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The argument is made up as follows:

1. Everything that begins to exist has an external cause.
2. The universe began to exist.
3. Therefore, the universe has an external cause.

If the first two premises above are true, then the conclusion must necessarily be true.

If either premise is false, however, then the conclusion must be false, as well.

EVERYTHING THAT BEGINS TO EXIST HAS AN EXTERNAL CAUSE

This premise is false if and only if there is something that begins to exist without an external cause, and this can only happen in two scenarios:

THERE IS SOMETHING THAT BEGINS TO EXIST WITH AN INTERNAL CAUSE

In other words, something creates itself.

This is impossible, because in order to create itself it must already exist, but in order to be created, it cannot exist. In other words, it must exist and not exist at the same time, and this violates the law of non-contradiction and is, therefore, logically impossible. Or to put it in symbolic notation, where p is existence, we would have,

$$p.\sim p$$

This cannot be true, because the law of non-contradiction states this proposition is false:

$$\sim(p.\sim p)$$

This self-creation problem means that the scenario is false.

THERE IS SOMETHING THAT BEGINS TO EXIST WITHOUT A CAUSE

In other words, something is created by nothing.

This is also logically impossible, because nothing produces nothing or in Latin *ex nihilo nihil fit*. Nothing means "not anything" and, therefore, has no properties, and this includes the property to bring into existence or create anything.

The logical argument for the proposition that nothing produces nothing is as follows:

1. If anything can begin to exist, then it is possible that anything exists.
2. If not anything exists, then it is not possible that anything exists.
3. If it is not possible that anything exists, then anything cannot begin to exist.
4. Therefore, if not anything exists, anything cannot begin to exist or in other words, not anything cannot bring into existence anything.
5. Not anything is nothing.
6. Therefore, nothing cannot bring into existence anything.
7. Therefore, *ex nihilo nihil fit*.

QUANTUM MECHANICS

However, a quantum physicist might argue that something can begin to exist without a cause, from nothing.

Quantum mechanics is a branch of physics concerned with atomic and subatomic systems. It developed because classical physics could not explain the behaviour of matter and radiation at extremely small scales. While classical physics can predict precisely how matter and radiation will behave, quantum mechanics generates only probabilities. Randomness is, therefore, a fundamental characteristic of quantum mechanics. In other words, at atomic scales, events appear to happen without a cause.

RADIOACTIVITY

The example given is of radioactive decay of atoms.

Radioactivity is a property of certain atoms with unstable nuclei that spontaneously emit certain forms of electromagnetic energy like gamma rays, and certain subatomic particles like alpha and beta rays. Gamma rays are electromagnetic radiation like radio, light and X-rays. Alpha rays are nuclei of helium atoms, and beta rays are streams of electrons.

Atoms are made up of three subatomic particles:

1. protons which are positively charged
2. neutrons which are neutral
3. electrons which are negatively charged

The mass of an atom is concentrated in its centre, which is called the nucleus, and this consists of protons and neutrons, except for hydrogen, which has only one proton and no neutron.

Whilst quantum mechanics can state precisely what proportion of atoms will decay, it cannot predict which particular nuclei will decay. On the assumption that all the nuclei are in an identical state in the beginning, the decay is, therefore, a random process.

However, this does not mean that the cause is unknown. It only means that the cause cannot be precisely traced to the effect. This is, therefore, a problem of measurement and is not evidence that something can begin to exist without a cause.

SOURCE OF RADIOACTIVE DECAY

The source of radioactive decay lies in the way subatomic particles are bound together to form the nucleus of an atom.

As mentioned before, hydrogen is made up of a nucleus of one positively charged proton, which binds the sole negatively charged electron together to form the atom.

For atomic nuclei having more than one proton, the positive charges on the protons generate electrostatic repulsion. A nuclear force is, therefore, required to neutralise electrostatic repulsion and bind the nucleus together.

This nuclear force:

- cannot be electrical, because it neutralises electrostatic repulsion without affecting the positive charges of the protons;
- acts as the "stickiness" to bind together subatomic particles, which are within close "sticking distance";
- acts only when neutrons are present in the nucleus with the protons.

Therefore, the source of radioactive decay is the relations among:

- the binding nuclear force
- electrostatic repulsion
- the motion of the nuclear particles which determines the "sticking distance" and therefore the "stickiness" of the binding nuclear force

According to quantum mechanics, the relations between the particles vary many times a second between certain ranges.

