Universe

Ma Hongbao, Yang Yan

Brookdale University Hospital & Medical Center, Brooklyn, NY 11212, USA
ma8080@gmail.com

Abstract: The Universe is all and everything of the space-time existing physically. According to the current opinions of the people, the universe includes all matter, energy and time, etc. The Universe follows a set of physical laws and physical constants. All matter is composed of three generations of leptons and quarks. These elementary particles interact via 3 fundamental interactions: the electroweak interaction which includes electromagnetism and the weak nuclear force; the strong nuclear force following the quantum chromodynamics and gravity that can be described by general relativity. The first two interactions can be described by renormalized quantum field theory, and are mediated by gauge bosons that correspond to a particular type of gauge symmetry. The estimated diameter of the observable Universe (observed by human) is about 93 billion light years or 28 billion parsecs.

[Ma H, Yang Y. **Universe.** *Academ Arena* 2015;7(1):90-95]. (ISSN 1553-992X).
http://www.sciencepub.net/academia. 10

Key words: universe; space-time; physics; people; life; matter; energy; quark; nuclear; force

1. Introduction

The Universe is all and everything of the space-time existing physically. According to the current opinions of the people, the universe includes all matter, energy and time, etc.

The word Universe derives from the Old French word *Univers*, which in turn derives from the Latin word universum. An alternative interpretation of unvorsum is everything rotated as one. The same synonyms are found in English, such as everything, the cosmos, the world and Nature. The broadest definition of the Universe is found in *De divisione naturae* by the medieval philosopher and theologian Johannes Scotus Eriugena, who defined it as simply everything: everything that is created and everything that is not created. More customarily, the Universe is defined as everything that exists, (has existed, and will exist). According to our current understanding, the Universe consists of three principles: space-time, forms of energy, including momentum and matter, and the physical laws that relate them. It is possible to conceive of disconnected space-times, each existing but unable to interact with one another. The entire collection of these separate space-times is denoted as the multiverse. In principle, the other unconnected universes may have different dimensionalities and topologies of space-time, different forms of matter and energy, and different physical laws and physical constants, although such possibilities are purely speculative.

Definition

According to the definition, the Universe is everything within our connected space-time that could have a chance to interact with us and vice versa. In the general theory of relativity, some regions of space may never interact with ours even in the lifetime of the Universe due to the finite speed of light and the ongoing expansion of space. For example, radio messages sent from Earth may never reach some regions of space, even if the Universe would live forever: space may expand faster than light can traverse it. The universe can be cosidered as disconnected spacetimes, each existing but unable to interact with one another.

Diameter

The estimated diameter of the observable Universe (observed by human) is about 93 billion light years or 28 billion parsecs. Scientific observation of the Universe has led to inferences of its earlier stages. These observations suggest that the Universe has been governed by the same physical laws and constants throughout most of its extent and history. The Big Bang theory is the prevailing cosmological model that describes the development of the Universe, which is calculated that the Big Bang began 13.8 billion years ago. Observations of supernovae have shown that the Universe is expanding at an accelerating rate.

Multiverse

There are various multiverse hypotheses, in which some physicists have suggested that the Universe might be one among many, or even an infinite number, of universes that likewise exist.

Throughout human history, several cosmologies and cosmogonies have been proposed to describe the observations of the Universe. The earliest quantitative geocentric models were developed by the ancient Greek philosophers and Indian philosophers. Over the centuries, more precise observations and improved theories of gravity led to Copernicus's heliocentric model and the Newtonian model of the Solar System. Further improvements in astronomy led to the realization that the Solar System is existed in a galaxy composed of billions of stars, the Milky Way, and that other galaxies exist outside it, as far as astronomical instruments can reach. Discovery of the red shift and cosmic microwave background radiation supposed that the Universe is expanding.

