

Anthropic Universe and Cosmic Origin

Najmuj Sahadat Sarkar*

Department of Physics and Astronomy, University of Delhi, Delhi, India

*Corresponding author: Najmuj Sahadat Sarkar, Department of Physics and Astronomy, University of Delhi, Delhi, India, Tel: 6295454694; E-mail: hh1564465@gmail.com

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Abstract

Basically in this paper I have tried to show how the anthropic principle is affecting our actual existence. The manipulation of the values of a few physical parameters and constants is fundamentally controlling our existence one at a time. If some events did not happen or if some events happened then we would not exist in this universe. Through the Anthropic principle we understand that we have no special place in this universe. Moreover, it is easy to understand that life is full of uncertainty only because of the anthropic principle. It is not known which equation expresses fate! But we are really lucky today. Here are some nuanced differences between the Weak Anthropic Principle or WAP and the Strong Anthropic Principle or SAP. There are also some special concepts related to flat, close, open universe and new mysteries of dark energy. Let's see how much luck helped us at the very beginning.

Keywords: *Anthropic principle; WAP; SAP; Dark energy; Inflation; CMB; FRW metric; Proton; Neutron; Atom; Star; Galaxy; Planet; Life; Observable*

Introduction

There are very few people in the scientific community who do not know about the “anthropic principle”. We all know that anthropic principle is basically of two types, namely weak anthropic principle or WAP and Strong Anthropic Principle or SAP. I think the anthropic principle cannot completely solve the fine tuning problem. According to WAP you exist in this universe because your actual existence depends on the accuracy or precision of the parameters found in nature. Because if the parameters were wrong, you would not exist in this universe today [1]. I'm not saying WAP is wrong. But it cannot explain why our universe is the way it is! In my opinion this is not a good theory to search for the existence of self in the universe. It still needs a lot of correction or modification. But at least my opinion is disappointing. If it is consistent with previous observations, it can make accurate predictions about future observations. So if it cannot explain reality, it can be proven wrong. But many say WAP is consistent with past observations. Scientists have not yet found any such situation in our universe, which can question our real existence! But scientists are unable to give any testable prediction. And it cannot be falsified. So WAP is more of a philosophy based theory than a science based theory [2-4]. Actually we could not understand it properly. Because of which there is more chaos in the scientific community. On the other hand, according to SAP, there is an infinite number of universes out there which have different parameters and different laws of physics or our universe is infinitely large. Different parameters and laws of physics in different space time parts of this infinitely large universe have arranged themselves in such a way that they can provide the conditions we want to form a biological system like ours [5]. For example, naturally we are stuck in the present, where the universe has managed to create the conditions that we need. My main point is that it would be very complicated to interpret both strong and weak separately. Because, it is almost impossible to say what form the universe will take in the case of WAP. Since WAP is not dependent on the universe map. The drawing says that the universe will be large or infinite. WAP says that you are living and observing in a part of the universe, because the conditions are favorable for your actual existence. If it were not, you would not be yourself to observe. So only SAP can speak of an infinite number of universes or places that are completely different in character. And in their infinite arrangement, fortunately our universe is favorable for your existence. Yes it can be considered acceptable. So luckily, what kind of luck! Let's shed some light on this. Even with all the uncertainties aside, the picture we paint of the evolution of the universe is truly remarkable [6]. With the help of modern telescopes, we are gathering more and more observational evidence to understand how the expansion of the universe began in a fraction of a second. Although the subject is very exciting, there are many characteristics of the universe that cannot be explained. If it were not for those unknown characteristics, we would suffer from non-existence. Let's analyze those trends statistically. Just as the DNA of the

