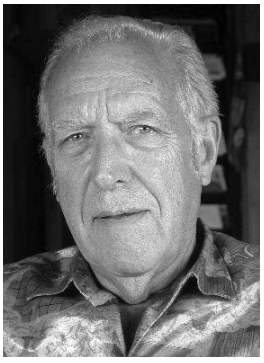
Why is there something rather than nothing?

By Robert G. Neuhauser



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There is no question that the universe exists. Each bit and piece of the universe exists and seems to be stable and to exist perpetually. In the realm of physics, however, a quandary remains. Some of what we (and physicists) know suggests to us that the bits and pieces that make up the universe should not have continued to exist after they were created. The question is, why do they continue to persist?

There is a universal acknowledgment within the scientific community that this entire visible creation originated in what is commonly called the Big Bang some 13.7 billion years ago. This unfathomable high concentration of energy transformed itself into the bits and pieces of what we call atoms, which constitute the entire physical universe. Those bits and pieces—protons and electrons—are insignificantly small in relation to everything that we normally encounter in our life. The protons form the nucleus of the atom, and this nucleus is surrounded by a cloud of electrons, which are infinitesimally smaller than the protons and are actually quite remote from the protons; if the protons of the nucleus of an atom were the size of a soccer ball, the nearest electron swarming about it would be about 30 miles away.

At the moment of the creation, the environment was too hot for these bits and pieces to be assembled into atoms. Only after the universe expanded and cooled down did those bits and pieces assemble themselves into the simplest of atoms: hydrogen and helium. Gravity then assembled these atoms into stars, which then forged those primitive atoms into the other ninety-some varieties of naturally-occurring atoms. Some stars exploded, and these newly assembled atoms proceeded to gather themselves together into a variety of celestial bodies, one of which is the third rock from the Sun that we inhabit. All of this was known a generation ago, but it did not suffice to answer the really big question about our beginnings.

The real question, still unanswered by science, is not how the universe began, but why it continues to exist. According to what we think that we now know, the universe should have reverted to a sea of energy right after it was created. Like the Gingham Dog and the Calico Cat, those original bits and pieces should have eaten each other up, leaving nothing but a sea of lower level energy inhabiting the universe.

The physics involved in this dilemma is intricate. Let's begin with some basics. If I showed you a lump of coal and a lump of gold, and asked you what was the difference between them, you might answer that they are made of different stuff, carbon stuff and gold stuff. The proper answer would be that the carbon in the coal is made of atoms that have six protons in their nuclei and the gold is made of atoms with seventy-nine protons in their nuclei, each having a corresponding number of electrons in a very remote shell. The only difference between gold and carbon is that the nucleus of each element's atom has a different number of the same basic bits and pieces. All atoms, the relatively stable material in this universe, are made of these same bits and pieces, assembled into different configurations. Their organization determines their reality and their characteristics.

We also have to bear in mind that the universe is expanding. As revealed by the astronomer Edwin Hubble in the 1920s and unanimously confirmed since, the universe is expanding from a single extremely hot and concentrated core of energy that transformed itself into the electrons and protons that create our entire physical universe (the event known as the big bang). The initial conditions of the universe can be duplicated in a minuscule scale in our high energy physics laboratories, where

a concentration of intense energy can create a few of the bits and pieces of which the physical universe is composed. This is accomplished in what are commonly called atom smashers or particle accelerators, such as the CERN-LHC (Large Hadron Collider) in Geneva and the SLAC (Stanford Linear Accelerator and Collider) particle accelerator in California. In these fearful and wonderful machines, physicists can actually create the bits and pieces that make up all of the known and knowable portions of the existing universe. But they also create something else: anti-matter.

What is anti-matter? This enigma was thrust upon the science community by the scientist Carl Anderson. In a laboratory high on a mountain top, Anderson was investigating the cosmic rays that bombard our stratosphere. His instruments detected a new, strange, fast-moving particle. It behaved like an electron, except that it bent in an opposite direction when it crossed a magnetic field and had a positive charge equal in energy to an electron's negative charge. He called this particle a "positron," but it has also been described as an anti-electron, because when it encountered an electron, both it and the electron annihilated themselves and produced a burst of energy. Both particles ceased to exist as particles and were turned into energy, vindicating Einstein's famous equation, $E=MC^2$. Matter was converted into energy.

When physicists used the first particle accelerators (such as the Cyclotron or Synchrotron) to direct atoms or parts of atoms into material targets at extremely high velocities, they called these machines atom smashers thinking that they were chipping off bits and pieces of the atoms. After the discovery of the anti-electron, they realized that they were actually *creating* these ephemeral particles—creating material from energy. This new realization not only changed the whole concept of atomic research, but also validated the hypothesis of the Big Bang, where an unfathomably large concentration of energy transformed itself into the bits and pieces that are still assembling and reassembling themselves itself into our physical universe.