Big Bang

According the Big Bang, the Universe expanded from an extremely hot, dense phase called the Planck epoch, in which all the matter and energy of the observable universe was concentrated. Since the Planck epoch, the Universe has been expanding to its present form, possibly with a brief period (less than 10^{-32} seconds) of cosmic inflation. The Universe is composed of ordinary matter (4.9%) including atoms, stars, and galaxies, dark matter (26.8%) which is a hypothetical particle that has not yet been detected, and dark energy (68.3%), which is a kind of energy density that seemingly exists even in completely empty space. Recent observations indicate that this expansion is accelerating because of dark energy, and that most of the matter in the Universe may be in a form which cannot be detected by present instruments, called dark matter (possibly about 95% of the mass-energy density of the Universe). The Big Bang theory is an important cosmological model for the birth of the universe. By Big Bang theory, at some moment all of space was contained in a single point from which the Universe has been expanding ever since. After the initial expansion, the Universe cooled sufficiently to allow the formation of subatomic particles, and later simple atoms. Giant clouds of these primordial elements later coalesced through gravity to form stars and galaxies. The Big Bang theory does not provide any explanation for the initial conditions of the Universe; rather, it describes and explains the general evolution of the Universe going forward from that point on.

The big Bang theory depends on the redshifts that the distances to faraway galaxies were strongly correlated with their. All distant galaxies and clusters are receding away from our vantage point with an apparent velocity proportional to their distance: that is, the farther they are, the faster they move away from us, regardless of direction. It is supposed that the earth is not at the center of a giant explosion, the only remaining interpretation is that all observable regions of the Universe are receding from all others. The continuous expansion of the Universe implies that the Universe was denser and hotter in the past.

The first subatomic particles included protons, neutrons, and electrons. Though simple atomic nuclei formed within the first three minutes after the Big Bang, thousands of years passed before the first electrically neutral atoms formed. The majority of atoms produced by the Big Bang were hydrogen, along with helium and traces of lithium. Giant clouds of these primordial elements later coalesced through gravity to form stars and galaxies, and the heavier elements were synthesized either within stars or during supernovae.

In the first phase, the very earliest universe was very hot, or energetic, that initially no matter particles existed or could exist perhaps only fleetingly. It was at this time that the forces merged into one unified force. Space-time expanded during an inflationary epoch due to the immensity of the energies involved. Gradually the immense energies cooled – still to a temperature inconceivably hot, and finally to the separation of the strong force from the electroweak force and the first particles.

History of the Universe - gravitational waves are hypothesized to arise from cosmic inflation, a faster-than-light expansion just after the Big Bang. In the second phase, this quark–gluon plasma universe then cooled further. The third phase started after a short dark age with a universe whose fundamental particles and forces.

History

In 2013, the European research team behind the Planck cosmology probe released the mission's all-sky map of the cosmic microwave background. The map suggests that the universe is slightly older than thought. According to the map, subtle fluctuations in temperature were imprinted on the deep sky when the cosmos was about 370,000 years old. An earlier interpretation of astronomical observations indicated that the age of the Universe was 13.8 billion years, and that the diameter of the observable universe is at least 93 billion light years or 8.8×10^{26} meters. According to general relativity, space can expand faster than the speed of light, although we can view only a small portion of the Universe due to the limitation imposed by light speed. Since we cannot observe space beyond the limitations of light or any electromagnetic radiation, it is uncertain whether the size of the Universe is finite or infinite.

When the distant of the regions of space are far enough from us, it’s true that we can never interact with them. The region that we can reach is the observable Universe. Nobody can interact with all of space. As the Universe everything, it will be meaningless consider the Universe’s beginning, death, and another Universe. There is only one Universe in the nature and it must be infinite in the time and space. If to talk any parallel Universe of another Universe, it must be included in the unique Universe, as Universe is all and everything. The only thing we can talk about is this observable part of the Universe and the unobservable part of the Universe currently, and any we called unobservable part of the Universe could be the observable part in the future.

The space visible from the Earth is a sphere with a radius of about 46 billion light years, which is called the observable Universe by the current Earth human. The diameter of a typical galaxy is 30,000 light-years, and the typical distance between two neighboring galaxies is 3 million light-years. The Milky Way Galaxy is about 100,000 light years in diameter. There are more than 100 billion galaxies in our observable Universe. Totally, the observable Universe could contain several hundred sextillion (several times of 1×10^{23}) stars. Interesting thing is that each mole contains 6.023×10^{23} particles.