body carries all the information of a human being, the Cosmic Microwave Background or CMB carries all the information and mysteries of the origin of our universe. CMB is a type of radiation that was emitted when the universe was only 380,000 years old. Astronomical observations have shown that the temperature deviation from one part of the CMB to another is 1 millionth of a degree. This temperature variation demonstrated subtle density variation. And there is no deviation in the parts near those regions. For which they have no form of contribution in creating any large galaxy or structure in the present universe. But there are other parts. It is because of them that later a large structure was able to be organized in the present universe. As we see today. But what if the density variation were much greater? Then a strange thing happened. In denser regions, more matter begins to accumulate. As a result, the matter in those parts would collapse quickly and become a black hole. No form of galaxy or stars were formed then. If not, somehow galaxies would have formed in those universes, but space would have been full of terrible X-rays, gamma rays, radiation. As a whole we could not have been created then [7,8]. Those galaxies would have a much higher density of stars. So the interaction or collision of star to star was very high. We could not survive under these conditions because no planetary system was created then. Therefore, it is very unfavorable for the creation and development of life. So now or the place where we are living is quite favorable. This optimization is possible only if the concentration fluctuation is at the right level. In short, neither more nor less. Another fate is that our universe is in a state between expansion and contraction. It is expanding, but not in the way it should be. If the expansion rate were too high, all the matter in the universe would move so far away from each other that new galaxies could not form. The conditions would have been unfavorable even for the formation of only galactic core atoms. But on the other hand, if the universe's expansion rate was too slow, gravity would win out. Then gravity would compress everything to form a black hole singularity again. In this case too, there would be adversity in favor of making or developing life. The creation of life on earth is largely dependent on luck. If matter and anti-matter were equal in the beginning of the universe, then they would have come in contact with each other and produced pure energy. But in reality it didn't happen like that. In the very beginning, matter was slightly more abundant than anti-matter in the universe. It was found that 10^8 matter and anti-matter pairs had one extra matter particle each. Each of these extra matter particles played an important role in determining our future. Today we see only matter in the universe. Can it not exist significantly?. If nuclear fusion reactions in stars were completed at a faster than normal rate, we would still be out of existence. Our cosmic explosion was from a primordial hot ball. There the density of matter was greatest. If somehow all the matter there had rapidly changed first to hydrogen, then to helium, then to carbon and iron, then no stars of any kind could have formed in the future. Since the existence of stars depends on the transition from hydrogen to helium through their main sequence. So that they can shine brightly. Strictly speaking, the atomic structure of stars depends on the formation of carbon atoms through the fusion of three helium atoms. And carbon is one of the primary building blocks of life. If the triple alpha system were slightly different, there would not be enough carbon in nature to allow life to form. Moreover, without enough carbon, oxygen could not be formed and a large amount of carbon would have remained permanently in the universe for billions of years. Some additional circumstances are at work throughout the universe for our actual existence. Particles called neutrinos are very rare in nature. Most of the neutrinos we have found in nature are left handed. Their interaction with ordinary matter particles is very rare. Supernova explosions occur when neutrinos are emitted from the core of a collapsing star. The energy of those particles is spread around the stellar envelope. Then they spread across space. Super nova explosions release heavy elements such as carbon, nitrogen, oxygen, calcium and iron. Which acts as one of the most important elements in making life on earth. If neutrinos do not interact with matter in any way, they will be ejected from the star's core, but they will not contribute to the explosion. On the other hand, if the neutrinos interact well with the matter, they will be trapped inside the stellar core. In this situation, the heavy elements will be trapped in the core of the collapsing star, unable to explode and escape. If gravity were a very strong force, the stars in the universe would have very little mass.

Then their lives would have been completed in only a few years compared to tens of billions of years. Not only that, if gravity had become a stronger force, the chemical addition reactions that take place in the center of the stars would not have increased in velocity. Even under this effect, there would be no possibility for those short lived stars to form life. Even if life did form in a universe with a strong gravitational force, it would have been created and formed on a very small scale. As a result, they could not easily move from one place to another or remained standing. We have seen that certain rules are responsible for the creation and development of complex life on earth. We still don't have a theory to explain why these rules are so accurate. So most scientists are hoping that the anthropic principle might solve that mess. The physical laws we observe in nature can reveal the mysteries of human existence. As I have said before, some classes of scientists have hypothesized that an infinite number of universes exist out there. Each universe has its own unique set of rules in place. Those called "multiverse". Maybe a universe is still being created somewhere or collapsing completely independent and these processes depict a singular direction of time. There are some universes that are expanding thousands of times faster than our universe. It is expanding so rapidly that no complex structure can form there. On a grand scale, our space or status in the universe is very insignificant. The multiverse is eternal and infinite!. This creates different inflating regions, which later evolve into separate universes. All the physical properties that we discovered mathematically, in a way they continue to influence us. Our thinking has given concrete structure to the power. And encouraged to think and ask all those questions, why our universe is this way? So is our universe very advanced and special among these outer universes? This is quite complicated, because finding the existence of extraterrestrials is not trivial! So far

