Two Universe Model of the Big Bang

by

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Physicists are now convinced that our universe began around 13.7 billion years ago. The Standard Model (SM) of Quantum Mechanics explains the origins of our universe back to 10^{-35} of a second after what scientists commonly call the Big Bang. To explain the universe before that point, theoretical physicists are studying Superstring Theory to develop a Theory of Everything (TOE). While Superstring Theory only exists as a mathematical model, SM is one of the most scientifically tested models. The volumes of data from the multitude of scientific experiments attest to the validity of SM.

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One of the major puzzles of Quantum Mechanics deals with the absence of observable antimatter in our universe. According to SM, whenever matter is created, it is created as a pair of fundamental particles – one particle is matter and the other is antimatter. So, for example, when scientists create an electron in a particle accelerator experiment, they also create a positron, which is the antimatter partner of the electron.

According to SM, when our universe was created in the Big Bang, equal amounts of matter and antimatter were generated. Yet scientists have not been able to detect large quantities of antimatter anywhere in our known universe. Physicists theorize that matter and antimatter must have segregated into different parts of our universe within moments after the Big Bang.

To search for antimatter, scientists look for areas of the universe that produce high concentrations of gamma rays. One property of matter and antimatter is that they annihilate each other upon contact producing gamma rays. If any large collection of antimatter exists in our universe, then the boundary

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between that concentration of antimatter and concentrations of matter will generate detectable levels of gamma rays due to particle-antiparticle annihilation. To date, insufficient levels of gamma rays have been detected to support SM's prediction of equal proportions of matter and antimatter in our universe.

So, where is all the antimatter? One answer may lie in the many conservation laws of physics. Let us start by examining the CP-symmetry of SM. CP-symmetry deals with the conservation of two different attributes of the fundamental particles of Quantum Theory. The charge (denoted by C) attribute deals with the charge of fundamental particles. A particle has either a positive charge (denoted by C^{+1}), a negative charge (denoted by C^{-1}), or a neutral charge (denoted by C^{0}). The parity (denoted by P) attribute deals with the spin of fundamental particles. A particle has either clockwise spin (denoted by P^{+1}) or counterclockwise spin (denoted by P^{-1}). The term "parity" is used for spin because, if you observe a P^{+1} particle in a mirror, it appears to be a P^{-1} particle.

When an electron-positron pair is generated in a particle accelerator experiment, it can be produced from a gamma ray with charge 0 and spin 1. Both of these attributes must be conserved in the electron-positron pair. The electron that gets generated has a +1 charge and a ½ spin. The positron has a -1 charge and a ½ spin. Thus the sum of the two particles has a 0 charge and a 1 spin, just like the original gamma ray.

To understand what happened at the time of the Big Bang, one must examine the conditions that existed at that instant. Electron-positron pairs were generated from a completely neutral (C^{0}, P^{0}) state (i.e. charge 0 and spin 0). The following two possible electron-positron pairs can be generated from this neutral state:

Case 1: An electron with charge -1 and spin +½, and a positron with charge +1 and spin -½, or

Case 2: An electron with charge -1 and spin -½, and a positron with charge +1 and spin +½.

For both of these pairing, when the two particles are added together, they yield a summed charge of 0 and a summed spin of 0 to conserve the neutral (C^{0}, P^{0}) state of the Big Bang.

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CP-symmetry by itself does not explain the missing antimatter. To explain antimatter, we need to expand CP-symmetry to CPT-symmetry. C and P still represent charge and parity as in CP-symmetry. The additional T attribute of fundamental particles is time. Just like charge and parity, a particle can go forward in time (denoted by T^{+1}) or backward in time (denoted by T^{-1}). As with charge and parity, the value of the time attribute must be conserved.

We traditionally think of our universe as going forward in time (i.e. T^{+1}). The use of the words "forward" and "backward" are misnomers when talking about time. In our macroscopic world, going backwards in time brings up images of people aging backwards and time travel where we go to a period in the past and relive that period of time. Neither of these scenarios is theoretically possible.

