# The Beginning of Space and Time

by

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For thousands of years, the creation story in the Book of Genesis was the best explanation for how our universe came into being. The story explained how God created the universe in six "days" through a set of distinct creation events culminating in the creation of mankind on the sixth day.

It was only in the last one hundred years that a scientific story of creation has evolved. Based on Albert Einstein's theory of general relativity and equations formulated by Alexander Friedmann, Georges Lemaître hypothesized in 1927 that the universe originated from a single point. In 1929, astronomer Edwin Hubble provided observational evidence that all galaxies indeed were moving away from each other. This theory has come to be known as the *Big Bang Theory.* Today, scientific calculations suggest that the universe was created around 13.75 billion years ago.

In the years since the formulation of the Big Bang hypothesis, scientists have built increasingly larger particle accelerators to study particle physics at ever increasing energy levels to understand what the first moments of creation were like. The largest of these particle accelerators, the Large Hadron Collider (LHD) on the border between France and Switzerland, has now come on line to give scientists the clearest experimental evidence yet on the creation of our universe.

Meanwhile, another group of physicists are laying out mathematically a *Theory of Everything* (TOE) based on *String Theory*. In this TOE, these theoretical physicists are trying to develop a model whereby our entire universe came from a single elementary particle. To date, this TOE is only theoretical with no experimental evidence to support it.

In this article, I will discuss the events that may have occurred at the earliest moments of creation. In particular, I will concentrate on the beginnings of space and time. Some of this will be based on scientific evidence from experiments in the large particle accelerators. Some of this will be based on the TOE model. Some will be based on scientific conjecture. And, finally, some will be based on faith, as faith is really just an extension of our science into that which has not yet been discovered.

## Before the Beginning

It is hard to contemplate what the conditions were like just prior to the Big Bang. Scientists conjecture that space and time did not exist. They argue that, even today, space and time still do not exist beyond the edges of our expanding universe.

We first need to come up with a working definition of space and time. Space is a measurement of distance in three dimensions - the usual length, width, and height. Space requires something to measure (i.e. matter). Just prior to the Big Bang, there was no matter. Hence, there was no space. Time is a measurement of how matter changes. Again, since there was no matter that could change prior to the Big Bang, there was no time.

Of course, one could argue that my use of the words “prior to the Big Bang” implies some concept of time. Unfortunately, our language does not provide a good word to describe conditions prior to the Big Bang. The best way I can describe it is that conditions prior to the Big bang were “outside” of space and time.

## The Moment of Creation

Neither the scientific evidence, nor scientific theory, identifies what caused our universe to begin. Some scientists conjecture that it can just happen spontaneously in the presence of gravity. Other scientists conjecture that the universe is some type of yo-yo that continuously explodes out and then collapses back onto itself in a repeating cycle.



Personally, I believe that there is a reality of intelligence that exists outside of space and time. This intelligence (or God, as some people call it) caused the creation of the universe. This is analogous to the reality of the human mind that can create things (e.g. symphonies) and be the cause of things (e.g. buildings) to occur in our physical world.

Whatever was the cause of creation, string theory holds that it happened in a manner strangely similar to the first act of creation in the Book of Genesis where it is stated:

> Then God said, “Let there be light,” and there was light. (Genesis 1:3)

At the moment of creation, there appeared a multitude of highly ordered and highly energized boson particles, which I will call the “primordial bosons”. An example of a boson is the photon, which is a particle of light. Contained within these primordial bosons were all the properties that define our universe. This is analogous to the human egg and sperm cells holding all the genetic coding needed for a human life to develop.

These primordial bosons had no mass. They existed as a point with no spatial dimensions. Bosons in general have the property that they can exist simultaneously at the same point. Today, we see this in the fact that two light beams can pass through each other without interference. When we stand outside at night pointing at the sky, there are millions of photons that exist simultaneously at the same point on our fingertip coming from the millions of different stars in the sky.

According to the TOE model, the primordial bosons were a unification of the four great forces of our universe - gravity, electromagnetism, the strong nuclear force, and the weak nuclear force. At this moment of creation, there was still no space. However, the moment does mark the beginning of a form of pseudo-time, denoted by $T^0$, because these primordial bosons were about to start changing.

The Specialization of the Four Great Forces

According to the TOE model, the first force to separate from the primordial bosons was gravity. Some of the primordial bosons separated out to form gravitons which are bosons that carry the force of gravity. This specialization of the graviton is purely theoretical as it has not yet been observed in any high energy physics experiments. According to the theory, this specialization occurred almost immediately (i.e. $<10^{-36}$ pseudo-time seconds) after the creation of the primordial bosons.

The second specialization of the primordial bosons occurred around $10^{-36}$ pseudo-time seconds after creation when gluons separated (or became specialized) from the remaining primordial bosons. The gluons are the carrier of the strong nuclear force. Not only did the gluons separate from the primordial bosons, but they specialized into eight unique flavors on gluons.

The last separation of the primordial bosons occurred around $10^{-12}$ pseudo-time seconds after creation when the remaining primordial bosons specialized into the weak nuclear force and the electromagnetic force. Three different types of bosons carry the weak nuclear force. These weak force carrying particles are the $W^+$, $W^-$, and $Z^0$ bosons. The electromagnetic force is carried by the photon, which we know as light particles. The separation of the electromagnetic force and the weak nuclear force has been observed in high energy physics experiments.