So here we have two sides of a process. Energy converted into matter in the particle accelerator, matter converted into energy in an atomic explosion or an atomic power plant. This is not a trivial thing. Since roughly a dime's weight of matter was converted into the energy released by the two atom bombs that vaporized parts of Hiroshima and Nagasaki, it would therefore take the amount of energy released by both of those explosions to create a dime's weight of atomic particles in any creation event.

All this is amazing enough. But we also have to keep in mind that every time a bit of matter is created from energy in the laboratories, an equal amount of anti-matter is also created.

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My own introduction to this news came while floating down the Grand Canyon of the Colorado on a 12-day raft trip with a group of physicists. One extremely articulate passenger, Dr. Wolfgang Panofsky, had just come home from a conference composed of Russian and U.S. scientists and politicians. He said that our countries had just come to an agreement on nuclear weapons: they would hold each other's population hostage to nuclear annihilation.

I asked one of our companions who he was. My informant's eyes widened as he said, "he's the Gawd of the linear accelerator!" (the two mile long atomic particle accelerator at Stanford University). This gentleman then began to describe the latest experiments in the new SPEAR Ring appended to the accelerator.

The Stanford Linear Accelerator was a modest-looking, two-mile-long galvanized tin shed, traversing some worthless land (the San Andreas Earthquake Fault) near Stanford University. The purpose of the linear accelerator at that time was to create, in a small controlled way, a small region of extremely high energy, in order to observe the creation of matter in that small region. Inside its two-mile-long narrow tin tunnel was a two-mile-long copper tube, the inside chamber of which had been turned into an ultra-high vacuum. This tube was flanked by hundreds of Klystron Electronic oscillators or power tubes similar to the 100-kilowatt transmitter tubes that broadcast the UHF-TV programs from most television stations throughout the world.

Electrons were injected into one end of this long evacuated tube. As they approached each Klystron tube station, the tube switched the opening ahead to a positive polarity, sucking the electron along faster and with higher energy. Then that small section of the pipe was switched to a negative voltage by the Klystron tubes, and propelled it on to the next Klystron station with another boost to its energy. Since nothing can go faster than the speed of light (Einstein again), the electron built up its mass and its inertial energy at each boost that it got as its speed approached the velocity of light. (So said Einstein, and so it does). When the electrons emerged at the end of the two

mile pipe, they were very powerful projectiles, massive electrons traveling within a minute fraction of the speed of light, but greatly increased in weight or mass and therefore possessing tremendous energy.

In the latest experiments that Panofsky was describing, massive magnets directed these electrons into a donut-shaped tube (the previously mentioned SPEAR ring), still under high vacuum conditions. The intent of the SPEAR ring design was to create, in an extremely small space, the same high-energy conditions that existed inside the Big Bang at the moment of creation. The electrons were bent around inside the donut-shaped tube by powerful magnets, as well as being kicked ahead with additional energy by more Klystrons power tubes arranged around the ring (requiring the electrical power of a small city).

Then, instead of injecting more electrons into the starting end of the linear accelerator tube, they injected positrons, sending them down the same path the electrons were sent by changing the polarity timing of the klystron tube voltage oscillations, which sucked the positively charged positrons in with a negative electric field and expelled them with a positive polarity field at each Klystron station. The experimenters directed the incredibly energetic electrons that emerged from the accelerator in one direction around inside the hollow donut-shaped SPEAR ring, and the equally energetic positrons around in the opposite direction. Then they forced the electrons and the positrons to collide at instrumented sections of the donut.

(Remember that this experiment is intended to create an extremely concentrated bit of energy and that the particles are just the *carriers* of energy. Consider the cartridge of a hunting rifle. If I rub the bullet over my hand, it does no harm. If I shoot it out of a rifle, the energy given to the projectile by the explosion of the gunpowder that propels it is blasted into the target, and that energy does the killing of the deer.)

At these intersections in the SPEAR ring, the electrons and the positrons collided and annihilated one another in a burst of energy; out of that explosion was created virtually every atomic particle that had ever been seen, as well as an equal number of anti-particles of those same bits and pieces. Here Einstein's equation was demonstrated as working in both directions. The particles and anti-particles in the counter-rotating beams were annihilating one another and a zoo of other particles and anti-particles were created from the energy of this collision.

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The energy possessed by the massive electrons and the positrons as they obliterate one another is converted into a plethora of smaller mass ephemeral particles whose matter is reconverted back into energy as these particles encountered their opposite incarnation. No particles are left over. Electrons that are created encounter a positron that was created and annihilate one another and produce more energy. The generated protons also encounter their anti-particle, and they too annihilate one another in a burst of energy. The process of their creation and disintegration back into energy is the subject that the scientists analyze.