these have remained only in theory. Most of the scientists consider these issues philosophical and metaphysical. Perhaps in the future our thinking about physics will advance further, so that we can explain why the value of the gravitational constant is fixed. What would happen if a little more or less? Moreover, the expansion rate of the universe is like this or why? Luck only happens once, but if it happens again and again, can it be called luck? Then there would probably be no need for the anthropic principle. No one can say exactly why we live in a universe that is complementary in every way. Different physicists have different opinions about the anthropic principle! We have come a long way, and we have a long way to go. So far we have managed to gather a great deal of information about the cosmos. This is one of the epochs in human history because we can now reveal the origins of the universe that contains us through both theory and observation.

Literature Review

In 1999, astronomer Royal Martin Rees published a paper called “just six numbers”. There he outlines 6 major scientific constants that make the universe biophilic. If the value of one of these 6 changes even slightly, the universe will be a completely different place. As a result no galaxy, no stars, no planets, no life can form. These numbers are:

- Number of physical dimensions (3 spaces+1 time).
- Gravity and electromagnetism range ratio.
- The ratio when mass is converted to energy, (*i.e.* when hydrogen is converted to helium).
- Amount of dark matter.
- Cosmological constant.
- The scale at which the universe appears very smooth.

This is an argument that is called the “fine tuning argument”. If the universe is a giant radio, it can be tuned to a precise frequency. That is a life creating frequency! Only one frequency can do that. For example, if gravity were weak in nature, galaxies, stars, planets and life could not have formed. The fine tuning argument is unlike any other “anthropocentric” statement. The universe is not a combination of all characteristics, but rather a combination of certain characteristics that are favorable for life. With an analogy I want to illustrate the fine tuning argument. Suppose you have committed a crime punishable by death. You are tied up and taken to a place where there are a hundred gun men. They want to shoot you from a certain distance. They will shoot at you whenever the judge gives the command. Now the judge gave the command, “open”, everyone looked at you and fired. But the strange thing is you didn’t die. Each of their shots missed. If one of them hits you in the head, you die. But in reality that didn’t happen to you. In other words, the whole matter of killing you was proved false because you didn’t die. Luckily you survived!. You survive after being shot by a hundred gun men at once. Overall we can say you exist. The same applies to our universe. The fine tuning argument is one of the most modern paradigms in astronomy. This is practically very important, because another scientific theory, such as evolution, was able to disprove the earlier dogmatic theory of human creation. Fine tuning is useful for analyzing the biophilic character of the universe. Moreover, on the other hand, there are many other chaotic situations, which present conflicting theories about our existence in the universe. Many say the universe is not entirely biophilic. Most of space is empty, cold and filled with horrible radiation. Therefore, life cannot develop everywhere in the universe. Our universe is “minimally biophilic”. At least we can firmly believe, “absence of source is not source of absence”! A biophilic universe is no wonder. We are in a universe from which it is not possible to see even the slightest glimpse of other universes. We have not yet been able to carry out any specific observations on a large scale. Therefore, we must accept this harsh truth. The way the universe is going, the only way to solve it is the way of logic. Let’s look at some more examples of the anthropic principle. As we all know life depends on water. Compared to other known substances known to man, the solid state of water *i.e.* ice is less dense than water. For which ice floats on water. If ice did not float on water, all water would turn to ice. Even so, the first life developed in water. In this case, the life of the earth also depends on the amount of salt in the water, the viscosity of the water and the amount of other elements present. Moreover, the earth is at a position from the sun where most of the water that freezes does not turn into ice, and ice does not turn into water when it melts. This location on earth is called the Goldilocks zone. If the earth were a little closer or further away than this, a drastic change in temperature would be observed. In this situation, the conditions were unfavorable for the creation and development of life on earth. If the level of gases present on Earth were high, then our blue planet would have a serious greenhouse effect. On the other hand, if there were not enough gases to cause the greenhouse effect, the planet would be exposed to dangerous levels of radiation. Earth’s albedo is how much sunlight is reflected by the earth versus the total amount of sunlight absorbed. If the albedo was higher, the earth would turn into a white ball of ice. But if the albedo were lower, the greenhouse effect would increase. Then its condition might have been like that of Venus. Another factor that is at work planet wide is the earth’s magnetic field. If the earth’s magnetic field were of a weak nature, there would be a tremendous amount of cosmic radiation. But if earth’s magnetic field were very strong, we would not experience any form of electromagnetic storm. Another factor that comes into play is the position of the solar system from the center of the galaxy. Our solar system is located 27000 light years from the center of the galaxy. If this distance were less, *i.e.* our solar system

