Science, the Bible, and Creation 103:
Addendum: Shape of the Universe, Cosmic Event Horizon

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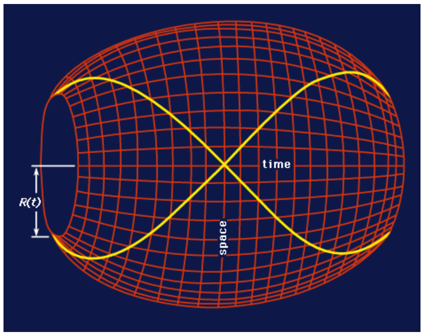
Addendum: The Shape of the Universe

In our discussion of cosmology, we based our illustrations on the analogy of a "spherical" universe along the lines of Einstein's 1917 curved model of the universe. As stated during the main study, Einstein's 1917 concept was similar to graph paper rolled into a cylinder. This model was modified by Friedmann who conceived of the shape of the universe as analogous to the surface of a "barrel lying on its side."

"**Cosmology -** The principle of equivalence in general relativity allows the locally flat space-time structure of special relativity to be warped by gravitation, so that (in the cosmological case) the propagation of the photon over thousands of millions of light-years can no longer be plotted on a globally flat sheet of paper. To be sure, **the curvature of the paper** may not be apparent when only a small piece is examined, thereby giving the local impression that space-time is flat (i.e., satisfies special relativity). It is o**nly when the graph paper is examined globally that one realizes it is curved** (i.e., satisfies general relativity). **In Einstein's 1917 model of the universe, the curvature occurs only in space,** with **the graph paper being rolled up into a cylinder on its side**…" – Britannica.com

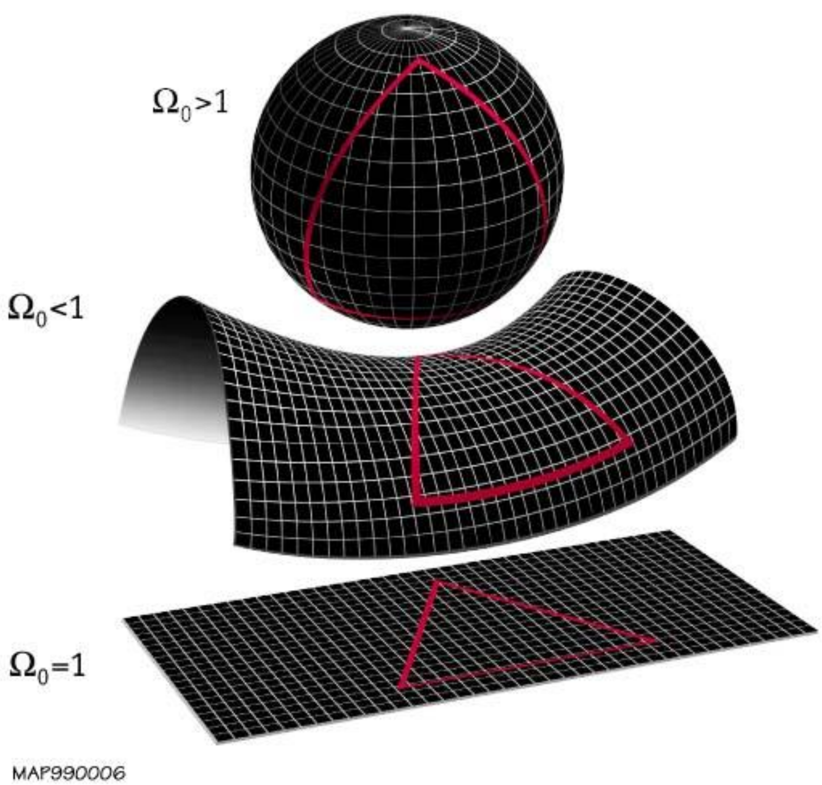
"**Cosmos, Relativistic cosmologies, Friedmann-Lemaître models – The geometry of space in Friedmann's closed models is similar to that of Einstein's original model; however, there is a curvature to time as well as one to space…The global space-time diagram** for the middle half of the expansion-compression phases **can be depicted as a barrel lying on its side.**" – Encyclopaedia Britannica 2004 Deluxe Edition

This "barrel on its side" concept of the universe is depicted in the following illustration from Britannica Encyclopedia and the subsequent caption below.



"**Cosmos, Relativistic cosmologies, Friedmann-Lemaître models** – **Curved space-time in a matter-dominated, closed universe** during the middle half of its expansion-compression phases. At each instant of time t, **the space axis forms a closed loop with radius R(t), the so-called radius of the universe, in an unobservable fourth dimension.** – From F.H. Shu, The Physical Universe (1982); University Science Books." – Encyclopaedia Britannica 2004 Deluxe Edition

But what if the universe has a different shape? Would this impact the role of the underlying assumptions? Let's start with the basics. Generally speaking there are 3 possible scenarios regarding the shape of space and they all deal with the extent to which space is curved.



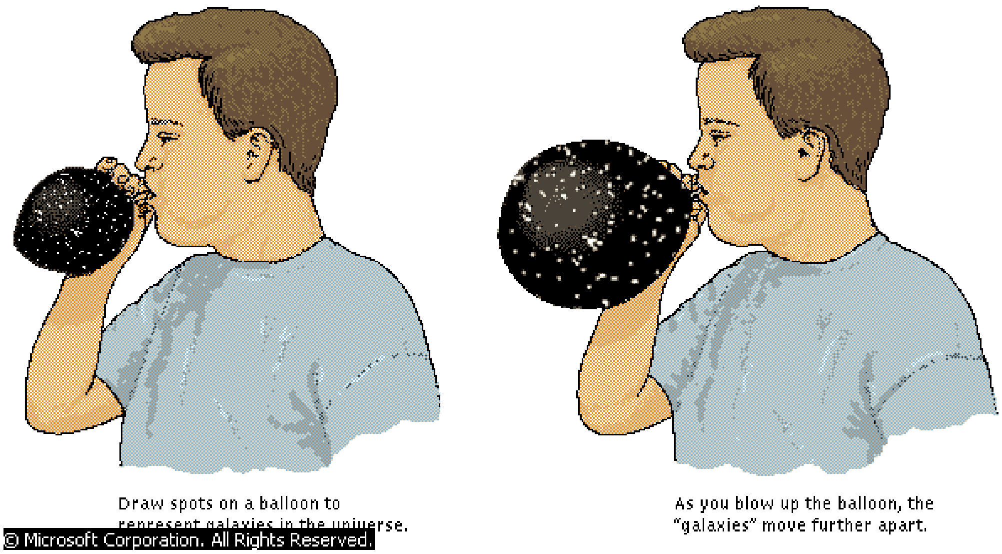
“**Caption:** The local geometry of the universe is determined by whether the density parameter Ω is greater than, less than, or equal to 1. From top to bottom: **a spherical universe** with Ω > 1, a **hyperbolic universe** with Ω < 1, and **a flat universe** with Ω = 1. Note that these depictions of two-dimensional surfaces are merely easily visualizable analogs to the 3-dimensional structure of (local) space.” – http://en.wikipedia.org/wiki/Shape_of_the_universe