In many atoms in nature with up to eighty three protons and a sufficient number of neutrons, the binding nuclear force keeps the nucleus stable, because no variations in relations are large enough to cause decay.

However, in atoms with more than eighty three protons, irrespective of the number of protons, electrostatic repulsion and variations in relations become large enough to cause decay.

It is then the unpredictable motions of nuclear particles that generate the randomness inherent in radioactive decay. The motion of nuclear particles is unpredictable because it is not possible to measure both their position and velocity at the same time.

This is the measurement problem of quantum mechanics.

THE MEASUREMENT PROBLEM

In 1926, Schrödinger developed the fundamental mathematical equation of quantum mechanics, and this differs fundamentally from Isaac Newton's laws of motion on which classical physics is based, because it generates only probabilities that a certain particle will be in a given place at a given time.

In 1927, Werner Heisenberg developed his uncertainty principle to show that it is impossible to precisely measure both the position of a subatomic particle and its exact velocity at the same time. The more accurately one measures the position, the less accurately one can measure the velocity, and vice versa.

In the macroscopic world, it is easy to measure both the position and the velocity of everyday objects because the uncertainties are negligible. Hence, it is easy to precisely trace the cause to the effect in the macroscopic world, and, therefore, to develop the deterministic laws of classical physics.

The uncertainties only become significant in the microscopic world of subatomic particles. Trying to measure the velocity of a subatomic particle knocks it about unpredictably, so that its position cannot be reliably measured at the same time. Therefore, one cannot precisely trace the cause of any quantum process to the effect, because this would require knowledge of both the position and momentum as initial conditions, and this is not possible in the microscopic quantum world using macroscopic measuring instruments.

Therefore, quantum mechanics does not predict that something can begin to exist without a cause. Rather that, at the extremely small scales of the microscopic quantum world, it is impossible to precisely trace the cause to the effect, because the measurement process does not provide reliable knowledge of both the position and momentum as initial conditions.

It is, therefore, the reality of human limitations expressed in the uncertainty principle that prevents human beings from precisely tracing the cause to the effect in any quantum process.

Therefore, the randomness inherent in quantum mechanics is fundamental. However, this does not mean that something can begin to exist without a cause, from "nothing."

UNIVERSE CREATED FROM VACUUM

Some quantum physicists have also suggested that the universe was created from a vacuum, which they consider to be "nothing", and, therefore, that there would be something, indeed everything, that began to exist without a cause, from "nothing".

The total number of protons in the universe is a whole number eighty digits long. The total number of electrons in the universe is also a whole number eighty digits long. Since the total electric charge in the universe is zero, these two numbers must be at least very nearly equal, digit by digit.

A vacuum also has zero electric charge. It is a state of minimum energy where quantum fluctuations can lead to the formation of particle-antiparticle pairs that annihilate one another because there is insufficient energy to maintain permanent existence.

However, as the universe began to expand, particles and antiparticles separated into the observable world. So it could be argued that the universe began to exist from "nothing."

However, as defined above, a vacuum is not "nothing"; it is still something, because a state of minimum energy is still something.

Therefore again, it is not true that something like the universe can begin to exist from "nothing."

Since there isn't anything that begins to exist without an external cause, everything that begins to exist must have an external cause.

THE UNIVERSE BEGAN TO EXIST

This premise is false if and only the universe did not begin to exist, and this can only happen in two scenarios:

1. The universe does not exist.
2. The universe always existed.

The first scenario is false because the universe clearly does exist!

The second scenario is false due to three reasons:

1. Infinite regress
2. Law of thermodynamics
3. Accelerating inflationary big bang theory

INFINITE REGRESS

If the universe always existed, it must have an infinite past. The universe cannot have an infinite past because the present cannot occur without a finite history, without a first cause which must be uncaused.

In philosophical terms, an uncaused cause is required to any event to prevent an infinite regress or the tracing of causes endlessly backward. If there is no such cause then the present event cannot happen. For example, an event 1 is caused by event 2 which is caused by event 3 which is caused by event 4 and so on forever. Will event 1 ever happen? The answer is no, because infinitival event never elapsed. There must, therefore, be an uncaused cause to a present event.

