of an enormous ball of light, called the "primeval light-ball." This "explosion of light" was dubbed the "big bang" by the British astrophysicist, Fred Hoyle.[11] The remnant of this primeval light-ball was first detected in 1965 by two American physicists, Arno Penzias and Robert Wilson, who were awarded the Nobel prize for physics for their discovery.

Comparing Kabbalah with Science

Let us summarize the three features of the kabbalah account of Creation: 1. The universe began through an act of creation; 2. Divine light played a central role in the creation and 3. There exist three intact *sefirot* and seven broken *sefirot*. Our task is to relate these features of the kabbalah account of Creation to the scientific theory of the creation of the universe.

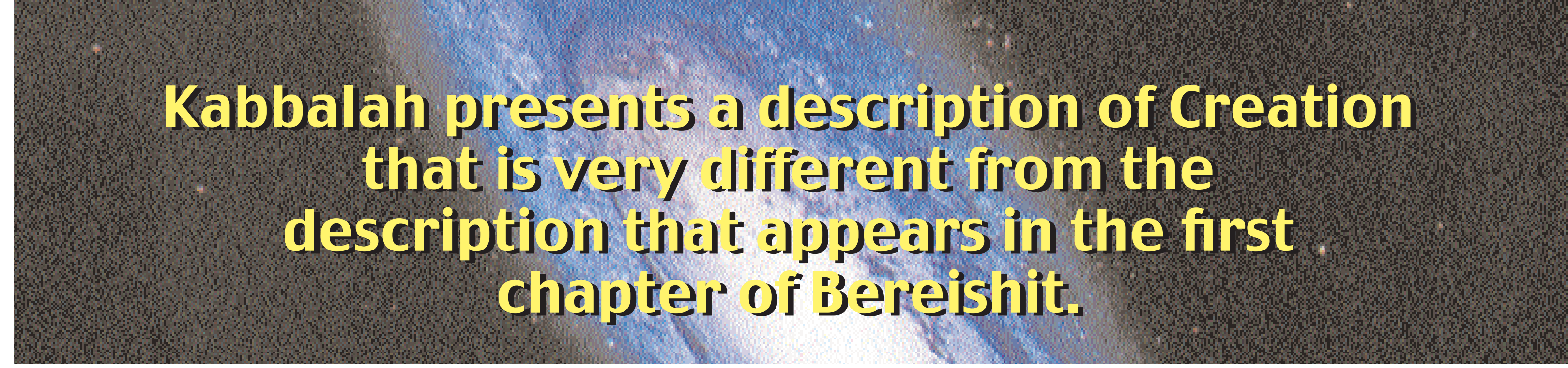
The first feature of the kabbalah account deals with an *event*—the Creation. Correspondingly, the big bang theory of cosmology asserts that the universe was indeed created. Today, it is hardly possible to carry on a meaningful discussion of cosmology without the creation of the universe assuming a central role.

The second and third features of the kabbalah account deal with *entities*—the Divine light and the ten *sefirot*. According to kabbalah, as stated previously, every entity of the spiritual world above descends, suitably garbed, into the physical realm of the world below. Therefore, the physical counterparts to the Divine light and the ten *sefirot* are to be sought in the world below.

The physical counterpart of the Divine light of kabbalah is the primeval light of the big bang. The standard theory of cosmology asserts that the entity that was created at the beginning of time was an enormous ball of light, popularly known as the big bang and hence, the name of the theory. With appropriate instrumentation, one can still observe the remnant of this primeval light that dates back to the very origins of time.

The difficulty resides in the third feature of the kabbalah account of Creation. What might be the physical counterpart of the ten *sefirot*? Since the *sefirot* are often described as the "dimensions of God," we propose that the physical counterpart of the *sefirot* in the world below are the spatial dimensions of the universe. According to this proposal, the three intact *sefirot* correspond to the three familiar dimensions of space: east-west, north-south, up-down.

This brings us to the crux of the problem: The total number of *sefirot* is ten. Is there any sense in which one can speak of a ten-dimensional universe? And what is meant by the broken *sefirot*? Is there such a thing as a



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The physical counterpart of the Divine light of kabbalah is the primeval light of the big bang.

broken dimension?

These questions are answered by string theory,[12] the modern scientific description of the universe. String theory asserts that the universe *consists of ten spatial dimensions*. This discovery has generated a great deal of excitement. On the cover of a recent scientific journal, the following words appeared: "String Theory and Space-Time with Eleven Dimensions."[13,14] The eleven dimensions of space-time posited by string theory consist of one time dimension and ten spatial dimensions.