As the matter, many very small particles are condensed into stars, most stars into galaxies, most galaxies into clusters, superclusters and, finally, into the largest-scale structures as we observe (such as the Great Wall of galaxies). The observable matter of the Universe is spread isotropically, and existing in a highly isotropic microwave radiation.

The Universe has a space-time continuum consisting of three spatial dimensions and one temporal (time) dimension. The space is nearly flat and the Euclidean geometry is experimentally true with high accuracy throughout most of the Universe. Space-time has a simply connected topology.

The Universe follows a set of physical laws and physical constants. All matter is composed of three generations of leptons and quarks. These elementary particles interact via 3 fundamental interactions: the electroweak interaction which includes electromagnetism and the weak nuclear force; the strong nuclear force following the quantum chromodynamics and gravity that can be described by general relativity. The first two interactions can be described by renormalized quantum field theory, and are mediated by gauge bosons that correspond to a particular type of gauge symmetry. A renormalized quantum field theory of general relativity has not yet been achieved. The modern cosmology began with Albert Einstein's 1915 general theory of relativity, which made it possible to quantitatively predict the origin, evolution, and conclusion of the Universe as a whole.

More information of the universe

All ideas concerning the very early universe (cosmogony) are speculative. No accelerator experiments have yet probed energies of sufficient magnitude to provide any experimental insight into the behavior of matter at the energy levels that prevailed during this period. Proposed scenarios differ radically. Some examples are the Hartle–Hawking initial state, string landscape, brane inflation, string gas cosmology, and the ekpyrotic universe.

The Planck epoch is an era in traditional (non-inflationary) big bang cosmology wherein the temperature was so high that the four fundamental forces—electromagnetism, gravitation, weak nuclear interaction, and strong nuclear interaction.

In inflationary cosmology, times before the end of inflation (roughly 10^{-32} second after the Big Bang) do not follow the traditional big bang timeline.

As the Universe expanded and cooled, it crossed transition temperatures at which forces separate from each other. These are phase transitions much like condensation and freezing. The grand unification epoch began when gravitation separated from the other forces of nature.

According to traditional big bang cosmology, the Electroweak epoch began 10^{-36} second after the Big Bang, when the temperature of the Universe was low enough (10^{28} K) to separate the strong force from the electroweak force (the name for the unified forces of electromagnetism and the weak interaction). In inflationary cosmology, the electroweak epoch ends when the inflationary epoch begins, at roughly 10^{-32} second.

Cosmic inflation was an era of accelerating expansion produced by a hypothesized field called the inflation, which would have properties similar to the Higgs field and dark energy. While decelerating expansion would magnify deviations from homogeneity, making the Universe more chaotic, accelerating expansion would make the Universe more homogeneous. A sufficiently long period of inflationary expansion in our past could explain the high degree of homogeneity that is observed in the Universe today at large scales, even if the state of the Universe before inflation was highly disordered.

Inflation ended when the inflation field decayed into ordinary particles in a process called "reheating", at which point ordinary Big Bang expansion began. The time of reheating is usually quoted as a time "after the Big Bang". This refers to the time that would have passed in traditional (non-inflationary) cosmology between the Big Bang singularity and the Universe dropping to the same temperature that was produced by reheating, even though, in inflationary cosmology, the traditional Big Bang did not occur.

According to the simplest inflationary models, inflation ended at a temperature corresponding to roughly 10^{-32} second after the Big Bang. As explained above, this does not imply that the inflationary era lasted less than 10^{-32} second. In fact, in order to explain the observed homogeneity of the Universe, the duration must be longer than 10^{-32} second. In inflationary cosmology, the earliest meaningful time "after the Big Bang" is the time of the end of inflation.

After cosmic inflation ends, the Universe is filled with a quark–gluon plasma. From this point onwards the physics of the early universe is better understood, and less speculative.

If supersymmetry is a property of our universe, then it must be broken at an energy that is no lower than 1 TeV, the electroweak symmetry scale. The masses of particles and their superpartners would then no longer be equal, which could explain why no superpartners of known particles have ever been observed.