The universe cannot, therefore, exist now without coming into existence, without beginning in the finite past. That is, the universe must have begun to exist.

LAWS OF THERMODYNAMICS

The universe cannot always have existed because it should have already suffered a "heat death" by the laws of thermodynamics, and it has not.

The laws of thermodynamics apply to all physical and biological systems, all of which vary in their energy state and their ability to perform useful work on their environment. A system is an entity distinct from its environment with which it exchanges heat, work and other forms of energy. It could be anything such as gas inside a cylinder, or the universe.

A system's condition is called its thermodynamic state, the characteristics of which are called state functions which, for gas inside a cylinder, are temperature and pressure.

A closed system is one which does not exchange heat, work or other energy with its environment. An open system is one which does.

A system is in thermodynamic equilibrium when there is no tendency for its state to change spontaneously. So the gas inside a cylinder will be in thermodynamic equilibrium if the temperature and pressure are uniform. Therefore, the system can only change by an external change in its state functions imposed by its environment.

FIRST LAW OF THERMODYNAMICS

The first law of thermodynamics says that the total energy of a system and its environment is conserved.

Since the universe is a closed system and does not, therefore, exchange heat, work or other energy with its environment, the total energy of the universe must, therefore, be constant whatever the processes taking place inside the universe.

SECOND LAW OF THERMODYNAMICS

The second law of thermodynamics says that the entropy of closed systems increases with time until maximum entropy is reached at thermodynamic equilibrium.

Entropy is a measure of the uniformity of distribution of energy in a system. So for gas inside a cylinder with heat insulated walls [so that heat energy cannot be transferred into the cylinder from its environment], heat will continue to flow spontaneously from the hotter regions to the colder regions until temperature is uniformly distributed.

Since the universe is a closed system, its entropy will increase with time until it suffers a "heat death" at maximum entropy in thermodynamic equilibrium.

"HEAT DEATH" OF INFINITELY-LIVED UNIVERSE

So if the universe always existed it must have existed for an infinite period. If the universe existed for an infinite period, it must have already suffered a "heat death" and be at maximum entropy in thermodynamic equilibrium with no heat, work or other energy available to do any further work. Since it is also a closed system, it cannot acquire heat, work or other energy from its environment.

And yet as is explained below, we observe that the universe is expanding as Edwin Hubble discovered in 1929.

Therefore by the laws of thermodynamics, the universe cannot always have existed and must have begun to exist.

STANDARD BIG BANG MODEL

In 1929 Edwin Hubble analysed the light of huge distant groups of billions of stars called galaxies to show that, most were receding from Earth at tremendous speeds.

He compared the light of certain giant stars in these galaxies to those of similar stars in our own galaxy whose distances were known. He observed that the light of these receding galaxies were shifted away from their normal wavelengths toward the red long-wavelength part of the spectrum of colour.

This redshift effect proved that the space in the universe was expanding, carrying the galaxies along in it and stretching the wavelengths of light emitted from these galaxies towards the red part of the spectrum of colour.

Hubble's study also provided evidence of the cosmological principle that the universe is isotropic or looks about the same in all directions, and is homogeneous or is about the same everywhere. Every cluster of galaxies, including our own, is receding away from all others in space as the universe expands so that an observer anywhere in the universe would see about the same thing.

Rewinding back to a few hundred thousand years from the beginning, electrons would have detached from their atoms in temperatures of thousands of degree Fahrenheit. At about a second from the beginning, the nuclei of atoms would have disintegrated into neutrons and protons in temperatures of billions of degrees. Even earlier than that, neutrons and protons would have disintegrated into quarks that would be embedded in a soup of mainly gamma ray radiation.

Moving forward in time again, as the universe rapidly cooled, a small proportion of protons and neutrons would have fused into elements heavier than hydrogen. So a few minutes after the big bang when this fusion had ended, the cooling gas would have consisted of nearly 75 per cent hydrogen and 25 per cent helium with trace elements of deuterium and lithium. This 3:1 hydrogen to helium ratio should, therefore, be present in the universe today.

Spectroscopic studies show that the visible matter in the universe is mostly hydrogen and helium in the 3:1 ratio predicted by the standard big bang theory. The small amounts of heavier elements such as present in the Earth and organisms were derived from the explosion of stars that produce these heavier elements by fusion reactions in their cores.