was located in one of the spiral arms of the galaxy, the solar system would still be exposed to terrible radiation. Life could not have been created under these conditions. Life on earth is also affected by the color of the sun. If the color of the sun were slightly red, blue or white, no photosynthesis would occur on the planet. Photosynthesis is the main biochemical process that led to the creation of life on earth. The above processes directly or indirectly affected life on earth is doing or will do. There are many other reasons that cannot be directly explained.

We live in a favorable planet, a favorable solar system, a favorable galaxy, a favorable universe. Now the question for us is we live in a universe where there are many constants and many cosmological parameters to explain our existence. Their value is also fixed and quite insignificant. How they functioned in a universe is still a mystery. Intelligent design theorists think that in order to disprove the anthropic principle, and to prove their theory (simulation hypothesis) correct, they hypothesize that all the constants of the universe, all the mechanics came from the head of a master mind. Much like giving instructions to a computer. Certain instructions are capable of creating certain simulations. According to them, biological processes alone are not enough to create life (DNA that carries information, complexity, irreducible complexity, etc.).

But to imagine a master mind in the universe is to accept everything. Then there will be no more scope for questioning. We know everything. The universe certainly cannot be like this. We stand at the very edge of knowledge. From where the initiation and expansion of something new is vast or immeasurable. We are close to the known, but far from the unknown.

String theory predicts a large number of possible universes. Which in scientific language is called background or vacua. A particular set of vacua or universes is called the “multiverse” or “anthropic landscape” or “string landscape”. Professor Leonard Susskind believes that a large number of vacua states reside outside. Which is hinting at the multiverse in a way. I call it “anthropic reasoning”. This is quite an inspiration to me substantive he wrote in his paper that all the physical properties we observe throughout the universe are uniquely suited for life. There is no mention that they will be unknown properties. But David Gross, Lubos Motl, Peter Woit and Lee Smolin think they are not predictive. Steven Weinberg writes in his paper that the “turning point” of modern science is the “anthropic principle”. Although the anthropic principle has nothing to do with god or supernatural forces! Because we have a “cosmological model”. By which it has been possible to solve the mystery of the origin of the universe to a large extent. Today humans have been able to equate cosmological parameters with biological diversity. Today, the complexity of the cosmos has succeeded in being concentrated in a monocular with all forms of cosmological observation.

Cosmological arguments have a long history! It started from the time of Plato and Aristotle. They were victims of many misconceptions at that time. However, the medieval philosopher and philosopher Thomas Aquinas believed that the existence of God can be proved in five ways. But a few decades ago, David Hume rationally disproved these cosmological arguments. If a large cosmological structure is created, then why can't we find clues about the existence of a designer at every point of that structure? He also said that the universe does not seem like god on a large scale! Many people raised the question, how can all cosmic coincidences be balanced on a thin knife? Which means, a certain engineer has given them equilibrium. However, the author supports the work of Michael A Corey, Paul Davies and other thinkers. In 2001 Corey published a physical and cosmological fact. In which sufficient information was shown very meticulously. Infinitesimal changes in them can give different dimensions to the existence of the universe as we know it.

