# Lecture 5

## Back to Symmetry

We will now continue to talk about symmetry. The concept of symmetry is one of the most important concepts in modern science. Last time we spoke about CPT symmetry, which stands for Charge, Parity, Time. Symmetry is modern science is used in the sense that if you interchange or reverse two complimentary concepts, then the end result will be the same, meaning that you will not be able to distinguish between the universe that you began with and the universe that you arrived at after your interchange. If all the electrons in the world would suddenly change into positrons, and all the positrons would change into electrons, then you would not be able to tell the difference. Parity symmetry means that if right and left reverse, which is basically that you would be looking at the universe through a mirror, then everything would remain the same, you would not be able to tell the difference. Time symmetry is the most difficult to understand because it says that if you reversed the order of things, everything would still remain the same. Time symmetry is the most counter-intuitive of the three and it is very difficult to understand what it means.

But, as we mentioned last time, none of these symmetries is complete by itself. Instead they are complete only in conjunction. Meaning, that if all the charges would reverse, and all the directions, the spatial extensions, and time would reverse, only then would you still see the same universe that we have now.

We mentioned that time relates to the mind, the intellectual level of the soul, while charge relates to the emotional, and parity relates to the habitual or behavioral faculties of the soul.

Now let us turn to two additional examples of symmetry that emerge from modern physics.

## Size does not matter

There is a symmetry principle, which derives solely from string theory considerations, which is the most amazing type of equivalence that can be imagined and this principle is denoted by the simple equation R = 1/R, where R is the radius of the

universe, which is very large, millions of light years. And yet, what this equation says is that our huge universe, which is billions of light years across is no different than a universe that is so tiny that it is inconceivably small, much smaller than even a photon. A universe with radius R is equivalent to a universe with radius 1/R. In other words, there is no difference between big and small.

## "He who is large is small (and large)"

Every thought which has any truth to it must have a source in the Torah. This very last thought, has a very explicit source in the *Zohar* which reads: "One that is very small is very big, and one that is very big is very small."[40]

What this implies of course is that a person who in his own eyes [41]is very small—he is very humble—from the perspective of the Almighty, that person is actually very great. In this world, which is the world of deceit, he is small, but in the world of truth, he is very big. And the opposite is also true, a person who in this world considers himself to be very big, great, and outstanding, in the world of truth, from the true perspective of the Almighty, he is actually very small.

What string theory adds to the regular interpretation of this statement from the *Zohar*, is that both sides are true simultaneously. The usual interpretation is that if you consider yourself to be small, in truth you are big, and if you consider yourself to be big, in truth you are small, or insignificant. But, now we are saying that to be very small is to be very big. Both are true simultaneously. So symmetry is telling me that I cannot tell the difference between the two things. Big and small are entirely equivalent. It is not just a question of perspective; they really are exactly the same. Again, this is the most counterintuitive result of modern physics. We usually think that we can tell the difference between big and small. Yet, here comes string theory and teaches us that we really cannot tell the difference between the two.

So we have just presented in short a symmetry principle, an equivalence principle, which is entirely different than CPT. It is much more than CPT symmetry.

## Super-Symmetry

Let us turn to super-symmetry. What super-symmetry says is that fermions and bosons can be interchanged. In this lecture we will

---

. מאן דאיהו זעיר איהו רב, ומאן דאיהו רב איהו זעיר .□

[41]. עלמא דקשוט

be talking about all the different types of elementary particles and what they have to teach us about our lives.

In general, in physics today we recognize two types of elementary particles: real particles and virtual particles. Real elementary particles divide into two categories: the *fermions* are the matter particles, and the *bosons* are the messenger, or force particles, which cause interactions. Examples of fermions are electrons and quarks, which make up the protons and the neutrons, which constitute matter.

The simple difference between bosons and fermions is in their *spin*. Elementary particles that have a half (or multiple of a half) spin are matter particles, or fermions. Elementary particles that a whole (or a multiple of a whole number) spin are messenger particles, or bosons.