Before the formation of atoms about 400,000 years after the big bang, light particles called photons would have scattered off the electrons that would later form part of atoms. Once atoms began to form, light would have a clear path through space.

So we would expect a "wall of light" called cosmic background radiation released from the early universe to reach us now at near the speed of light. Since the universe is expanding, this light should be redshifted into the microwave region of the spectrum of colour. Since the universe is also isotropic and homogeneous, this microwave glow should be observed from all directions in the sky and with uniform intensity.

In 1965, it was discovered that a nearly uniform glow of microwave radiation was coming from all directions in the sky. Later satellite observations proved that the microwave radiation belonged to the blackbody spectrum of colour, which was predicted for a hot flowing gas of the early universe.

THE BIG BANG SINGULARITY

If the universe is expanding, then rewinding back in time compresses the universe towards an extremely small dense and hot initial state until the volume of the universe reaches zero at the Big Bang singularity.

In the Big Bang singularity, there is neither matter nor energy nor space nor time. In other words, there is nothing and nowhere in and prior to the singularity. The Big Bang created matter, energy, space and time.

The universe, therefore, began to exist with a Big Bang. This is the standard big bang theory of the universe.

COSMOLOGICAL INFLATION

However the standard big bang model does not explain the isotropic and homogeneous nature of the universe.

For example, the temperature of the cosmic background radiation from different regions of the early universe is very nearly the same. In the standard big bang model before the formation of atoms, the photons were scattered by the electrons. So, light would have been prevented from heating up the different receding regions of the early universe to the same temperatures.

From the 1980's, inflation theory developed to explain the isotropic and homogeneous nature of the universe.

At the 10^{-35} second after the big bang, the rapidly cooling universe became trapped in a "false" or temporary vacuum in which gravity, which is ordinarily an attractive force between each and every body in the universe, repelled regions of the early universe into an extremely fast expansion. This flattened space and allowed the regions already in communication to become spread over vast regions. With cosmological inflation, the universe cools to very low temperatures, and this generates a transition to the true vacuum state releasing vast amounts of energy that reheated the universe that condensed to the universe we have today.

Quantum mechanics predicts tiny rapid fluctuations in local energy in a vacuum. Inflation would expand these microscopic irregularities so greatly allowing the gravitational clustering required to form galaxies. Since the vacuum contains microscopic irregularities that inflation would expand, small temperature fluctuations in cosmic background radiation would be expected. In 1992, the COBE satellite detected small temperature fluctuations in the cosmic background radiation. So there is evidence for inflation theory.

However, inflation does not explain the period before 10^{-35} second and particle physics has not yet explained the origin of the "false" vacuum.

ACCELERATING EXPANSION

In 1998 two studies were undertaken to determine the expansion rate of the universe.

They compared the distances of supernovae with their recessional speed. Supernovae are a class of brilliant exploding stars that can be seen even in distant galaxies. It was found that considering the redshift of their light; the distant supernovae were fainter than would be expected.

This would happen only if space were expanding at an accelerating rate thereby increasing the redshift effect over time so that light from distant supernovae reaches us fainter than would be expected if the redshift effect and, therefore, the rate of expansion of the universe was constant.

Given the supporting evidence for the accelerating inflationary big bang model, we can be reasonably confident that the universe is about 13-14 billion years old

Therefore, the universe must have begun to exist 13-14 billion years ago.

MULTIVERSE

However, some have postulated the multiverse hypothesis, whereby our universe is just one part of a subset of a hypothetical collection of potentially infinite number of universes. The idea is that then our universe always existed in its current form or its previous incarnations, and, therefore, the universe never began to exist.

The major candidates for multiverses are set out below:

ETERNAL INFLATIONARY MULTIVERSE

The inflationary multiverse is based on the aforesaid process of cosmological inflation whereby the extremely rapid expansion or inflation is driven by repulsive gravity in a false vacuum that creates regions of space far larger than the observable universe. If the transition to non-inflation in the true vacuum state occurs at different times and places, there will be regions where inflation is still occurring leading to distinct post inflationary regions of which our universe is only one.

If inflation is past-eternal, then it could be argued that our universe always existed.