As the Universe's temperature falls below a certain very high energy level, it is believed that the Higgs field spontaneously acquires a vacuum expectation value, which breaks electroweak gauge symmetry. This has two related effects:

At the end of this epoch, the fundamental interactions of gravitation, electromagnetism, the strong interaction and the weak interaction have now taken their present forms, and fundamental particles have mass, but the temperature of the Universe is still too high to allow quarks to bind together to form hadrons.

The quark–gluon plasma that composes the Universe cools until hadrons, including baryons such as protons and neutrons, can form. At approximately 1 second after the Big Bang neutrinos decouple and begin traveling freely through space. This cosmic neutrino background, while unlikely to ever be observed in detail since the neutrino energies are very low, is analogous to the cosmic microwave background that was emitted much later.

The majority of hadrons and anti-hadrons annihilate each other at the end of the hadron epoch, leaving leptons and anti-leptons dominating the mass of the Universe. Approximately 10 seconds after the Big Bang the temperature of the Universe falls to the point at which new lepton/anti-lepton pairs are no longer created and most leptons and anti-leptons are eliminated in annihilation reactions, leaving a small residue of leptons.

After most leptons and anti-leptons are annihilated at the end of the lepton epoch the energy of the Universe is dominated by photons. These photons are still interacting frequently with charged protons, electrons and (eventually) nuclei, and continue to do so for the next 380,000 years.

During the photon epoch the temperature of the Universe falls to the point where atomic nuclei can begin to form. Protons (hydrogen ions) and neutrons begin to combine into atomic nuclei in the process of nuclear fusion. Free neutrons combine with protons to form deuterium. Deuterium rapidly fuses into helium-4. Nucleosynthesis only lasts for about seventeen minutes, since the temperature and density of the Universe has fallen to the point where nuclear fusion cannot continue. By this time, all neutrons have been incorporated into helium nuclei. This leaves about three times more hydrogen than helium-4 (by mass) and only trace quantities of other light nuclei.

At this time, the densities of non-relativistic matter (atomic nuclei) and relativistic radiation (photons) are equal. The Jeans length, which determines the smallest structures that can form (due to competition between gravitational attraction and pressure effects), begins to fall and perturbations, instead of being wiped out by free-streaming radiation, can begin to grow in amplitude.

Hydrogen and helium *atoms* begin to form as the density of the Universe falls. This is thought to have occurred about 377,000 years after the Big Bang. Hydrogen and helium are at the beginning ionized, i.e., no electrons are bound to the nuclei, which (containing positively charged protons) are therefore electrically charged (+1 and +2 respectively). As the Universe cools down, the electrons get captured by the ions, forming electrically neutral atoms. This process is relatively fast (and faster for the helium than for the hydrogen), and is known as recombination. At the end of recombination, most of the protons in the Universe are bound up in neutral atoms. Therefore, the photons' mean free path becomes effectively infinite and the photons can now travel freely

The photons present at the time of decoupling are the same photons that we see in the cosmic microwave background (CMB) radiation, after being greatly cooled by the expansion of the Universe.

The first stars and quasars form from gravitational collapse. The intense radiation they emit reionizes the surrounding universe. From this point on, most of the Universe is composed of plasma.

Large volumes of matter collapse to form a galaxy. Population II stars are formed early on in this process, with Population I stars formed later.

Gravitational attraction pulls galaxies towards each other to form groups, clusters and superclusters.

The Solar System began forming about 4.6 billion years ago, or about 9 billion years after the Big Bang. A fragment of a molecular cloud made mostly of hydrogen and traces of other elements began to collapse, forming a large sphere in the center which would become the Sun, as well as a surrounding disk. The surrounding accretion disk would coalesce into a multitude of smaller objects that would become planets, asteroids, and comets. The Sun is a late-generation star, and the Solar System incorporates matter created by previous generations of stars.

The Big Bang is estimated to have occurred about 13.8 billion years ago. Since the expansion of the Universe appears to be accelerating, its large-scale structure is likely to be the largest structure that will ever form in the Universe. The present accelerated expansion prevents any more inflationary structures entering the horizon and prevents new gravitationally bound structures from forming.

As with interpretations of what happened in the very early universe, advances in fundamental physics are required before it will be possible to know the ultimate fate of the Universe with any certainty.