And to understand the existence of time, he tries to show a mechanism that is affected by the activation of the initial states of the universe. Corey says early in his book that he can prove the existence of god. And when I first read it, I realized that it seemed logically consistent. But at the end of the book he tries to explain that trying to find a designer in a design is a completely futile attempt. As noted above, a group of theorists reviving the cosmological argument believe that at least some biological structures may exhibit a special intelligent design. If so, it implies the existence of an intelligent designer behind the intelligent design of that particular biological structure. Because they only come into existence through materialistic mechanical processes, like those hypothesized by Darwin and various forms of Darwinian evolution. Another very important paradigm is the entropy of the universe. It started from a very “low entropy state”. For which the big bang is a “highest ordered stage”! Since cosmic inflation, the entropy of the universe has been steadily increasing. Order has turned into chaos. Low entropy state (space was quite microscopic before inflation) started due to some random quantum fluctuation. But today we can experience a thermodynamic unidirectional flow of time. That came from the big bang, flowing through the present stellophrenic phase and heading into the future. It is true that, in initial time, the universe grew from a very small portion of space. Which was extremely orderly. Then it starts to inflate automatically. What if the beginning of the universe had been very different? If only entropy had been high instead of low at the beginning of the universe! Then the living world would not be affected by it? Of course our actual existence depends on entropy as well. A British philosopher William Paley called the anthropic principal “design in nature”. In his book natural theology, he presented a final truth about the existence and work of god. He tried to imagine, suppose two objects are on the ground. Take one stone and the other a watch. Now the general question is where these two items are coming from? In the

case of rock, it is natural that it is one of trillions of trillions of rock fragments. But what about the clock? The watch has completely different features! It is very well designed by any clock maker! So that it can work well. Paley used this simple fact as one of the means for the origin and development of life on earth. The complexity of living things comes from a watch maker. According to him, if there is a creation somewhere, it should also have a creator. Paley tried to explain that any intelligent plan of creation of nature can be called teleological argument. Teleology is the study that analyzes nature's structural tendencies. Starting with the ancient Greeks, basically when the world will end, all those weird things. Teleological arguments have been criticized since Paley's time. Philosopher David Hume (1711-76), on the other hand, raised another problem regarding Satan or evil. How death and its suffering can explain the existence of an ideal designer. The answer is, of course, that the structure of nature refers only to one dimension of theology! Death and its suffering are a part of creation. Deliverance from certain sins also reveals God's eternal truth and existence. When Darwin's "origin of species by means of natural selection" was published in 1859, it again raised questions on Paley's theology! The claim made this time is about nature's "mechanistic self ordering" process.

Discussion

Mutation provides random changes and nature arranges everything as it is. So that the animals can adapt themselves according to the favor of nature. However, there were many misconceptions about Darwin's theory at the time. But later they were revised. But it is still a viable perspective in most design debates today. As time went on, the arguments against Paley's theory became stronger and stronger. There is not just one clock, but thousands of clocks.

Which are beautifully designed to show the correct time. In this case the clock is only a reference; to me a clock is a thousand mathematical equations, which are carefully and beautifully balanced. All these equations are used to determine the natural constants of matter and its medium. Their small amount of quality manipulation can bring about catastrophic changes! Scientists today call it "cosmic coincidence". Let us illustrate the doctrine of special design with three more examples. First imagine the mass of the proton. Elementary particles carry special significance. The mass of the proton is one of the reasons for its own stability throughout the universe. Free neutrons, on the other hand, are slightly heavier particles, which change into protons. An electron and anti-neutrino have a half-life of only 12 minutes. Simply put, free neutrons do not exist in nature at all. If somehow the mass of the proton is increased by 0.2%, it will become an unstable particle. It will quickly become neutrons, positrons and neutrinos. But in reality nothing like that happens. But what if protons were slightly heavier? The complications we faced then are quite remarkable. A hydrogen atom is made up of only one proton. Proton being slightly heavier means that its decay process would have started. And we lose the existence of the hydrogen atom.

Helium cannot be formed without hydrogen. Without helium, carbon, nitrogen, oxygen cannot be formed. Yet as a whole we would not have come into existence. But currently our universe is made up of 75% hydrogen and 25% helium atoms. The mass of the proton is designed to be slightly less than that of the neutron. Its influence is also operative in the universe. Because it can prevent the universe from contracting. Although protons have nothing to do with mutation or natural selection. Because the mass of the proton is one of those physical properties that has remained virtually unchanged since the beginning of the big bang. The second instance of creation has to do with the most elementary mechanics of the universe. As I said earlier it is gravity. In nature the gravitational force acting between two mass objects is proportional to the square of the distance between them (r distance). 300 years ago today that was invented by Isaac Newton. This primordial force holds or holds the universe. Gravity helps keep the moon's orbit from earth. Gravity helps keep the earth's orbit from the sun correct. Again, gravity helps maintain the solar system's orbit from the center of the galaxy. Scientists have always wondered about the factor 2 in this equation.