Whilst this model is based on generally accepted process of cosmological inflation, there nevertheless remains the problem of:

- infinite regress: "What caused the original 'big bang' of the multiverse?"
- the violation of the Borde-Guth-Vilenkin incompleteness theorem

BORDE-GUTH-VILENKIN INCOMPLETENESS THEOREM[1]

Borde, Guth and Vilenkin showed that any universe or multiverse which is on average expanding cannot be past-eternal.

Since eternal inflation causes eternal expansion, any multiverse based on eternal inflation cannot be past-eternal. It may be eternal in the future, but it cannot be eternal in the past.

Therefore, any inflationary multiverse must have begun to exist.

The assumption of an inflationary multiverse only pushes back the beginning of our universe.

[1] *Inflationary spacetimes are not past-complete*, Cornell University Library, http://arxiv.org/pdf/gr-qc/0110012v2.pdf, 14 January 2003

Our universe, therefore, must have begun to exist.

ETERNAL CYCLICAL MODEL

In these models, it is believed that the "big crunch" of a collapsing universe would evolve into the "big bang" of a later expanding universe, and this process continues indefinitely in the future.

If the cycles of "big bang" and "big crunch" are past-eternal, then it could be argued that our universe always existed.

There are a number of problems with this model:

- our universe does not have the greater than critical density required to generate a "big crunch" in the future
- problem of infinite regress
- increasing entropy with each cycle, leading to eventual "heat death"

CRITICAL DENSITY

Critical density is the density required to render space flat. A flat universe is one which expands forever with gravity slowing the expansion so that its rate approaches zero.

Visible matter in our universe accounts for only about one percent of critical density. "Dark matter" accounts for another twenty to twenty five percent of critical density. "Dark matter" consists of objects such as undetected planets, brown dwarfs, neutron stars and black holes and of "cold" matter which is neither made from protons nor neutrons like ordinary matter. Together, visible and "dark matter" account for twenty three per cent of critical density.

It is believed that "dark energy" is responsible for the accelerating expansion of the universe. Unlike gravitational force that reduces with distance, the strength of "dark energy" increases with distance. "Dark energy", which provides a negative pressure, a cosmic repulsive force, to drive the accelerated expansion of our universe, accounts for seventy three per cent of critical density.

So our universe is at critical density, flat and, therefore, does not support these models of the multiverse.

INFINITE REGRESS

If our current universe developed from a prior "big crunch" which itself followed an earlier "big bang" and this process is traced endlessly back, our own universe would not exist, because the infinitival "big bang" is never reached. There must, therefore, be a beginning and the most logical starting point is the singularity, from which the "first universe" exploded in the "first big bang" to collapse into "first big crunch" and so on until our current universe is reached.

Therefore, there is still a defined origin for the multiverse and this means that everything including the multiverse still began to exist.

INCREASING CYCLICAL ENTROPY

Since the universe is a closed system, its entropy will increase with time by the second law of thermodynamics until it suffers a "heat death" at maximum entropy in thermodynamic equilibrium. With each cycle, therefore, the entropy of the universe will increase until there will not any energy left to "big bang" into another cycle.

In order to avoid the "heat death" of eternal cyclic model, it is postulated that the universe expands with each cycle. However then, by the Borde-Guth-Vilenkin incompleteness theorem, this means that the eternal cyclic universe cannot be past-eternal.

Like the eternal inflationary model, the eternal cyclic model may be eternal in the future, but it cannot be eternal in the past.

Therefore, any eternal cyclic multiverse must have begun to exist.

The assumption of an eternal cyclic multiverse only pushes back the beginning of our universe.

Our universe, therefore, must have begun to exist.

EMERGENT COSMIC EGG MODEL

In this model, the universe originated from a "cosmic egg" that existed forever until it breaks open to produce an expanding universe.

Since the "cosmic egg" is initially static and not expanding, the Borde-Guth-Vilenkin incompleteness theorem is not violated.

However, Mithani and Vilenkin prove that the emergent cosmic egg model collapses quantum mechanically and cannot, therefore, be past-eternal.[2]

OCKHAM'S RAZOR REDUNDANCY

Ockham's Razor is a philosophical principle that "plurality should not be posited without necessity." Therefore, it gives precedence to the simpler more comprehensive explanation in order "entities are not to be multiplied beyond necessity."

By Ockham's Razor, the simplest most comprehensive explanation remains the one universe model because the cause of the "first" universe would remain whatever the number of the universes, but the idea of more than one universe raises more questions, as we have seen above. Multiple universes are examples of "entities…multiplied beyond necessity."