“**Shape of the universe – Under the assumption that the universe is homogeneous and isotropic**, the **curvature of the observable universe, or the local geometry, is described by one of the three "primitive" geometries** (in mathematics these are called the model geometries):

- 3-dimensional **Flat Euclidean geometry, generally notated** as E^3
- 3-dimensional **spherical geometry with a small curvature**, often notated as S^3
- 3-dimensional **hyperbolic geometry with a small curvature**.” – wikipedia.org

"**What is the shape of the universe? - There are three general possibilities. First**, like your balloon, the universe might have what we call **positive curvature, like a sphere. In this case, which we call a "closed" universe, the universe would be finite in size but without a boundary, just like the balloon.** In a closed universe, you could, in principle, fly a spaceship far enough in one direction and get back to where you started from…**The second possibility is that the universe is flat.** This kind of universe you can imagine by **cutting out a piece of your balloon material and stretching it with your hands.** T**he surface of the material is flat, not curved, but you can expand** and contract it by tugging on either end. **Flat universes are infinite in spatial extent, and have no boundaries.** Parallel lines are always parallel and triangles always have 180 degrees. Flat universes expand forever, but the expansion rate approaches zero. **Finally, the universe might** be "open," or **have negative curvature.** Such universes are **sort of saddle-shaped.** They are also **infinite and unbounded.** Parallel lines eventually diverge, and triangles have less than 180 degrees. Open universes expand forever, with the expansion rate never approaching zero." - January 1999, Dave Kornreich, http://curious.astro.cornell.edu/question.php?number=62

As we can see, the universe can have a positive curve similar to a sphere, a negative (or hyperbolic) curve, or no curve. A few other points are worth noting from the last quote above. First, notice that a flat universe and the negatively curved universe are infinite and unbounded whereas a spherical universe is finite but also without a boundary. Second, it is also noteworthy that the second to last quote above affirms that homogeneity and isotropy are assumptions that are factored into the model of the universe. And third, notice that a spherical shaped universe is compared to an expanding surface of a balloon. This is essentially the model we employed during our main study in which we noted that the expanding spherical surface of a balloon has a finite area but no boundaries or edges.



"Expanding Universe Experiment – One way to understand the concept of an expanding universe is to draw dots, representing galaxies, on a balloon. As the balloon is inflated, each dot moves away from all the others. To a person viewing the universe from a galaxy, all other galaxies would seem to be receding. The distant galaxies appear to be moving away faster than the near ones, **which demonstrates Hubble's law.** Some astronomers believe that this expansion will continue forever, whereas others think that at a certain point the universe will begin contracting. " – Encarta, Microsoft Corporation. All Rights Reserved.

Up until recently, modern consensus seemed to favor the idea of a flat universe.

"**Universe may be curved, not flat** – Now, **two cosmologists show that the data are consistent with a Universe that is curved slightly, similarly to a saddle.** If their model is correct, **it would overturn the long-held belief that the cosmos is flat."** – Ron Cowen,
20 September 2013, http://www.nature.com/news/universe-may-be-curved-not-flat-1.13776;

As can be seen from the quote above, new data suggests that the universe may not be flat but could instead have a negative curvature, roughly depicted as "saddle shaped." However, it is also admitted the new data fits other shapes as well, including a dodecahedron shape (akin to a soccer ball) or a horn shape.

"**Shape of the universe –** Although **the shape of the universe is still a matter of debate** in physical cosmology, based on the recent Wilkinson Microwave Anisotropy Probe (WMAP) measurements '**We now know that the universe is**

flat with only a 0.4% margin of error', according to NASA scientists…According to cosmologists, on this model **the observational data best fit with the conclusion that the shape of the universe is infinite and flat, [2] but the data are also consistent with other possible shapes, such as the so-called Poincaré dodecahedral space[3][4]and the Picard horn.[5]…** Based on analyses of the WMAP data, cosmologists during 2004–2006 focused on the Poincaré dodecahedral space (PDS), but horn topologies (which are hyperbolic) were also deemed compatible with the data." – wikipedia.org

The "Poincare dodecahedral" is actually a version of the positively curved universe, somewhat similar to a sphere. Similarly, "horn-shaped" universes are a version of hyperbolic geometry, in other words, a negatively curved universe.

"Shape of the universe – A positively curved universe is described by spherical geometry, and can be thought of as a three-dimensional hypersphere, or some other spherical 3-manifold (such as the Poincaré dodecahedral space), all of which are quotients of the 3-sphere…For **hyperbolic** local geometry, many of the possible three-dimensional spaces are **informally called horn topologies**, so called because of the shape of the pseudosphere, a canonical model of hyperbolic geometry…Various models have been proposed for the global geometry of the universe. In addition to the primitive geometries, these proposals include the:

- **Poincaré dodecahedral space, a positively curved space, colloquially described as "soccerball-shaped",** as it is **the quotient of the 3-sphere** by the binary icosahedral group, which is very close to icosahedral symmetry, the symmetry of a soccer ball. This was proposed by Jean-Pierre Luminet and colleagues in 2003[3][10] and an optimal orientation on the sky for the model was estimated in 2008.[4]
- **Picard horn, a negatively curved space,** colloquially described as "funnel-shaped", for the **horn geometry**.[5]" – wikipedia.org

Determining the shape of the universe is also difficult because of certain limitations to our perspective. In particular, the situation might be analogous to the curved surface of the earth. When humans look around us, even when we look to the horizon (the farthest distance we can see), the earth appears to be flat. Of course, we know that it isn't flat. It is a sphere. But the curvature of that sphere is on a scale that exceeds the ability of the human eye to detect it by direct observation. Conversely, on the scale that the human eye can observe, the curve is so slight that it appears essentially flat. It turns out that the same might be true for the universe. Even if the universe is nearly flat as far as we can observe, when viewed as a whole even a slight curvature could be significant.