The concept of "whole" and "half" is straight out of the teachings of the 12th century Kabbalist, Rabbi Avraham Abulafia. Abulafia explains that the world has to simultaneously have both whole and half. In kabbalistic terminology, this refers to the masculine and feminine aspects of reality, where the "whole" represents the masculine and the "half" represents the feminine. In modern physics, these two aspects, whole and half, appear in the context of the spin of an elementary particle.

What is particle spin? You can think of spin as being the number of times that you have to rotate a particle in order to bring it back to its starting position, so essentially spin is a symmetry consideration, because we are asking under what kind of rotation will the particle return to its initial state?

Matter particles, or fermions, need to be spun multiples of 180° in order to return to their initial state. 180° is half of a full 360° rotation. Messenger particles, or bosons, have to be spun a whole number of times, meaning multiples of 360° in order to return to their initial state. Following the kabbalistic terminology noted above, we can correspond matter particles, which have multiples of half spin, with the feminine aspect of reality and messenger particles, which have multiples of whole spin, with the masculine aspect of reality.

Super-symmetry is fairly simple to express: if you would exchange all the fermions for bosons and all the bosons for fermions, the universe would stay the same and you would not know the difference. In our spiritual language, you could say that if all the men were exchanged for women and all the women were exchanged for men, then the universe would stay the same and you would not be able to tell the difference.


2 Hausner St. ◆ Jerusalem 96431 ◆ tel.: 972.547.533770 ◆ info@gpsociety.org

## Super-partners

What super-symmetry implies is that every particle has a super-partner. The partner of every elementary particle that we know of, has spin exactly ½ less than that particle. What this means is that every matter particle has a messenger-particle partner lurking somewhere in the quantum world, but these super-partners have yet to be found.[42] The same is true for every messenger particle with whole spin. It too has a super-partner, with spin ½ less, which identifies it as a matter particle.

It is important to stress the difference between anti-particles and super-partners. These are not the same at all. Every particle has an anti-particle with negative the amount of electrical charge that it has. Regarding super-symmetry and super-partners we are dealing with the particles' spin and claiming that every particle has a super-partner with ½ less spin than it has. If these super-partners would be found, it would prove super-symmetry. This would not yet prove that super-string theory is correct, but it would support it.

Why is it so difficult to find these super-partners? The problem with observing these super-partners is that they are very heavy, which means that you need a lot of energy to create them and they exist for a very short amount of time. This is also a counter intuitive notion, because we would think that the bigger something is, the easier it should be to observe them. The bigger the elementary particle is, the less time it exists, giving you less time to find it. One of the objectives of building bigger and bigger particle accelerators is to be able to create heavier particles. One of the hopes is that in these new, more powerful accelerators we will be able to observe the conjectured super-partners of super-symmetry.

## Super-symmetry and the sanctification of marriage

The Torah allusion to super-symmetry, which states that the two basic types of particles, bosons and fermions, can be interchanged, is to be found in the beginning of the second chapter of the tractate of *Kidushin*, the Talmudic tractate that deals with marriage and the sanctification of a woman by the man. The *mishnah* states that the husband can sanctify a woman in marriage either himself or by messenger, and the woman can accept

---

[42]. Science has not yet proven that super-partners exist. Using our analogy into male and female, the super-partner is like the marriage partner. Every person who is still single has to believe that they have a partner somewhere out there, and that they have simply not found them yet.

the sanctification of marriage from a man either herself or by messenger. In other words, the groom can give the wedding ring (or an amount of money) to a messenger to take it to a woman who perhaps lives far away, in order to sanctify her to be betrothed to him. The messenger can then go to the woman and sanctify her for the person who sent him.

The same thing is true of the woman. She can receive the ring directly, or she can send a messenger to receive the ring.