It is not necessary to explain the origins of our universe by postulating the existence of a multiverse. Therefore, the accelerating inflationary big bang model remains the best explanation for the origin of our universe.

THE UNIVERSE HAS AN EXTERNAL CAUSE

Since it is true:

- that everything that begins to exist has an external cause
- that the universe began to exist

it is true that the universe has an external cause.

Let's call this external cause, God.

[2] *Did the universe have a beginning?* Cornell University Library, http://arxiv.org/pdf/1204.4658v1.pdf, 20 April 2012

In the Muslim divine revelation, the Qur'an, God asks,

أَمْ خُلِقُوا۟ مِنْ غَيْرِ شَىْءٍ أَمْ هُمُ ٱلْخَٰلِقُونَ ﴿٣٥﴾ أَمْ خَلَقُوا۟ ٱلسَّمَٰوَٰتِ وَٱلْأَرْضَ ۚ بَل لَّا يُوقِنُونَ ﴿٣٦﴾

Were they created by nothing? Or were they themselves the creators?

Or did they create the heavens and the earth? Nay but they have no firm belief.[3]

The implicit assumption in God's question is that the universe began to exist, and this has now been proven.

It has also been proven that the universe was neither created by "nothing", nor did it create itself.

Therefore, the only answer to God's question is that the universe had an external cause, which we will call God.

DIVINE ATTRIBUTES DERIVED FROM THE COSMOLOGICAL CAUSAL ARGUMENT

We have reasoned so far that God caused the universe to exist, because He is the uncaused cause of the "big bang":

- from which time began to exist, and therefore God cannot be temporal and must be eternal
- from which energy and matter began to exist, and therefore God cannot be material and must be immaterial
- from which space began to exist, and, therefore, God cannot be spatial and must be transcendent

FIRST-ORDER DIVINE ATTRIBUTES

I shall call these attributes of the first-order, because they are rationally derived first, namely that God is:

- the uncaused cause or creator
- eternal
- immaterial
- transcendent

[3] Surah At-Tur Chapter 52 Verses 35-36

SECOND-ORDER DIVINE ATTRIBUTES

From these first-order divine attributes, we can further deduce second-order divine attributes:

- that He cannot depend on material causes, because, as the uncaused cause of the material universe, He existed before material creation
- that He must be unimaginably powerful to create the universe, because the "big bang" happened without a material cause and the power required to create the universe cannot therefore be imagined by material creatures, like you and I
- that He cannot be immanent or exist in the material universe, because, as the uncaused sole cause of the material universe, He is immaterial, and to be immanent would require Him to be material
- that He must know everything, for example, what will happen before it happens, because He created and transcends time, and, for example, the laws of energy, matter and space, because He created and transcends all of them
- that He must be personal with a will

GOD IS PERSONAL

God is personal for the following reasons:

A PERSONAL EXPLANATION IS THE ONLY CAUSAL EXPLANATION

There cannot be a scientific explanation for the creation of the universe out of nothing, because a scientific explanation requires the presence of something: of constants and initial conditions on which scientific laws can act.

Since the universe was created out of nothing, there are no constants and initial conditions on which scientific laws can act and therefore there is no scientific explanation for the creation of the universe out of nothing.

Therefore, the only explanation for the creation of the universe is a personal one.

ONLY AN INDEPENDENT PERSON CAN PRODUCE A FINITE EFFECT

An eternal cause should produce an eternal effect, and yet the universe was created 13-14 billion years ago, a finite time ago. Since the Cause of the universe created time, it is eternal.

Yet, the only way this finite effect of creation could be produced would be if the Cause either began to exist or changed its state before the creation of the universe.

If the Cause began to exist, it would not be eternal. It would not be the First Uncaused Cause and therefore could not be the creator of the universe.

A Cause can change its state by itself or change its state due to an external Cause. A Cause which changes its state due to an external Cause cannot be the First Uncaused Cause. Therefore, the First Uncaused Cause can only be one that can change its own state.

The only thing that can change its own state is a person with an independent will.

Therefore, the only explanation for the creation of the universe 13-14 billion years ago is an immaterial, eternal and transcendent person with a Will which is independent of all causes, material and immaterial. This person chose to create the universe 13-14 billion years ago.