"Shape of the universe – Even if the universe is not exactly spatially flat, the spatial curvature is close enough to zero to place the radius at approximately the horizon of the observable universe or beyond." – wikipedia.org

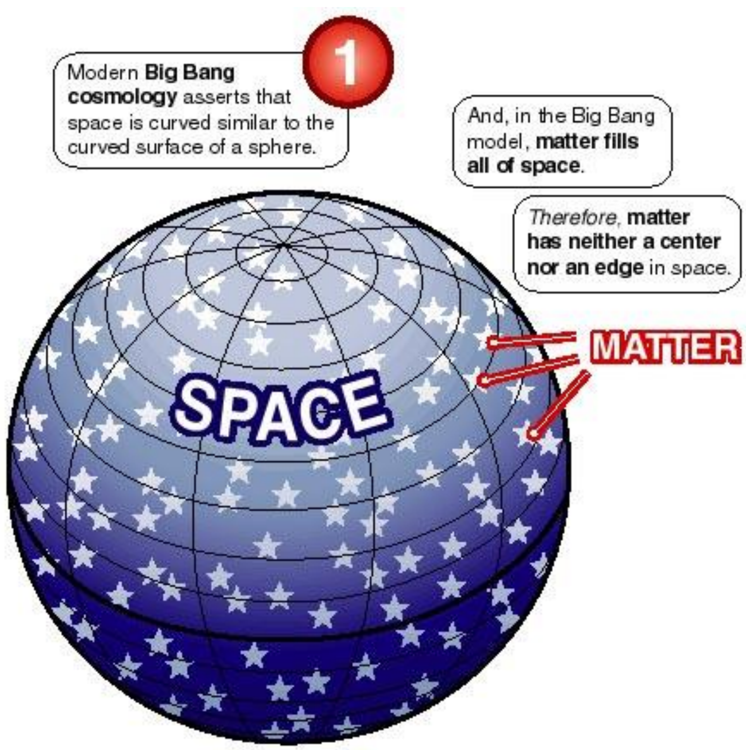
"Shape of the universe – Current results and analysis do not rule out a bounded global geometry (i.e. a closed universe), but they do **confirm that the spatial curvature is small, just as the spatial curvature of the surface of the Earth is small compared to a horizon of a thousand kilometers or so.**" – wikipedia.org

Currently, the issue of the shape of the universe is considered unresolved.

"**Shape of the universe - Although the shape of the universe is still a matter of debate in physical cosmology…**" - wikipedia.org

"**What is the shape of the universe? Most astronomers would like to know the shape of the universe too!**...What determines the shape of the universe is its density (and the Cosmological Constant, a sort of anti-gravity force allowed by General Relativity). It is difficult to figure out what the density of the universe actually is, but it seems that the universe is probably flat." - January 1999, Dave Kornreich, http://curious.astro.cornell.edu/question.php?number=62

Now that we understand the basics regarding the possible shape of the universe, we can return to our central concern, which is the impact that shape has on underlying assumptions that relate to age. In our initial discussions, we utilized the sphere-shaped model when discussing these underlying assumptions, as can be seen in the illustration below.



Since there are other options regarding the shape of the universe, we should consider them as well. In our study, we also saw that even in 1932, when Einstein developed a model of the universe with zero curvature, he retained the assumptions of homogeneity and isotropy.

"**Cosmos, Relativistic cosmologies, The Einstein–de Sitter universe – In 1932 Einstein and de Sitter** proposed that the cosmological constant should be set equal to zero, and they **derived a homogeneous and isotropic model** that provides the separating case between the closed and open Friedmann models; i.e., **Einstein and de Sitter assumed that the spatial curvature of the unive**rse is neither positive nor negative but rather zero. **The spatial geometry of the Einstein–de Sitter universe is Euclidean (infinite total volume), but space-time is not globally flat** (i.e., not exactly the space-time of special relativity). **Time again commences with a big bang and the galaxies recede forever, but the recession rate (Hubble's "constant")** asymptotically coasts to zero as time advances to infinity." – Encyclopaedia Britannica 2004 Deluxe Edition

Most importantly, as we have already seen these two assumptions (homogeneity and isotropy) still underlie the 3 possible shapes for the universe today.

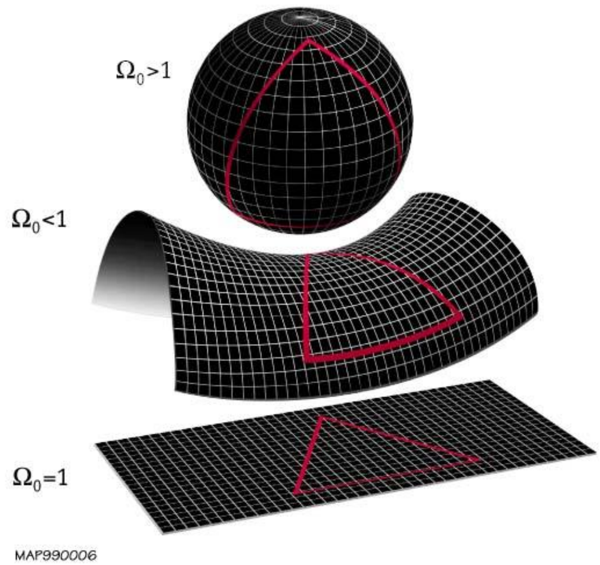
"**Shape of the universe – Under the assumption that the universe is homogeneous and isotropic**, the **curvature of the observable universe, or the local geometry, is described by one of the three "primitive" geometries** (in mathematics these are called the model geometries):

- 3-dimensional **Flat Euclidean geometry, generally notated** as E^3
- 3-dimensional **spherical geometry with a small curvature**, often notated as S^3
- 3-dimensional **hyperbolic geometry with a small curvature**." – wikipedia.org

It is also important to note the direct relationship between the issues of being finite and unbounded or edgeless. While all 3 general shapes are conceived of as "boundless" or "edgeless," only the positively curved universe is edgeless while finite in volume as can be seen in the quote below. The flat universe and the negatively curved universe are also conceived of as edgeless but they are infinite in volume.