The Beginning of Time

The specialization of the four great forces of our universe occurred in what I called pseudo-time because things are happening at the sub-atomic level in the reality of particle physics. Particle physics has laws very different than the reality of our physical universe. Space and time, however, are concepts that exist within the reality of our physical universe.

Before we can have space and time, we need some form of matter (i.e. atoms, protons, and neutrons). So far, we only have bosons that have become specialized into the four great forces. To understand the origins of matter, we need to look at two groups of bosons - the gluons and the photons. The gluons and photons are in a class of bosons called gauge bosons which means they conserve the symmetries of our universe. These symmetries include charge (C), parity (P), time (T), as well as many others properties.

It has been shown in particle accelerators that gauge bosons at sufficient energy levels will change into a pair of particles, called fermions. In order for the pair of fermions to preserve symmetries, one fermion has to be the anti-particle of the other. If one fermion has a positive charge ($C^+$), then the other fermion has a negative charge ($C^-$). If one fermion has right parity ($P^+$), then the other fermion has left parity ($P^-$). Similarly, if one fermion goes in one direction of time ($T^+$), then the other fermion goes in the opposite direction of time ($T^-$).

Another property of fermions is that they follow what is called the Pauli Exclusion Principle, named for Wolfgang Pauli who developed the concept. The Pauli Exclusion Principle states that identical fermions cannot exist in the same quantum state at the same point in time. To laymen, this means that two fermions cannot occupy the same space at the same time. This is quite different from bosons where millions of them can exist at the same point on our fingertip. If a fermion and its anti-particle ever try to occupy the same space at the same time, they annihilate each other and convert back into a gauge boson. The Pauli Exclusion Principle is the main separator of our universe into matter and energy. All matter in our universe is made up of fermions. All energy in our universe is contained within the bosons and the four great forces.

In my opinion, the creation of the fermion pairs from the gauge bosons was the beginning of time. To prevent themselves from instantly annihilating each other, the fermion pairs travel in opposite directions of time so they are not affected by the Pauli Exclusion Principle. As a result, half of our physical universe travelled forward ($T^+$) in time, while the other half travelled backwards ($T^-$) in time. Of course, the terms "forward" and "backward" are only relative. For all we know, the universe that we see around us may be the one traveling in $T^-$.

## The Beginning of Space

A very rapid expansion of our universe began when the multitude of gauge bosons started creating a multitude of fermion pairs. Consider the case of popcorn in a popper. As each kernel pops, it shoves the other kernels out of the way in an explosive fashion. Now imagine that these kernels occupy the exact same space as all the other kernels. This is like our primordial bosons which do not follow the Pauli Exclusion Principle. When these boson popcorn kernels pop, they change into fermions which must follow the Pauli Exclusion Principle. As a result, they shove all the other fermions out of the way in a very explosive fashion, just like the popping corn in our popper.



This rapid expansion of the universe, however, has not yet created our concept of space. While fermions cannot occupy the same point in space, they are still spatially non-dimensional particles. Like bosons, fermions only exist as a point. So, like pseudo-time, we now have a sort of pseudo-space.

To understand what happens next, we need to look at the separate fermions created by the gluons and the photons. When gluons "pop", they create a quark and antiquark pair. Experiments with particle accelerators have identified six different quarks (and their antiquark counterparts) that can be formed. However, only two of them (the up-quark and the down-quark) are of interest to us because they are the only ones stable over time. The other four are unstable and decay rapidly into either the up-quark or the down-quark.

If you recall, the gluon is the carrier of the strong nuclear force. Gluons hold quarks, in groups of three, in close proximity to each other. Two up-quarks and a down-quark form a proton. One up-quark and two down-quarks form a neutron. Protons and neutrons, which are the building blocks for the nucleus of atoms, do have spatial dimensions. In my opinion, the beginning of space occurs when the first protons and neutrons form. Scientists theorize that these protons and neutrons began to form in less than one second after the Big Bang.

<u>The Rest Is History</u>

We have not yet talked about the fermions created from the photons. When a photon “pops”, it creates a lepton pair. The stable leptons are the electron (with a negative charge) and the positron (an antiparticle with a positive charge). Like the quarks, these electrons and positrons are spatially non-dimensional. Experiments with particle accelerators have identified heavier leptons also being formed by photons at different energy levels. But, like the heavier quarks, these heavier leptons rapidly decay into electrons and positrons.

As mentioned earlier, the photon is the carrier of the electromagnetic force. It is this force that causes the negatively charged electron to orbit around an atomic nuclei consisting of positively charged protons and neutrally charged neutrons. In the direction of time opposite to us, the same thing happens. But, it is positively charged positrons that go into orbit around atomic nuclei consisting of negatively charged anti-protons and neutrally charged anti-neutrons. When electrons (or positrons) go into orbits around atomic nuclei (or anti-nuclei), atoms are formed. According to scientists, the first atoms did not appear until about 377,000 <u>years</u> after the Big Bang.

The combinations of different numbers of protons and neutrons in atomic nuclei became our Periodic Table of Elements. The number of electrons orbiting around the nuclei gives us our properties of chemistry. Over time, these atoms formed compounds. Some of these compounds were organic that caused the formation of life. The rest is history - not a bad story for something that started out as a creation of primordial bosons (i.e. light).