The Hebrew wording of the *mishnah* leaves it open to a simple misunderstanding. In the original Hebrew, the conjunction connecting "himself" with "by messenger" is what is usually understood as the "and" conjunction.[43] Nonetheless, this is not the simple, literal meaning of the mishnah, for sometimes the conjunctive "and" is understood to mean "either/or." So though one might conclude that both forms of sanctification—in person *and* by messenger—are needed in order to get married, this is not the case. A man can sanctify his wife *either* himself, in person, *or* by messenger. He does not have to do both.

## Virtual particles and literal readings of the Mishnah

Nonetheless, many times, a Kabbalistic interpretation can reveal how the literal meaning is also correct. In this case, the Kabbalistic interpretation would be that the mishnah is also alluding to our subject of matter and messenger particles. The man who is sanctifying symbolizes the matter particle and his messenger sent to sanctify his bride symbolizes messenger particles. What modern quantum mechanics has revealed is that every direct interaction between particles involves both matter and messenger particles, which are actually virtual particles. In order to describe this process one needs to use diagrams developed by Richard Feynman, a Jewish physicist from Caltech, and probably the greatest physicist after Einstein. Feynman diagrams reveal how whenever there is a quantum interaction, even a direct interaction like an electromagnetic interaction between to electrons, both sides actually exchange messenger photons, which are virtual particles.

Going back to the mishnah. First let us say that perhaps the greatest interaction in the Torah is that of sanctifying a woman in marriage. Whenever there is an interaction, at some level, there are either actual or virtual messengers that are being passed back and forth to facilitate the interaction.

---

[43] האיש מקדש בו ובשלוחו, the vav here literally means "and."


2 Hausner St. ◆ Jerusalem 96431 ◆ tel.: 972.547.533770 ◆ info@gpsociety.org

## Two fires

Let us see another example of this. In Hebrew, "man" is איש, and "woman" is אשה. They share the two letters אש and the two additional letters י-ה which differentiate between them have a relationship of a whole (10 = י) and a half (5 = ה). י-ה is also a sanctified Name of God. Thus, Rabbi Akiva says that if a man and a woman merit to manifest the yud of the man and the hei of the woman and to unite them into a holy Name, then the Divine Presence dwells between them. If they do not merit to manifest and unite these two letters, the two left-over letters in each word alef and shin, which together spell "fire" (אש) will consume them. This fire is either the fire of unholy passion, or the fire of anger. If the yud and hei are united, then the fire becomes holy fire, the fire of sacrifices in the Tabernacle. Everything that the Torah describes regarding the service that takes place in the Tabernacle alludes to secrets of both creation and the secrets of the chariot.

So now, both the man and a woman has a messenger in addition to being able to sanctify in person. These messengers are like angels. In fact, we usually explain that everything in the QM world, all the elementary particles, can be understood as angelic "entities." This is especially true of the force particles, which act as messengers.

So if the male and the female both have messengers, then the male fire represents both the male and his messenger, and the same goes for the woman.

In the beginning of the Song of Songs, we find the phrase: "…support me with fires."[44] In the Temple there were two fires that simultaneously burned on the altar and consumed the sacrifices that were placed on it. The first was a fire that came from below, meaning that it was lit by the priests. That was the female fire. In direct response to the fire that we brought, fire would descend from heaven. That was the male fire. These are the two fires that are referred to in this phrase.

So, as we said, both the man and the woman have the two letter alef and shin in common. Now we can say that the common shin, which is the initial of the word "messenger" (שליח), which both the male and female contain.

There is a question raised in the Talmud about what happens if the messenger has "second thoughts." I send him to sanctify a woman, but when he meets her he decides to sanctify her for himself. This creates all kinds of problems, but in quantum mechanics this corresponds to an example of super-symmetry, because the boson (the messenger) has decided to become a fermion

[44]. סמכוני באשישות.