Quite a revelation, but after I heard this account, there was a niggling question remaining in my mind. If every time energy is converted into matter, an equal amount of similar anti-matter is created, and if, when these matter and anti-matter particles touch or intersect one another, they annihilate one another and turn back into energy, why was there anything still existing from the original creation event?

One solution would be to say that particles and anti-particles just separated into matter and anti-matter regions of space. But if there were galaxies that contained only anti-matter, and an anti-matter galaxy were to brush a galaxy of stars of the type of matter that forms our galaxy (we know that galaxies really do brush one another), then the ensuing explosion would far surpass any other pyrotechnics that we can see with our deepest probing telescopes. Those stars and anti-matter stars would annihilate one another in an unbelievably large a burst of energy. Such events we just do not see.

In spite of diligent searches and theoretical studies, there is absolutely no evidence that any portion of our universe is composed of anti-matter, and no answer to the question of why, as the bits and pieces of our universe emerged from the big bang (those particles and anti-particles) they did not completely annihilate one another. In a word, why are we and the rest of the observable universe here? When all of these matter and anti-matter particles that would have been created in the Big Bang met one another, why did they not annihilate each other, just leaving a lower density sea of energy that expands into the void—no stars, no atoms, no earth and no us?

This dilemma has not escaped the notice of nuclear scientists, experi-

menters and philosophers, and many other high energy experiments have been undertaken in the hope of shedding some light on it.

There are some ephemeral states of matter called mesons, neither protons nor electrons, that exist as smaller, unstable assemblies of parts of the subatomic particles that protons are made of, and that decay back to energy in a peculiar way, such that scientists say that they are "breaking symmetry." That is, they are breaking the traditional rules of logic and the orderly order of the behavior of other atomic particles. One of these particular particles is called the B-meson. If physicists can understand the process by which B-mesons decay back to energy, a process that seems to be different from the processes undergone by other and better-understood particles, they may have a clue as to why there is only matter and not anti-matter in our universe.

For the past four or more years, the SLAC facility has devoted most of its vast system of accelerators and detectors to what they call "the B factory," where they are studying the decay of B-mesons, which are created by tuning the energy of the electron and positron beams so that they generate a usable number of these fleeting particles. The equipment has been further modified to produce the desired collisions at the right time and the right place so that they can be efficiently measured. If the experimenters can ever untangle the how and why of the "unbalanced" way this particle decays (it seems to leave behind slightly more matter than it does anti-matter), they just might find out why the basic primordial particles that make up our universe do endure and why no anti-matter stars or galaxies have been detected in the universe.

Over 450 scientists worldwide are monitoring the data from the B-factory tests both at Stanford and on the internet, and trying to extract usable information to solve this dilemma. A similar machine is operating in Japan, with equal attention from the global scientific research community. The CERN Large Hadron Collider was also modified and expanded so that its bigger and higher energy machines can join the search. All this effort is costing billions of dollars every year, attesting to its importance to the scientific community. Maybe the CERN physicists have solved the problem. Along with the announcement in October 2013 of finding the Higgs Boson (commonly called the God Particle), the CERN officials also cryptically announced that they had solved the B-meson puzzle. With no further explanation!

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On the scientific community's wish list has been an extremely long and much more powerful linear accelerator, possibly more than fifty miles long (twenty-five times longer than the SLAC machine.) This new machine, if it is ever built (China and Japan are both interested), would be capable of producing extremely higher power particle beams and exploring deeper into the mystery of not only the how, but also the why of the processes that result in our existence. Suppose that only a fraction of the energy/power in the creation event was converted into matter that survived extinction, (that fraction that constitutes us and the rest of the observable universe)? Where did the rest of the energy go?

Two Nobel prizes have been awarded for the discovery of the background microwave radiation that is observable coming from every direction in the universe. The first award was for the actual detection and identification of this radiation, and the second for its precise measurements and some conclusions as to its significance. One of these conclusions is that this microwave background possesses, in total, about all of the energy that would be left over if only a small amount of the energy of the Big Bang were converted into the matter that persisted and which makes up the observable universe, with the rest being converted back to electromagnetic radiation by the recombination and mutual annihilation of most of the primordial matter and anti-matter. This has led to the tentative conclusion that this residual background microwave energy is the energy released when most of the particles created from the energy of the Big Bang ate each other up. The much smaller part of the initially created matter that somehow escaped this annihilation perhaps went on to evolve into our observable universe—into all of stars, that are as numerous as the grains of sand on every beach of the world, and into you and I, anchored here on the third rock from the Sun.

But the mystery remains: why did those original bits and pieces not all annihilate one another? As Dr. Panofsky said to me, science follows the rules, but who made the rules? My personal conclusions: that immense creative power that converted itself into the universe, following its own internal laws of physics, is in fact the Creator. That Creator assembled itself into this evolving creation. The Creator also established the laws by which it would operate. We are privileged to be a part of the Creator's wonderful on-going adventure.

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