This relationship "always seemed a little more efficient". In an evolved universe, no one expects such a simple relationship. Why is the factor so accurate; why not 1.99 or 2.001? The gravity force was repeatedly checked with a sensitive torsion balance, which showed that the factor was actually 2, (2.00000 to the least five decimal places). As with the mass of the proton, any value other than 2 would lead to an eventual catastrophic decay of the orbits and the entire universe. Gravity force clearly demonstrates the elegant and essential design. Another very elementary mechanics of nature is the force of attraction or repulsion between electrical charges. The strength of electrical force is observed during lightning when electrons interact with charged objects. The Coulomb force acting between two charges is proportional to the square of the distance between them. Much like gravity! Because the electrical force is stronger than gravity, the factor 2 is measured more efficiently than gravity. Distance dependence of electric force, measured exactly to 2 to 16 decimal places (2.0000000000000000). So again we get factor 2. This is one of the best limits of scientific testing. These "natural" laws, such as gravity and electrical force, can be called God's laws. Some class of theistic physicists thinks that they must reflect his purposeful plan. As we saw earlier, hydrogen is one of the most common elements in the universe. The temperature in the early universe was billions of degrees between 10 and 1000 seconds after the Big Bang. About 25% of the total hydrogen present in the universe at that time was converted into helium through nuclear fusion reactions. If the strong interaction were 2% stronger than it is now, then all the hydrogen would have changed into helium within moments of the universe's beginning. Then compounds like water could not be formed in the universe. And life is impossible

without water. If the strong interaction were slightly weaker, deuterium (heavy hydrogen) would not be very stable. This means that nitrogen and phosphorus are also very important elements for life. They are formed in the core of stars, when fusion reactions of other elements with deuterium are completed at certain temperatures. If the electromagnetic interactions were three times stronger and the other forces were of the same strength, any element with an atomic number greater than 6 would never have been formed. In the case of all these elements, the electromagnetic force acting between the protons in the nucleus is greater than the nuclear force of the protons in the nucleus. Then perhaps life giving elements such as nitrogen and oxygen could not have been produced. If the previously mentioned gravity were 1000 times stronger, the lifetime of stars would be 10 million years instead of 10 billion years. Whenever life tries to develop and evolve they will not get enough light and heat. Because, it has been observed that life on earth took about 10 million years to evolve. How can life be possible if stars have a lifespan of 10 million years! What if all the forces were equal in strength and there was less matter in the universe? Then the evolution of the universe will be very different. If the density of ordinary matter was 10% compared to the current value, then any kind of large structures such as star cluster, galaxy cluster, super cluster, they could not be formed. Even so, there are about 10 million superclusters in the universe. Such a situation has never happened in the universe. So do we have a special place in the universe? I do not know the answer! But the anthropic principle is able to answer in one way. All ordinary matter, such as us, planets, stars are all made of atoms. Around an atom centered around the nucleus (positive charge), the negatively charged electrons move along fixed orbits. Atoms are very microscopic. A typical atom has a diameter of about 0.0001 micron (a micron is one millionth of a meter). A nucleus, on the other hand, which carries all the mass of the atom, is about 0.000000001 micron in diameter. Protons are positively charged but electrons are negatively charged *i.e.* equal but opposite. So the total charge of the atom is zero. If the amount of negative charge of the electron outside the nucleus of the atom were slightly to and fro. Then the atoms present in the universe would have become unstable. In such a situation, there would be no favorable environment for the creation of life. Every 100 million years a large meteorite hits the earth. The former meteorite hit earth 64 million years ago under its influence.