"**What is the shape of the universe? - There are three general possibilities. First**, like your balloon, the universe might have what we call **positive curvature, like a sphere. In this case, which we call a "closed" universe, the universe would be finite in size but without a boundary, just like the balloon.** In a closed universe, you could, in principle, fly a spaceship far enough in one direction and get back to where you started from…**The second possibility is that the universe is flat.** This kind of universe you can imagine by **cutting out a piece of your balloon material and stretching it with your hands.** T**he surface of the material is flat, not curved, but you can expand** and contract it by tugging on either end. **Flat universes are infinite in spatial extent, and have no boundaries.** Parallel lines are always parallel and triangles always have 180 degrees. Flat universes expand forever, but the expansion rate approaches zero. **Finally, the universe might** be "open," or **have negative curvature.** Such universes are **sort of saddle-shaped.** They are also **infinite and unbounded.** Parallel lines eventually diverge, and triangles have less than 180 degrees. Open universes expand forever, with the expansion rate never approaching zero." - January 1999, Dave Kornreich, http://curious.astro.cornell.edu/question.php?number=62

We can see the reasons for these correlations if we look once again at the illustration of the 3 general possible shapes.



Out of these 3, it is clear that both the flat and the negatively curved shapes have edges. This is most apparent in the flat universe at the bottom but also occurs in the negatively curved space in the middle. By contrast, the sphere has no edges. You never arrive at a point where you can't go any further. Yet, the surface area is finite. A balloon can expand or contract, but at any given moment, its surface area can be measured in finite terms. But, in the illustration all 3 shapes actually have finite surface areas. Neither the negatively curved shape nor the flat shape is infinite in surface area. This is due to the limitations of the illustration, but it allows us to see the relationship between edges and infinite volume (or in this case area). The only way to remove the edges from the negatively curved shape or the flat shape is to extend their surface area infinitely in all directions.

Incidentally, Einstein's 1917 model fits with the finite, boundless, curved model.

"**Cosmology** – …**in 1917 Einstein presented a mathematical model of the universe in which the total volume of space was finite yet had no boundary or edge**." – Britannica.com

In our main study, we discussed a problem of mass and gravity throughout the universe as described by Sir Isaac Newton.

"**Cosmos, Large-scale structure and expansion of the universe, Gravitational theories of clustering** – The fact that **gravitation affects all masses** may explain why the astronomical universe, although not uniform, contains structure. **This natural idea, which is the basis of much of the modern theoretical work on the problem, had already occurred to Newton in 1692. Newton wrote** to the noted English scholar and clergyman Richard Bentley: 'It seems to me, that if the matter of our Sun & Planets & **all ye matter in the Universe was eavenly scattered throughout all the heavens, & every particle had an innate gravity towards all the rest & the whole space throughout wch [sic] this matter was scattered was but finite: the matter on ye outside of this space would by its gravity tend towards all ye matter on the inside & by consequence fall down to ye middle of the whole space & there compose one great spherical mass. But if the matter was eavenly diffused through an infinite space, it would never convene into one mass** but some of it convene into one mass & some into another so as to make an infinite number of **great masses scattered at great distances from one to another** throughout all yt infinite space. **And thus might ye Sun and Fixt stars be formed supposing the matter were of a lucid nature.**'" – Encyclopaedia Britannica 2004 Deluxe Edition

As Newton explains, if "all the rest & the whole space" in which "matter was scattered" is "finite" then there would be a massive gravitational pull at the middle of the finite space. Notice also that Newton's concern, as expressed in the last lines of the quote, is that a universal central gravitational pull would have prevented the stars from spreading out and forming in the first place. But, "if the matter was eavenly diffused through an infinite space, it would never convene into one mass." In short, an infinite distribution of matter and mass removes the central gravitational pull that would otherwise result if matter was distributed in a finite volume. There are only two ways to avoid this. The first is to distribute matter infinitely, which is to say without an edge or boundary where the distribution of matter stops. The second is to remove the edge of the distribution of matter by placing on a curved surface like a sphere.

Currently, there is no definitive conclusion on whether the universe is finite or infinite, as we can see from the quotes below.

"ESA: Is the Universe finite or infinite?
Joseph Silk: We don't know. The expanding Universe theory says that the Universe could expand forever [that corresponds to a 'flat' Universe]. And that is probably the model of the Universe that we feel closest to now. But **it could also**

be finite, because it could be that the Universe has a very large volume now, but finite, and that that volume will increase, so only in the infinite future will it actually be infinite.

…

ESA: Planck will measure the Cosmic Microwave Background (CMB), which carries information on the geometry of the Universe. **Will we be able to find out if the Universe is finite or not?**

Joseph Silk: Even if with our Cosmic Microwave Background data we can prove that the Universe is flat, we still won't know whether it's finite or infinite.

ESA: Then **how are we going to know whether the Universe is infinite?**

Joseph Silk: With great difficulty! We may never know it."