Of the ten spatial dimensions, three are the usual dimensions previously mentioned (up-down, east-west, north-south), while the other seven dimensions have become "compacted" (in the language of string theory) and, as a result, are not directly accessible to our senses. This is why it was previously thought that we inhabit a universe of only three dimensions.

The importance of these amazing scientific statements lies in the fact that they imply a correspondence between science (string theory) and kabbalah. One may identify the physical counterpart of the seven broken *sefirot* of kabbalah with the seven compacted dimensions asserted by string theory.

Gravity

To understand why scientists speak of a ten-dimensional universe, one must study gravity. Over the years, the theory of gravity has undergone a number of important changes, which we shall now describe.

1. In 1687, the first theory of gravity was proposed by Sir Isaac Newton. In his *Principia*, the most important book of science ever written, Newton introduced the idea that every two objects in the universe attract each other with a force, called gravity, whose magnitude depends on the distance between the objects. This proposal enabled Newton to explain planetary motion, as well as many other phenomena, such as the tides.

Gravity is one of the four forces in nature. The other forces are the two nuclear forces (that operate within the atomic nucleus) and the electric force (or, more correctly, electromagnetic force, since electricity and magnetism are two aspects of the same force).

2. In 1905, Albert Einstein proposed the special theory of relativity, establishing the relationship between matter (M) and energy (E) through his famous formula $E=Mc^2$, where the letter c refers to the speed of light. Einstein's theory of special relativity has been confirmed countless times and is one of the fundamental principles of science.

Every scientific theory *must* be compatible with the theory of special relativity. The theories of the nuclear forces and the electric force were found to be consistent with special relativity. However, Newton's theory of gravity did not conform to the principles of relativity. It took Einstein a decade to formulate a new theory of gravity that *was* consistent with special relativity. In 1916, Einstein announced his theory of gravity, which he called the "general theory of relativity," considered by leading scientists to be "the most beautiful of all existing physical theories."[15]

3. The most surprising result of Einstein's theory is that gravity is not a force, but rather, it is a "distortion of space."[16] The gravitational attraction between two objects is not due to one object pulling on the other object, as is the case for the electric force between two electric charges. Instead, gravity works as follows: The first object "distorts" the space around it, and the second object moves in reaction to this distortion of space. Since we cannot see the distortion of space, it appears *as though* the two objects are attracted to each other by means of a force.

This concept can best be explained by means of the illustration in Figure 1. In the top part of the figure, one sees a stretched rubber sheet on which a small ball lies motionless. The bottom part of the figure shows what occurs after a large ball has been placed on the rubber sheet. The effect of the large ball is to distort the rubber sheet, with the distortion being greatest in the vicinity of the large ball but much less further away.

As a result of the distortion of the rubber sheet, the small ball begins to move toward the point of maximum distortion (which is where the large ball lies). Therefore, the small ball moves *towards* the large ball. However, *there is no force of attraction between the two balls*. The motion of the small ball

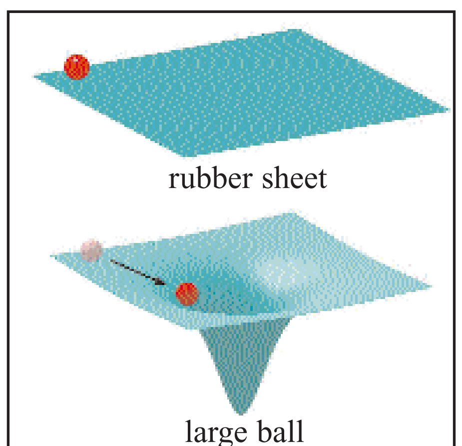

Figure 1

is caused by the distortion of the rubber sheet, which in turn is caused by the large ball.

The rubber sheet represents space whose "distortion" is invisible to us. We see only the small ball moving towards the large ball. Therefore, Newton assumed that a force of attraction (gravity) exists between every pair of masses. However, Einstein demonstrated that gravity is not a force at all, and that the correct description of gravity is a distortion of space.

The theories of gravity proposed by Einstein and by Newton are fundamentally different. In practice, however, the *predictions* of these two theories are very similar. In fact, their predictions are so similar that for two centuries, no one doubted Newton's theory. However, whenever the two theories do differ somewhat in their predictions, it is always Einstein's theory that agrees with the detailed observations. Therefore, Einstein's theory of gravity has become accepted by all scientists.

In summary, gravity is not a force, but rather a distortion of space. Thus, gravity is totally unlike the other three forces of nature. We shall soon see the importance of this.