At the level of fundamental particles, SM does not favor T^{+1} over T^{-1}. T^{+1} and T^{-1} just represent two different arrows of time. If fact, CPT-symmetry requires that particles in (C^{-1}, P^{-1}, T^{-1}) follow laws identical to particles in (C^{+1}, P^{+1}, T^{+1}). A person living in a T^{+1} universe experiences nothing different than a person living in a T^{-1} universe. For all practical purposes, our own arrow of time could be T^{-1}.

When electron-positron pairs are generated from gamma rays in the laboratory, the gamma rays exist in our T^{+1} universe. As a result, both the electron and the positron must also exist in T^{+1} to conserve the T attribute. But, the Big Bang created both space and time. At the moment of the Big Bang, only a neutral (C^0, P^0, T^0) state existed. When electron-positron pairs were generated from the time neutral (i.e. T^0) conditions of the Big Bang, one of the following situations must occur:

Case 1: The electron is T^{+1} and the positron is T^{-1}, or

Case 2: The electron is T^{-1} and the positron is T^{+1}.

SM does not require that Case 1 and Case 2 happen in equal proportions. Hence, we will assume that Case 1 occurs more frequently than Case 2. Immediately following the Big Bang, our T^{+1} universe became filled with more T^{+1} electrons (from Case 1) than T^{+1} positrons (from Case 2). These T^{+1} positrons were quickly annihilated by some of the surplus T^{+1} electrons, leaving our universe populated almost exclusively with T^{+1} electrons. Similarly, the T^{-1} universe became populated almost exclusively with T^{-1} positrons. Note, also, that T^{+1} electrons and T^{-1} positrons can never annihilate each other because they exist in their respective arrows of time keeping them forever from coming into contact with each other.

So far, we have talked only about electron-positron pairs. However, the same argument holds for quarks and antiquarks. Up quarks and down quarks are the fundamental particles for building protons and neutrons. Similarly, anti-up quarks and anti-down quarks are the particles for building antiprotons and antineutrons. Electrons, protons and neutrons come together to form the atoms of matter in our T^{+1} universe. In a similar fashion, atoms of antimatter in the T^{-1} universe are formed from positrons, antiprotons, and antineutrons. As a result, both the T^{+1} and T^{-1} universes have all the fundamental particles necessary to develop more complex structures.

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In the opening moments after the Big Bang, two separate universes began to form. The T^{+1} universe (i.e. our universe) was filled with matter following our arrow of time. The T^{-1} universe was filled with antimatter following the opposite arrow of time. SM dictates that particles of antimatter in T^{-1} will behave just like particles of matter in T^{+1}. As a result, both universes developed similarly using the same laws of physics. As each universe cooled, the collection of elementary particles formed simple atoms. Gravity caused the simple atoms to form into stars and galaxies. The stars manufactured more complex atoms. Planets formed, and the complex atoms combined to form molecules. Eventually, both universes created molecules complex enough to form life.

Is it possible to detect the presence of this antimatter universe? We will not find it by looking for concentrations of gamma rays, because there are no spatial boundaries between the two universes. Our best chance for detecting the antimatter universe may come by building ever more powerful telescopes. Telescopes help us peer backwards in time because they allow us to see objects billions of light years away. The light from these objects has been travelling for billions of years. When we view this light in a telescope, we see how the objects appeared those billions of years ago. Currently, the Hubble telescope holds the record by viewing objects that are 12.5 billion light years away. With the Big Bang occurring around 13.7 billion years ago, we are still at least a billion light years short of viewing the antimatter universe.

What might we see if we build a telescope that can see objects farther than 13.7 billion light years away? At first, we might begin to see the light of the early simple galaxies of the antimatter universe. As telescopes become even more powerful, we may begin to see more advanced spiral galaxies similar to our own Milky Way galaxy. If our telescope technology develops to the point where we can view objects 27.4 billion (i.e. 2 x 13.7 billion) light years away, we may see an antimatter world very similar to our own.

So where is all the antimatter that was created during the Big Bang? It may exist in the galaxies of another universe, far away in a time prior to the Big Bang.

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