- European Space Agency; *Is the Universe Finite or Infinite? An Interview with Joseph Silk;* Interview 2, May 2001; http://www.esa.int/Our_Activities/Space_Science/People/Is_the_Universe_finite_or_infinite_An_interview_with_Joseph_Silk

Does the Universe have an edge, beyond which there is nothing? – Galaxies extend as far as we can detect... with no sign of diminishing. **There is no evidence that the universe has an edge.** The part of the universe we can observe from Earth is filled more or less uniformly with galaxies extending in every direction as far as we can see - more than 10 billion light-years, or about 6 billion trillion miles. **We know that the galaxies must extend much further than we can see, but we do not know whether the universe is infinite or not.** When astronomers sometimes refer (carelessly!) to galaxies "near the edge of the universe," they are referring only to the edge of the OBSERVABLE universe - i.e., the part we can see….Then where did the idea that the universe was once a point come from? **For much of the twentieth century, astronomers and physicists believed that space** might NOT be infinitely large - that is, space **might actually curve around on itself to form a "closed universe."** This unusual three-dimensional shape was discovered in the mid-1800's by the great mathematician Bernhard Riemann. **The shape was later favored by Einstein as a possible shape for the universe. Such a closed universe would have a finite volume, yet no boundaries or edges…Current evidence shows that our part of the universe appears not to be curved. This tells us that either the universe is infinitely large, or else is so large that we cannot detect its curvature from the tiny portion we can observe -- just as we could not tell that the Earth was curved if our measurements were confined to a sandbox!** – Brief Answers to Cosmic Questions; http://www.cfa.harvard.edu/seuforum/faq.htm

"WMAP has confirmed this result with very high accuracy and precision. We now know (as of 2013) that the universe is flat with only a 0.4% margin of error. This suggests that the Universe is infinite in extent; however, **since the Universe has a finite age, we can only observe a finite volume of the Universe.** All we can truly conclude is that the Universe is much larger than the volume we can directly observe." – NASA, *Will the Universe expand forever?* http://map.gsfc.nasa.gov/universe/uni_shape.html

Since modern science has not "proven" and may never prove that the universe is infinite, as we can see from the quotes above, we might still make a few comments on the implications of such a notion. In some sense, the finite spherical model is more advantageous philosophically because it does not require the existence of an infinite amount of space or infinite matter. The proposition of infinite functions well as a mathematical concept, but as a real description of the physical world it raises certain problems.

First, infinite space and matter requires exceeding what we can observe to the largest possible degree. For any cosmology that is based on empiricism and observation, assuming the existence of an infinite amount of unobservable physical evidence should be a last resort. Here we want to emphasize "last resort." Our point here is not that infinity must be avoided at all costs, but rather that options which require assuming as little as possible should be considered first and thoroughly ruled out before adopting such a pragmatically challenging notion as infinite unobservable matter.

Second, consider the practical difficulty that an infinite universe poses regarding the basic observation of expansion. If the universe is currently infinite in volume, it cannot increase in volume. In other words, a universe that already has infinite volume cannot expand. Yet expansion has been observed.

Third, consider the implications for the age of the universe. The Big Bang theory teaches that the universe began and expanded through an inflationary period and resumed the current rate of observable expansion. Since the universe had a beginning, it could not have started off as infinite in volume. It would have to go from finite to infinite. But this is not possible in a real world setting. No matter how high you count or how many widgets you acquire, you will never go from a finite number to an infinite amount. And not only is it physically problematic to go from a finite amount of anything, whether volume or widgets, to an infinite amount of it, but there would never be enough time to reach infinity either. Even inflationary expansion, as fast as it is, still occurs at a calculable, finite rate. The current expansion rate, which theoretically has been occurring since fractions of a second after the initial big bang, is even slower. How could the universe go from a finite volume to an infinite volume at a finite rate of expansion? This, too, seems pragmatically undesirable. Moreover, it suggests that even with a 14-20 billion year-old universe, there still has not been enough time for an infinite universe to come into existence at any finite rates of expansion. Simply put, there isn't enough time for an infinite universe to develop from any beginning. It is perhaps possible to avoid the difficulties of an achieved infinitude (especially in a finite amount of time) by supposing that the universe was instantly infinite as soon as the Big Bang occurred. However, the suggestion of an instantly infinite universe is certainly not natural, empirical, or necessary. And it would still suffer from difficulties relating to infinite quantities of real items (such as matter and volume) as we continue to discuss in our next point. In addition, an instantly infinite universe would seem contradictory to assertions that the universe was different at various stages of the Big Bang. For instance, the quote below describes how during the inflationary period, the universe grew 1050 "times its previous size" and, of course, it has continued to expand at a non-inflationary expansion rate since, meaning it is even larger now. But, once again, it would be nonsense to describe the universe as instantly infinite and yet being a smaller infinite volume and a larger infinite volume. Such distinctions are meaningless and absurd.

"**Cosmology, III MODERN COSMOLOGY, E Inflationary Theory** – The **inflationary theory deals with the behavior of the universe for only a tiny fraction of a second at the beginning of the universe…The inflationary theory states that, starting only about 1 x [10 raised to a power of -35] second after the big bang and lasting for only about 1 x [10 raised to a power of -32] second, the universe expanded to 1 x [10 to a power of 50] times its previous size. The numbers 1 x [10 raised to a power of -35] and 1 x [10 raised to a power of -32] are very small-a decimal point followed by 34 zeros and then a 1, and a decimal point followed by 31 zeros and then a 1, respectively. The number 1 x [10 to a power of 50] is incredibly large-a 1 followed by 50 zeros.**" – "Cosmology," Microsoft® Encarta® Encyclopedia 99. © 1993-1998 Microsoft Corporation. All rights reserved.

Fourth, consider the implications of infinite amounts of matter distributed throughout infinite space. This also results in practical absurdities. For instance, modern evolutionary cosmology asserts that the universe is comprised of 4% ordinary matter and ordinary energy and approximately 96% dark matter and dark energy, as we have seen in our main study. But if there is an infinite amount of matter, then these percentages are meaningless. If both ordinary matter and dark matter are infinite, how can one of them be in a lesser amount than the other? They both exist in infinite quantities!

The following quote from Wikipedia.org summarizes both the problems with applying the concept of infinity to real objects and quantities as well as the fact that even a flat universe could still be finite.