2 Hausner St. ◆ Jerusalem 96431 ◆ tel.: 972.547.533770 ◆ info@gpsociety.org

(a matter particle). The messenger has transformed into the person sanctifying. The same is also true for the woman.

## Three symmetries and three aspects of love

We have now seen three different examples of symmetry:

- CPT (Charge Parity Time)
- Size equivalency
- Super-symmetry

Each of these is totally different from the two others. To give these three a model, we refer to the three parts of the second verse of the Shma: "And you will love God with all of your heart, with all of your soul, and with all of your might." The three aspects of the love of the Almighty are thus:

- Love with all of your heart
- Love with all of your soul
- Love with all of your more

## CPT and the heart

The sages say that to love with all of one's heart means to love God with both the positive and negative inclinations. Meaning, that one has to reach in one's consciousness an equivalency, a symmetry, or parity between the left and right sides of the heart (which are explained in the Tanya to harbor the negative and positive inclinations, respectively). As explained earlier, parity symmetry must come together with time and charge symmetry. Actually, all of CPT as corresponded to the intellectual, emotional, and habitual faculties, actually correspond to these faculties of the heart in itself. Meaning, that form whatever angle of your heart, whether it be the habitual, the emotive, or even the innermost aspect of the heart, its intellect, you should have parity between the good and evil inclinations. Practically, this means that we have to be flexible enough to change the way in which we serve God, as explained yesterday in relation to the Akeidah (the Binding) of Isaac. Even if my primary way of serving God is through fear, by being flexible enough to also serve through love this opens up the same possibility for someone who serves out of love.

## Super-symmetry and the soul

Super-symmtery corresponds to loving God with all of one's soul. Why? One's soul represents one's function, or role in life. Feynman explanation for the paradox inherent in the quantum world was that in reality all possible paths are taken simultanesously. In order to figure out why a particle reaches a certain

destination, you had to sum over all the possible paths that lead to that destination. Sometimes, there could be an infinite number of possible paths. Nonetheless, we have to take the sum over all of these possibilities in order to fully describe what happened. In life, sometimes I am trying to reach some goal and then all of a sudden I realize that perhaps I have to take the complete opposite direction to get to that destination. CPT symmetries mean that possible paths involve opposite directions along parity, charge and time also have to be summed in order to get the final outcome, sometimes I have to change my left with my right to reach the goal, or change charge, or go backwards in time. But, super-symmetry is not just a change of path to get to the same outcome, it represents a complete change in one's "goal," as it were. CPT symmetry is a change of path, but not a change of goal.

One way to see this is in Rebbe Nachman's story of the Seven Beggars. People were trying to reach the Tree of Life, but each one thought that there is a different path to reach it. It was impossible to make peace between these people because each had a different idea how to reach the goal. Rebbe Nachman explained that the difference in directions is a consequence of the different goals that they have. Each person in essence possesses the characteristics of the goal that he or she is trying to achieve.

We see this same problem in politics. Take for instance the politics of the Jewish people today. We have many groups, each with good intentions of reaching peace on Earth, but they do not agree with one another, because they each have a different path. So, people will never really agree on the path to take unless they find someone who can already embody the goal that they are trying to achieve. If we see someone living already with the goal that we are looking for, someone who is already experiencing this reality, then we might be able to agree on the path. This is like the Rebbe teaching us that to get to the revelation of the Mashiach we have to first live with Mashiach, we have to embody the very goal that we are seeking. Only then can we come to agree on a common path.

But, now returning to super-symmetry, we say that it is not just about changing one's direction, one's path, but changing the goal, changing one's "mission statement." In the language of physics, are you a boson or a fermion? Super-symmetry is thus about changing one's purpose in life, one's very identity. Super-symmetry implies that if all the goals were interchanged, the world would stay the same.