4. The 1920s witnessed the development of quantum theory. The revolutionary aspect of quantum theory is that the universe is probabilistic, rather than deterministic, as had been believed previously. Quantum theory asserts that it is impossible in principle to predict what will happen in the future. One can only predict what *might* happen in the future with various probabilities. (The best layman exposition of quantum theory is that of Nobel laureate Richard P. Feynman, *QED: The Strange Theory of Light and Matter* [New Jersey, 1998].)

Quantum theory has been confirmed by thousands of experiments, and has become established as a basic principle of science. Every correct theory *must* be compatible with quantum theory. Feynman received a Nobel prize for devising the procedure, called "renormalization," that makes the theory of the electric force compatible with quantum theory. Feynman's procedure also succeeds for the nuclear forces. However, when scientists applied Feynman's procedure to Einstein's theory of gravity, the results were meaningless.[17] This failure was shown to be due to the fact that gravity is not a force, but rather a distortion of space. It is this feature that makes Einstein's theory of gravity incompatible with quantum theory.

This is a very serious problem indeed. Quantum theory is certainly correct, and Einstein's theory of gravity is also certainly correct. How can it be that two correct theories of nature cannot be made compatible with each other? Why is it impossible to formulate a consistent theory of "quantum gravity"?

5. The apparent contradiction between quantum theory and Einstein's theory of gravity is resolved by string theory. (An excellent layman exposition of string theory has been given by string theorist Brian Greene in *The Elegant Universe*.)

String theory is a new conceptual framework for describing the physical universe. According to the previous conception, the basic entities of the universe are particles—electron, quark, photon, et cetera. String theory asserts that the basic entities of the universe are tiny strings. These strings can vibrate (like a violin string), and the energy of vibration appears as a particle through the Einstein relation between energy and mass ($E=Mc^2$).

If one applies string theory to a three-dimensional universe, nothing is gained. In three dimensions, string theory fails to yield a theory of quantum gravity. Moreover, a similar failure occurs for any number of spatial dimensions fewer than ten. However, for a ten-dimensional universe, string theory does yield a theory of quantum gravity. In other words, if our universe consists of ten spatial dimensions (plus one dimension of time), then according to string theory, Einstein's theory of gravity is indeed compatible with quantum theory. This important success has made string theory the leading candidate for what is often called The Theory of Everything.

In summary, scientists have discovered that Einstein's theory of gravity can be consistent with quantum theory *only* if the universe consists of ten spatial dimensions.[18] Since these two theories *must* be consistent with each other, it follows that *the universe must be ten dimensional*.

6. This raises the following questions: How can one reconcile string theory (ten-dimensional universe) with our everyday experience (three-dimensional universe)? What is the meaning of the missing seven dimensions? Why do we not experience them?

String theory provides the answers. The seven missing dimensions have become compacted to such a small size that it is impossible to experience them. Whereas each of the three usual dimensions extends to infinity, the other seven dimensions extend for only a very minute distance. As Gabriele Veneziano, the originator of string theory, explains:

Electrons are strings that move around freely in three of the ten spatial dimensions but are stuck within the other seven.… The partial mobility of electrons and other particles explains why we are unable to perceive the full ten-dimensional glory of space.[19]

The concept of a compacted dimension is illustrated in Figure 2 (see next page). The top part of the figure shows a pipe whose three dimensions are its length and its cross-sectional area. The bottom part of the figure shows the cross-sectional area so diminished that the pipe has been reduced to a thread. As the cross-sectional area is further diminished, these two dimensions become observable only with difficulty, and eventually, it becomes impossible to observe them.

According to string theory, the extent of a compacted dimension is a billionth of a billionth of a billionth of the radius of an atom (called the "Planck length," in honor of Nobel laureate Max Planck). Such a small size can never be detected with any measuring device. This is the meaning of a "compacted dimension"—a dimension that exists but is far too small to be measured. Even though the compacted dimensions cannot be measured *directly*, they have very significant *indirect* effects on the universe.

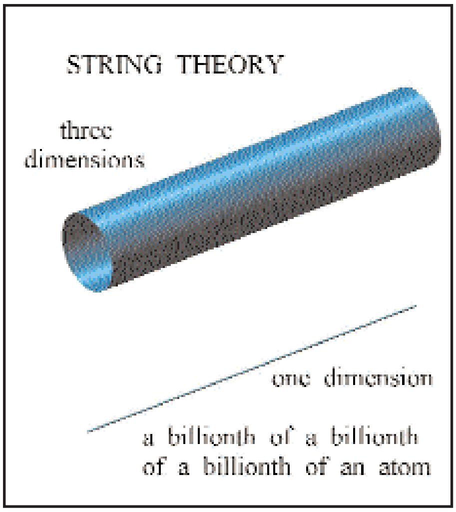

Figure 2

One of these indirect effects is that the compacted dimensions lead to a consistent theory of quantum gravity.[20]