"**Infinity – Infinity (symbol: ∞) is an abstract concept describing something without any limit** and is relevant in a number of fields, predominantly mathematics and physics. The English word infinity derives from Latin infinitas, meaning "the state of being without finish", and which can be translated as "unboundedness", itself calqued from the Greek word apeiros, meaning "endless".[1] **In mathematics, "infinity" is often treated as if it were a number (i.e., it counts or measures things: "an infinite number of terms") but it is not the same sort of number as the real numbers.** In number systems incorporating infinitesimals, the reciprocal of an infinitesimal is an infinite number, i.e., a number greater than any real number… **Mathematics – As in real analysis, in complex analysis** the symbol ∞, called **"infinity", denotes an unsigned infinite limit.** $x \to \infty$ means that the magnitude $|x|$ of x grows **beyond any assigned value. Physics -** In physics, approximations of real numbers are used for continuous measurements and natural numbers are used for discrete measurements (i.e. counting). **It is therefore assumed by physicists that no measurable quantity could have an infinite value,** for instance by taking an infinite value in an extended real number system, or by requiring the counting of an infinite number of events. **It is for example presumed impossible for any body to have infinite mass or infinite energy. Cosmology – Cosmologists have long sought to discover whether infinity exists in our physical universe: Are there an infinite number of stars? Does the universe have infinite volume? Does space "go on forever"? This is an open question of cosmology. Note that the question of being infinite is logically separate from the question of having boundaries. The two-dimensional surface of the Earth, for example, is finite, yet has no edge.** By travelling in a straight line one will eventually return to the exact spot one started from. **The universe, at least in principle, might have a similar topology.** If so, one might eventually return to one's starting point after travelling in a straight line through the universe for long enough. **If, on the other hand, the universe were not curved like a sphere but had a flat topology, it could be both unbounded and infinite.** The curvature of the universe can be measured through multipole moments in the spectrum of the cosmic background radiation. **As to date, analysis of the radiation patterns recorded by the WMAP spacecraft hints that the universe has a flat topology. This would be consistent with an infinite physical universe. However, the universe could also be finite, even if its curvature is flat.” –** wikipedia.org

For all these reasons, a curved, finite universe is more practical as a model of a real, physical universe. Nevertheless, the same dynamic exists concerning the underlying assumptions even in a universe of infinite volume. When it comes to the distribution of matter, we have to assume that significant gravitational objects such as planets, stars, galaxies and superclusters of galaxies, etc. are distributed infinitely throughout all of space. But this is just an assumption. It is not an observation. It could well be the case that significant gravitational objects such stars, planets, comets, galaxies and superclusters of galaxies, etc. exist beyond our view and yet are exist only in a limited area of the universe. If so, even if the universe itself was infinite, there would be an edge to the distribution matter and a central gravitational pull, just as described by Newton.

Beyond this, the question arises concerning why a central, cumulative gravitational pull is being avoided in modern cosmology. Why prefer a pragmatically difficult concept like infinite amounts of volume or matter instead of a collective pull at the gravitational center of the universe? It is clear why Newton desired to avoid this. In Newton’s day, there was no accepted mechanism countering gravity and sustaining the universe against collapse by means of such a central, gravitational pull. But this is not the case today. Modern cosmologies have relied upon the existence of "dark energy" to explain the expansion of the universe.

We discuss dark matter and energy in depth in our main study. But for our current discussion, the most critical characteristic proposed for dark energy is that it provides a counterforce to gravitational pull. As can be seen in the quotes below, even in modern cosmological models it is dark matter, not Newton's infinite distribution of matter, which prevents the collapse of the universe.

"**Dark energy** – **repulsive force** that is the **dominant component (73 percent) of the universe.** The remaining portion of the universe consists of ordinary matter and dark matter. Dark energy, in contrast to both forms of matter, is relatively uniform in time and space and **is gravitationally repulsive, not attractive, within the volume it occupies. The nature of dark energy is still not well understood. A kind of cosmic repulsive force was first hypothesized by Albert Einstein in 1917 and was represented by a term, the "cosmological constant,"** that Einstein reluctantly **introduced into his theory of general relativity in order to counteract the attractive force of gravity and account for a universe that was assumed to be static (neither expanding nor contracting)**. - britannica.com

"**Universe, Changing views of the universe** – Studies of nearby stars, distant galaxies, and the CMB radiation give scientists an idea of the types of matter and energy that make up the universe. These studies suggest that **the universe consists of about 4 percent ordinary matter and radiation.** The matter consists mainly of hydrogen and helium. The radiation includes light, radio, and other waves as well as cosmic rays. The rest of the universe is made up of matter and energy that scientists cannot directly observe. About 23 percent of the universe is dark matter, matter that does not emit, reflect, or absorb observable light or other radiation. **The remaining 73 percent of the universe is composed of dark energy. Dark energy is a little-understood form of energy that is apparently making the universe expand more and more quickly.**" – Worldbook, Contributor: Kenneth Brecher, Ph.D., Professor of Astronomy and Physics, Boston University.

Most importantly, notice that the quote above from Britannica.com explains that dark matter was proposed specifically "in order to counteract the attractive force of gravity and account for a universe" that is not currently contracting on itself. We should also consider that both ordinary matter and energy and dark matter are thought to potentially exert gravitational pull, as indicated by the quote below.

"**Cosmology, The future of the universe – The universe is presently expanding, but its distant future depends on its present density. Suppose all the matter detected to date is all that exists.** There would be an average of about one atom of hydrogen in 1 cubic yard (0.76 cubic meter) of space. **The universe would be open. It would continue to expand without limit.**

Eventually, all stars would exhaust the energy that makes them shine. **But suppose the universe contains large amounts of dark matter, material that has not yet been detected.** If the average density of matter in space were as much as 10 atoms of hydrogen per cubic yard, **the universe would be closed. In perhaps 20 billion to 40 billion years, the expansion would stop. The galaxies would then start to come together again,** and matter would approach infinite density." – Worldbook, Contributor: Kenneth Brecher, Ph.D., Professor of Astronomy and Physics, Boston University.

Since ordinary matter and energy are said to account for 4% of the universe and dark matter is said to comprise 23% of the universe, this means that the universe is comprised of three times as much material (dark energy) exerting a repulsive force compared to the amount that exerts gravitational pull. With dark energy comprising 73% of the universe, this means that roughly three-quarters of the universe is acting to countermand gravity and prevent contraction. Consequently, Newton's concern that a finite distribution of matter would result in a central gravitational pull that would have prevented expansion and caused all matter to collect in a "great spherical mass" in the "middle" of space is no longer particularly relevant in modern cosmology which posits the existence of dark energy. In short, there is no reason to avoid a finite distribution of matter or the resulting cumulative, central gravitational pull.