To be able to change one's mission in life requires sacrifice. In a sense, one is dying in order to become something else. To

reach your super-partner you have to sacrifice your life, your very purpose. This is what is meant by the words "with all of your soul," which the sages explain means: "Even if He claims your soul," meaning even if He takes your soul. What the Arizal says about this is that if a person has fulfilled his mission in life, the night of that day on which the function was fulfilled is very dangerous. Every night when a person is asleep, the soul goes above and is told that it has finished its work. The only way to remain alive and come back down is by assuming a completely new function, a completely new purpose for one's life. This is one of the simplest intentions of the verse: "My soul, I long for you at night."[45] The only way to claim my soul back is by sacrificing myself, sacrificing my identity. This is the only way to make it through the night. This is like a fermion becoming a boson. So far for the second level and aspect of loving the Almighty.

## Size symmetry and one's infinite nature

The third level of love that is above even sacrifice is described in the verse as "with all of your might." How can something be more than sacrifice? One reading that is given by the sages, which is difficult to understand, is that "with all of your might" means "with all of your money." It is sometimes more difficult for a person to give up all of his money, to give up his bank account, than it is for him to give up his life. How can we understand this?

One simple explanation is that giving up one's bank account is like giving up what one will bequeath as an inheritance to one's offspring, to coming generations. Spiritually, this is like giving up one's power to procreate, which in Chassidut is explained to represents one's infinite power, because the power of procreation, the power to give birth and to sustain one's self through one's offspring is an infinite power, the most powerful of all human powers. Thus, giving up all of one's possessions, all of one's might, all of one's money, is like giving up all of one's future generations; all that one would have bequeathed to the coming generations. So giving up one's continuity is definitely more difficult than giving up one's identity.

But, let us see another explanation. מאדך does not mean "might," rather it means "very much." This is one's most extreme being. What is this "very muchness"? For many people this is indeed their bank account. This is exactly the idea behind the final form of symmetry derived directly from string theory. Being

[45]. נפשי איויתיך בלילה

able to accept that size does not matter; that being small is exactly the same as being big. Translated into wealth this means that even if you are very wealth it is exactly the same as being very poor.

The way that the sages describe this idea in reference to money is that wealth is described in metaphor like a wheel that revolves in the world—a wheel of fortune. Normally, the symbol of the wheel is meant to give a person the understanding that even if right now you are at the very top of the wheel and you have wealth, nonetheless, the wheel revolves and either you or your children will someday find yourselves at the bottom of the wheel. And likewise, even if now you are at the bottom of the wheel and poor, at some later time, either you or your children will find yourselves on top.

But now, what size symmetry as derived directly from string theory is saying is that there is no time-dependence, as it were. Being big and being small, being rich and being poor, being on top and being on bottom, they are exactly the same.[46] Not only that, they are happening simultaneously. Even if you are at the very top right now, you are really also at the very bottom, on a wheel there is no difference between top and bottom. If you are very very big, you are also very very small. This is the ultimate realization in pursuing love of the Almighty. If a person can reach this consciousness then that is giving up his "very muchness." Every person has an infinity to him, which is his "very muchness," which is much more difficult to give than giving up one's finite being.

"With all your heart" means being able to switch careers. Super-symmetry thus implies that we should, like the Lubavitcher Rebbe said, never retire. Always find some new goal to pursue. Even when you have finished one career, pick up a new one.

R=1/R means being able to give up one's infinity, whether it be one's smallness (infinitesimalness) or one's greatness (infinity).

---

[46]. For clarification: in the Ba'al Shem Tov's teachings this is known as the measure of equality (מדת ההשתוות). A person should relate to all of his circumstances with equanimity. Everything is equally good and meaningful, for everything that makes up one's life is directly from the Almighty. For example, if one is being mocked by other people or one is being praised by others, it does not matter. One should thank God for both and see that both are necessary and good. See Tzava'at Haribash, 2.


2 Hausner St. ◆ Jerusalem 96431 ◆ tel.: 972.547.533770 ◆ info@gpsociety.org