Today all dinosaurs worldwide have suddenly become extinct. This sudden extinction of all the dinosaurs, along with other animal species, is one of those periodic extinction events in our planet's history. The sudden disappearance of dinosaurs has puzzled scientists for years. What could have caused the sudden demise of these highly successful creatures after enjoying such a long period of dominance? What is the reason for their sudden removal from the pages of nature? After years of debate, the mystery of what caused the sudden and complete extinction of the dinosaurs was finally solved in 1980 by Nobel laureate Luis Alvarez and his son Walter. The two showed that a massive meteorite from space had collided with earth, causing a global catastrophe. This explanation for the extinction of other animals, including the dinosaurs, *i.e.* the impact of a meteorite or comet impact with the earth, is also popularly known as the "impact theory". Scientific evidence in favor of the impact theory quickly accumulated and by 1987, Professor Alvarez could point to 15 different scientific facts that supported the theory. Now I will try to show some mathematical relations with general FRW cosmology. I will also try to explain how the geometry of our universe is affected depending on the value of k. Overall these conditions are essential for our existence. The metric form of FRW is

$$ds^2=dt^2-a^2(t) [\{dr^2/(1-kr^2)\}+r^2d\theta^2+r^2\sin^2\theta d\phi^2].....equation 1$$

Here a(t), t denotes the scale factor in cosmic time. k is the curvature parameter. And coordinate r, θ and φ, refers to comoving coordinate. A freely moving particle can come to rest in this coordinate system. On the other hand, the shape or geometry of the universe depends on the constant k. If the value of k is +1 then the universe is closed. In that case it will collapse quickly. On the other hand if k is -1 then the universe will be open *i.e.* then it will expand forever and if the value of k is 0, then the universe will be flat. So if the value of k is 0, the universe will be in the intermediate state between the expansion variations we found for the previously mentioned close and open systems. From all the theoretical models and observations we have made, it is clear that the universe is flat but there is a margin of error of 0.4%. Now the question is if the universe was not flat, then its origin would have been different. The cosmic evolutionary history would also have been very different. In these circumstances, there would have been various adversities in the creation of life in any other part of the universe. Let's discuss some more mathematical rules.

Consider an ideal perfect fluid, which can be the source of the energy momentum tensor (consider, in the early universe, matter behaves like a viscous fluid) which is completely homogeneous and isotropic in its rest frame. In this case, the energy momentum tensor will be of the form:

$$T(\text{Energy-momentum tensor})=\text{Diag}(\rho,-p,-p,-p).....equation 2$$

If there was no homogeneous and isotropic distribution of matter at the very beginning of the universe, then the shape of the universe would have been very different. And there was a lot of uncertainty about whether we could exist or not. Where ρ is the energy density of the fluid, p is the pressure of the fluid. So we get two independent equations from Einstein's equation, respectively

$$H^2= (\dot{a}/a)^2=(8\pi G\rho/3)-k/a^2.....equation 3$$

$$\ddot{a}/a = (4\pi G/3) \times (\rho + 3p) \dots \text{equation 4}$$

Here H is acting as the Hubble parameter. If the value of the Hubble parameter had been slightly different, our universe would have expanded slightly more or faster. As a result, there would not have been enough time to create life. Equation 3 is known as Friedmann equation and equation 4 is known as acceleration equation. From equation 4, accelerated expansion starts for $\rho + 3p < 0$. The energy momentum tensor is conserved for the superiority of Bianchi identities. What if the energy momentum tensor was not conserved? Maybe the continuity equation didn't work then. Because according to the continuity equation:

$$\rho + 3H(\rho + p) = 0 \dots \text{equation 5}$$

We can rewrite equation 3 as:

$$\Omega(t) - 1 = k/(aH)^2 \dots \text{equation 6}$$

Here $\Omega(t) = \rho(t)/\rho_c(t)$, a dimensionless density parameter. And $\rho_c(t) = 3H^2/8\pi G$ is critical density. The distribution of matter in the universe is determined by spatial geometry. If the value of the critical density of the universe were different, then the value of Ω might also be different. And the conditions of the universe would not be as favorable as they are now. The value of critical density in the universe is about $8.5 \times 10^{-27} \text{ kg/m}^3$. A small difference could have made a big difference. I am trying to give some examples below, what changes will be made in the geometrical structure of the universe if the value of Ω is changed. As mentioned earlier the value of k also has an effect in this case.

$$\Omega > 1 \text{ or } \rho > \rho_c \rightarrow k = +1 \dots \text{equation 7}$$

$$\Omega = 1 \text{ or } \rho = \rho_c \rightarrow k = 0 \dots \text{equation 8}$$

$$\Omega < 1 \text{ or } \rho < \rho_c \rightarrow k = -1 \dots \text{equation 9}$$

Current observations have proved that the universe has flat geometry that is $\Omega \approx 1$. This is only possible when $\rho = \rho_c$! This condition is quite significant.