Ultimately, a massive, universal "center of gravity" created by a finite distribution of all matter remains a reasonable, scientific possibility regardless of whether the universe is finite or infinite in volume and regardless of whether its shape is spherical, saddle-shaped, or flat.

Consequently, our initial illustrations regarding the effects of a "center of gravity" in a positively curved universe could easily be adapted to a flat or negatively curved universe with the same implications if you change the underlying assumptions. For example, 2 alternate versions applied to a flat universe of infinite volume instead of a positively curved universe of finite volume. (**Please note:** The edges of each figure have been blurred to represent that space continues infinitely rather than having a hard edge or stopping point.

Figure: "Flat Universe 1" – Depicting an infinite universe with matter distributed throughout all of the infinite volume of space.

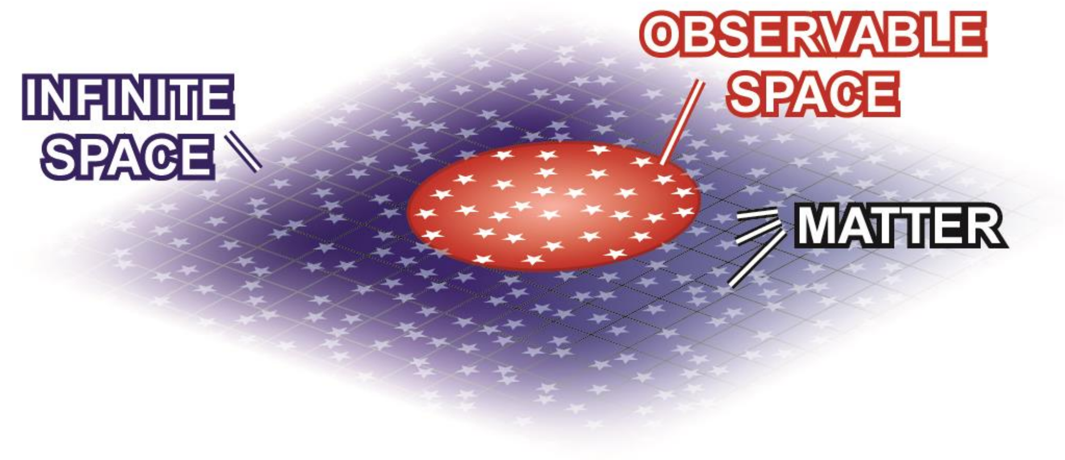
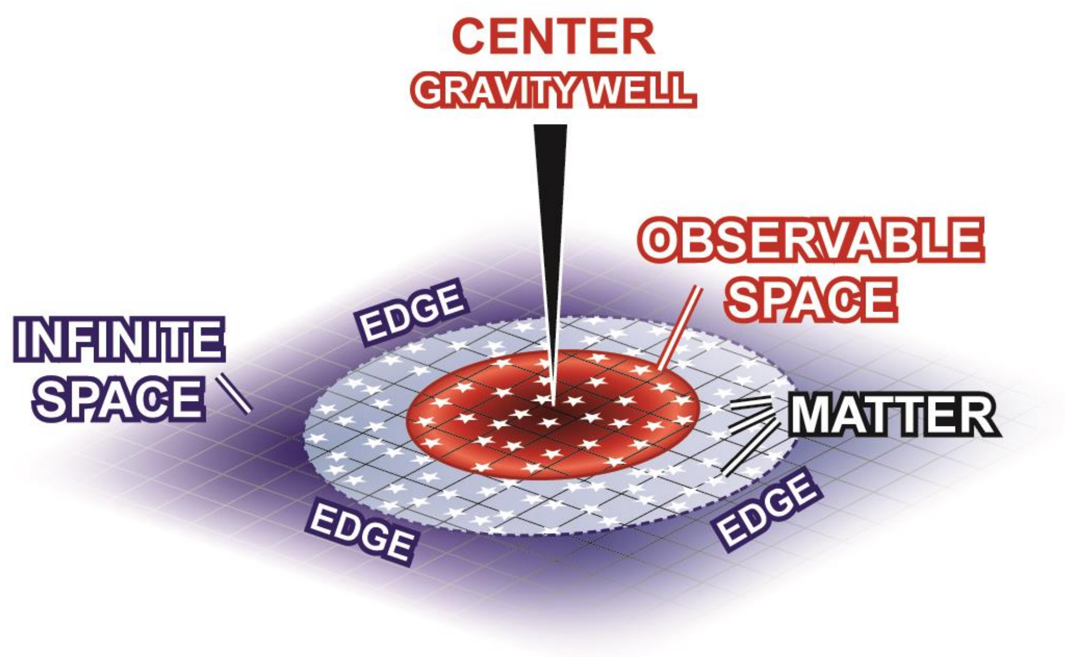


Figure: "Flat Universe 2" – Depicting an infinite universe with a finite distribution of matter that does not fill all of the infinite volume of space.



Addendum: Cosmic Event Horizon Update

In our main study, we cite the article below from Encyclopedia Britannica, which describes what it calls the "cosmic event horizon." This cosmic event horizon is essentially the limit of far we can see of the universe from earth. And this limit is created by the fact that, light travels at a specific speed and in a universe that has a finite age (i.e. a beginning), there is only enough time for light to travel a certain distance. As the quote indicates, this factor is useful for explaining why the night sky is not completely illuminated by starlight. Essentially, the sky is dark because most stars in the universe are too far away for their light to reach the earth within the theoretical age of the universe.

"**Cosmos, Cosmological models, Early cosmological ideas – In 1610 Kepler provided a profound reason for believing that the number of stars in the universe had to be finite. If there were an infinity of stars, he argued, then the sky would be completely filled with them and night would not be dark!** This point was rediscussed by the astronomers Edmond Halley and Jean-Philippe-Loys de Chéseaux of Switzerland in the 18th century, but it was **not popularized as a paradox until Heinrich Wilhelm Olbers** of Germany took up the problem **in the 19th century. The difficulty became potentially very real with Hubble's measurement of the enormous extent of the universe of galaxies with its large-scale homogeneity and isotropy. His discovery of the systematic recession of the galaxies provided an escape, however**…**The modern consensus is,** however, that **a finite age for the universe is a far more important effect. Even if the universe is spatially infinite, photons from very distant galaxies simply do not have the time to travel to the Earth** because of the finite speed of light. **There is a spherical surface, the cosmic event horizon (roughly [10 raised to the power of 10 or 10,000,000,000] light-years** in radial distance from the Earth at the current epoch), **beyond which nothing can be seen even in principle; and the number (roughly [10 raised to the power of 10 or 10,000,000,000]) of galaxies within this cosmic horizon, the observable universe, are too few to make the night sky bright."** – Encyclopaedia Britannica 2004 Deluxe Edition

As we can also see, the quote above identifies the limit on how far we can see at 10 billion light years from earth. The quote below explains that it is a common misperception that we should be limited to seeing only objects that are less than 13.8 billion years from earth, which is the approximate theoretical age of the universe.