Kabbalah, Science and Creation—A Summary

String theory is the modern scientific framework for understanding the universe. One of the most important discoveries of string theory is that we inhabit a ten-dimensional universe. Of these ten dimensions, three are the familiar dimensions of space, while the remaining seven became compacted during the process of Creation and, as a result, "we are unable to perceive the full ten-dimensional glory of space."[21]

Kabbalah, which describes the spiritual world above, speaks of ten *sefirot*. Of these ten *sefirot*, three remain intact while the other seven became broken during the process of Creation. The ten-dimensional universe of the world below is to be identified as the physical counterpart of the ten *sefirot* of the world above. Similarly, the seven compacted dimensions of the world below are the physical counterpart of the seven broken *sefirot* of the world above. The world above and the world below are, respectively, the spiritual and physical expressions of the universe.

The world above was happy, and the world below rejoiced when the Torah was received on Mount Sinai (*Yotzrot* of Shavuot, Musaf of the first day). JA

Notes

1. Nathan Aviezer, *In the Beginning*: *Biblical Creation and Science* (New Jersey, 1990) and *Fossils and Faith* (New Jersey, 2002); Gerald Schroeder, *Genesis and the Big Bang: The Discovery of Harmony Between Modern Science and the Bible* (New York, 1990) and *The Science of G-d: The Convergence of Scientific and Biblical Wisdom* (New York, 1997); Yehudah Levi, *Facing Current Challenges* (New York, 1998) and *Science in Torah: The Scientific Knowledge of the Talmudic Sages* (New York, 2004).

2. See, for example, Aviezer, *In the Beginning*, chap. 1.

3. This statement relates to Torah words that have *physical* content. However, there are also Torah words in the first chapter of Bereishit that have only *spiritual* content, such as, "The spirit of God hovered over the surface of the water" (1:2). Clearly, science can tell us nothing about the meaning of this Torah phrase.

4. *Sefer Etz Chaim*.

5. Ibid., *heichal aleph* (*adam kadmon*), *sha'ar aleph*, *drush iggulim veyosher*.

6. There are four major pieces of evidence: 1. The discovery of the remnant of the initial ball of light that fills the universe; 2. The hydrogen-to-helium ratio in the universe; 3. The expansion of the galaxies and 4. The perfect black-body spectrum of the microwave background radiation measured by the COBE space satellite in 1990, and the additional measurements of this radiation made by the MAP space satellite launched in 2001.

7. George Musser, "Four Keys to Cosmology," *Scientific American* (February 2004): 30.

8. *The Elegant Universe* (London, 1999), 345-346.

9. *Commentarii* 2, no. 11 (1972): 15.

10. *The Large Scale Structure of Space-Time* (Cambridge, United Kingdom, 1973), 364.

11. Scientists often use the term "electromagnetic radiation," which means the same thing as light. To avoid technical terminology, we use the word light.

12. String theory has gone by a variety of names during its development, including superstring theory, brane theory and M-theory, with the last designation being popular among the cognoscenti. Here we shall use the more widely known name of "string theory," even though we shall be quoting the latest results of M-theory.

13. Questions and Answers, *Scientific American* (November 2003): front cover.

14. Einstein's theory of special relativity asserts that space and time are interwoven, and one therefore speaks of *space-time*. However, we shall restrict our discussion to *spatial* dimensions. The concept of *time* in kabbalah is a subject that requires a separate article.

15. Lev Landau and Eliav Lifshitz, *The Classical Theory Of Fields*, 2d ed. (Oxford, 1962), 260.

16. Einstein's theory of gravity also implies a distortion of time (called time dilation) since time is linked to space. However, we will not be discussing time here.

17. The calculated value for many measurable quantities was found to be infinity. Also, the theory had internal inconsistencies.

18. String theory also yields a consistent theory of quantum gravity for a universe having twenty-six dimensions, and for a universe having an even higher number of dimensions. However, scientists concentrate on the lowest number of dimensions (ten), for which there exists a consistent theory of quantum gravity.

19. "The Myth of the Beginning of Time," *Scientific American* (May 2004): 43.

20. Another important effect of the compacted dimensions concerns the magnitude of the forces of nature. At normal (low) energies, the magnitude of the forces ranges from the very strong nuclear force to the very weak force of gravity. At a specific very high energy, called the Planck energy, it has been shown that all the forces of nature must have the same magnitude. Calculations show that this prediction is correct *only* if the universe has additional compacted dimensions.

21. Veneziano, 43.