Consider the universe filled with barotropic perfect fluid, which has an equation of state parameter. It is determined by w. *i.e.*

$$w = P/\rho \dots \text{equation 10}$$

Now if we assume, w is a constant and solve equations 3 and 4 (when k=0), we get:

$$H = 2/3(1+w)(t-t_0) \dots \text{equation 11}$$

$$a(t) \propto (t-t_0)^{2/3(1+w)} \dots \text{equation 12}$$

$$\rho \propto a^{-3(1+w)} \dots \text{equation 13}$$

Where t_0 is a constant. The above solution is useful for $w \neq -1$, If somehow $w = -1$, then $a \sim \infty$ would be and $\rho \sim 1$. This situation is not logical. In this case the universe would not have been as significant as it is today. So the statement is false. So $w \neq -1$ is observationally and theoretically consistent. The radiation dominated stage of the universe lasted for 380,000 years starting from the Big Bang. And the matter dominated stage lasted from 3,80,000 years to 9.5 billion years. According to the calculation, $w = 1/3$ for radiation dominated universe and $w = 0$ for matter dominated universe. So the mathematical relation for scale factor, time and density for both universes will be

$$\text{Radiation: } a(t) \propto (t-t_0)^{1/2}, \rho \propto a^{-4} \dots \text{equation 14}$$

$$\text{Matter: } a(t) \propto (t-t_0)^{2/3}, \rho \propto a^{-3} \dots \text{equation 15}$$

Statistically, it can be seen that the density of the radiation dominated universe was much lower than that of the matter dominated universe. If this accident had not happened, the universe would have been different in nature today. Maybe the era dominated by

radiation was still going on. And it would not have been suitable for the creation of life at this time. Maybe after many more billion years life would have arisen. This is my personal opinion though. But both perspectives relate to a decelerated universe. It is seen from equation 4 that to get an accelerated expansion, the equation of state has to satisfy the following situation. *i.e.*

$$w < -1/3. \dots \text{equation 16}$$

This condition has been theorized for dark energy. For a cosmological constant Λ we have $w = -1$, which implies a constant energy density, *i.e.* $\rho\Lambda = \Lambda/8\pi G$ and fortunately the hubble parameter has a constant value $H = \sqrt{\Lambda/3}$. In this case the scale factor will increase exponentially, thus:

$$a(t) \propto e^{Ht} \dots \text{equation 17}$$

Equation 17 directly or indirectly signals dark energy. If the equation were not proportional to time, but related to some additional parameter, then theory and observation could not be equated. Things progressed more and more complicated. But recent observations have shown that $w < -1$ can satisfy the equation of state differently. The equation of state relates to the phantom dark energy component. For which a separate consideration is required. We first saw that $w < -1$ for a contracting universe. So it can be another expanding solution! Much like this:

$$a(t) = [t(s) - t]^{2/3(1+w)} \dots \text{equation 18}$$

Where $t(s)$ is a constant. This corresponds to a super inflationary solution, where the Hubble rate and scalar curvature increase.

$$H = n/[t(s) - t], \quad n = 2/3(1+w) > 0 \dots \text{equation 19}$$

$$R = 6(2H^2 + \dot{H}) = 6n(2n+1)/[t(s) - t]^2 \dots \text{equation 20}$$

The Hubble rate diverges as t from $t(s)$, implying an infinitely large energy density at finite time in the future. The scale factor increases infinitely as t goes from $t(s)$. This situation is known as the big rip singularity. Catastrophic conclusions are not inevitable in these models and are avoided in certain models equipped with top hat potential, phantom fields.

Conclusion

We can say more loudly, when the curvature of the universe was large, quantum effects become more important. Why the curvature was higher can only be analyzed with the singularity. All mathematical models go to singularity and become useless. If there was no singularity, there would be no Big Bang. And if there was no Big Bang, our existence would have become a mere fantasy.

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