"**Observable universe** – **The observable universe consists of the galaxies and other matter that can, in principle, be observed from Earth in the present day because light** and other signals from those objects **has had time to reach the Earth since the beginning of the cosmological expansion**…The age of the universe is estimated to be 13.8 billion years. While it is commonly understood that nothing can accelerate to velocities equal to or greater than that of light, **it is**

a common misconception that the radius of the observable universe must therefore amount to only 13.8 billion light-years." – Wikipedia.org

As indicated in the quote above, there is a common misperception that we should be able to view only light from 13.8 billion light years due to the fact that the universe is estimated to be 13.8 billion years old and nothing can travel faster than the speed of light. This would seem to preclude light reaching the earth from farther away than 13.8 billion light years in 13.8 billion years of time. However, this is a misperception because, as the quote below explains, the universe expands at a rate faster than the speed of light.

"**Observable universe** – However, **due to Hubble's law regions sufficiently distant from us are expanding away from us much faster than the speed of light** (special relativity prevents nearby objects in the same local region from moving faster than the speed of light with respect to each other, but **there is no such constraint for distant objects when the space between them is expanding**." – Wikipedia.org

And this factor would allow for light to reach the earth from objects that are at present farther away from the earth than 13.8 billion light years. While the light itself cannot travel faster than light speed, it can cross greater distances because the space through which it is traveling is expanding while the light is in transit. This has the effect of elongating the wavelength of light, as discussed in our section on redshift, but it also allows the light to essentially traverse a larger distances than its own movement and speed can accomplish by themselves. By way of analogy, imagine your best running speed and how far you could get in an hour running at that speed. There is a limit. But if the road behind you is also expanding between where you are now and where you started from, there is actually a greater distance between you and your point of origin than your top speed could possibly achieve on its own in an hour. In some sense, we must factor in not only the distance light can travel on its own but also the distance that the universe expands while that light is traveling.

And the current understanding is that we observe not just 10 billion light years from the earth, but 47.7 billion light years in any direction or roughly 93 billion light years from one side to the other.

"**Observable universe** – **According to calculations**, the comoving distance (current proper distance) to particles from the CMBR, which represent **the radius of the visible universe, is about 14.0 billion parsecs (about 45.7 billion light years),** while the comoving distance to the edge of the observable universe is **about 14.3 billion parsecs (about 46.6 billion light years),[1] about 2% larger**. The best estimate of the age of the universe as of 2013 is 13.798 ± 0.037 billion years[2] but **due to the expansion of space humans are observing objects that were originally much closer but are now considerably farther away** (as defined in terms of cosmological proper distance, which is equal to the comoving distance at the present time) than a static 13.8 billion light-years distance.[3] **It is**

estimated that the diameter of the observable universe is about 28 billion parsecs (93 billion light-years),[4] **putting the edge of the observable universe at about 46–47 billion light-years away**.[5][6]" – Wikipedia.org
But despite the fact that this is a much greater distance that the 10-billion light years reported by Britannica's 2004 Deluxe Edition, the critical fact is that there is still a considerable portion of the universe that remains in principle beyond our ability to observe. The quote below provides some estimates on the age of the universe.

"**Observable universe** – **According to the theory of cosmic inflation** and its founder, Alan Guth, if it is assumed that inflation began about 10 [raised to the power of −37] seconds after the Big Bang, then with the plausible assumption that the size of the universe at this time was approximately equal to the speed of light times its age, that would suggest that **at present the entire universe's size is at least 3x10 [raised to the power of 23] times larger than the size of the observable universe.**[12] There are also **lower estimates claiming that the entire universe is in excess of 250 times larger than the observable universe.**[13] If the entire universe is at least 250 times larger than the observable universe, then the entire universe would have a diameter in excess of 176 gigaparsecs (**575 billion light years**)." – Wikipedia.org

As we can see, lower estimates suggest that the universe as a whole is 250 times larger than what we can observe. Upper estimates place it at more than a billion billion times larger than what we can observe. Consequently, even though the cosmic event horizon is larger than what was originally reported from Encyclopedia Britannica, the relevant fact is that we cannot observationally verify whether matter has a finite or infinite distribution. It could very well be the case that matter is distributed beyond the cosmic event horizon but is still finite in distribution. Consequently, the larger event horizon does nothing to undermine the possibility that there is a universal, "center of gravity" that would dilate time, particularly earlier universe.

But perhaps most importantly, the cosmic event horizon tells us something critical about starlight and the age of the universe. In particular, the charge is often raised that the creationist view in which the earth is roughly 6,000-10,000 years old does not have enough time for starlight to reach the earth from billions of light years away. This argument hinges on the idea that starlight cannot traverse a distance greater than the speed of light would allow in the time allotted by the age of the universe. However, it turns out this is not the case. Even in evolutionary cosmology, star light can be seen from 46 billion light years away from the earth which exceeds the distance light can travel in the allotted timeframe (in this case 13.8 billion years) by 32 billion light years. More critical than the age of the universe is the role of expansion. The role of expansion can allow light to traverse greater distances than the speed of light could accomplish on its own in a given amount of time. And this means that ultimately, whether "young earth" creationism can account for distant starlight is determined, not by its 6,000-10,000 year age limit, but by the way expansion operates in a creationist model. And that, in and of itself, is an important revelation. In short, the creationist model is not disproved on the grounds that it doesn't allow enough time for starlight to reach the earth. A 6,000-year period could indeed be enough time so long depending on other factors involved in the universe's formation including how and when the universe expanded.