Over a timescale of a billion years or more, the Earth and Solar System are unstable. Earth's existing biosphere is expected to vanish in about a billion years, as the Sun's heat production gradually increases to the point that liquid water and life are unlikely; the Earth's magnetic fields, axial tilt and atmosphere are subject to long term change; and the Solar System itself is chaotic over million- and billion-year timescales; Eventually in around 5.4 billion years from now, the core of the Sun will become hot enough to trigger hydrogen fusion in its surrounding shell. This will cause the outer layers of the star to expand greatly, and the star will enter a phase of its life in which it is called a red giant. Within 7.5 billion years, the Sun will have expanded to a radius of 1.2 AU—256 times its current size, and studies announced in 2008 show that due to tidal interaction between Sun and Earth, Earth would actually fall back into a lower orbit, and get engulfed and incorporated inside the Sun before the Sun reaches its largest size, despite the Sun losing about 38% of its mass. The Sun itself will continue to exist for many billions of years, passing through a number of phases, and eventually ending up as a long-lived white dwarf. Eventually, after billions more years, the Sun will finally cease to shine altogether, becoming a black dwarf.

This scenario is possible only if the energy density of dark energy actually increases without limit over time. Such dark energy is called phantom energy and is unlike any known kind of energy. In this case, the expansion rate of the Universe will increase without limit. Gravitationally bound systems, such as clusters of galaxies, galaxies, and ultimately the Solar System will be torn apart. Eventually the expansion will be so rapid as to overcome the electromagnetic forces holding molecules and atoms together. Finally even atomic nuclei will be torn apart and the Universe as we know it will end in an unusual kind of gravitational singularity. At the time of this singularity, the expansion rate of the Universe will reach infinity, so that any and all forces that hold composite objects together will be overcome by this expansion, literally tearing everything apart.

If the energy density of dark energy were negative or the Universe were closed, then it would be possible that the expansion of the Universe would reverse and the Universe would contract towards a hot, dense state. This is a required element of oscillatory universe scenarios, such as the cyclic model, although a Big Crunch does not necessarily imply an oscillatory Universe. Current observations suggest that this model of the Universe is unlikely to be correct, and the expansion will continue or even accelerate.

This scenario is generally considered to be the most likely, as it occurs if the Universe continues expanding as it has been. Over a time scale on the order of 10^{14} years or less, existing stars burn out, stars cease to be created, and the Universe goes dark. Over a much longer time scale in the eras following this, the galaxy evaporates as the stellar remnants comprising it escape into space, and black holes evaporate via Hawking radiation. In some grand unified theories, proton decay after at least 10^{34} years will convert the remaining interstellar gas and stellar remnants into leptons (such as positrons and electrons) and photons. Some positrons and electrons will then recombine into photons. In this case, the Universe has reached a high-entropy state consisting of a bath of particles and low-energy radiation. It is not known however whether it eventually achieves thermodynamic equilibrium.

The heat death is a possible final state of the Universe, estimated at after 10^{1000} years, in which it has "run down" to a state of no thermodynamic free energy to sustain motion or life. In physical terms, it has reached maximum entropy.

If our universe is in a very long-lived false vacuum, it is possible that a small region of the Universe will tunnel into a lower energy state. If this happens, all structures within will be destroyed instantaneously and the region will expand at near light speed, bringing destruction without any forewarning (Wikipedia, 2015).

Discussion

Einstein's field equations include a cosmological constant (Λ), that corresponds to an energy density of empty space. Depending on its sign, the cosmological constant can either slow (negative Λ) or accelerate (positive Λ) the expansion of the Universe. Although many scientists, including Einstein, had speculated that Λ was zero, recent astronomical observations of type Ia supernovae have detected a large amount of dark energy that is accelerating the Universe's expansion. The dark energy corresponds to a positive Λ. The Λ is a measure of the zero-point energy associated with virtual particles of quantum field theory, a pervasive vacuum energy that exists everywhere, even in empty space. The Universe has at least three spatial and one temporal time dimension. According to the special theory of relativity, spatial and temporal separations are interconvertible by changing one's motion.

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12/11/2014