A MODEL OF THE UNIVERSE

The Expansion of which is Attributed

to a Force Exerted by Space

by

Steven M. Cohen

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Abstract

In this paper, I construct a model of the universe based on what is now known about the cosmos. A significant difference between this model and others is the interpretation of the cosmological red shifts as resulting from accelerations of distant objects rather than constant velocities. This theory accounts for many phenomena which are not satisfatorily explained by other theories. Some implications of this theory are: the velocities of bodies away from us are constantly increasing at a rate which decreases with time, the universe is smaller than presently believed and there exists a fifth natural force which is inherent in space and dependent upon volume.

Introduction

"There are several kinds of theory in physics. Most of them are constructive. These attempt to build a picture of a complex phenomena out of some relatively simple proposition. The kinetic theory of gases, for instance, attempts to refer to molecular movement the mechanical, thermal, and diffusional properties of gases. When we say that we understand a group of natural phenomena, we mean that we have found a constructive theory which embraces them."[1]

-A. Einstein

All through time, since the beginning of man, cosmological theories have been put forth and either accepted or rejected as observations agreed or disagreed with them. In theory, the Earth was replaced by the Sun as the center of the universe and the Sun was later moved from the center of the universe to a branch of it. It was then discovered that even our own galaxy, which was then thought to comprise the greater part of the universe, was merely one of millions of island universes which were spread throughout space.

Man's view of the universe has expanded with the aid of such instruments as the optical telescope, radio telescope and spectrometer so that we now know a great deal about objects in the cosmos which were not even known to exist fifty years ago. Along with the expanding view of the universe, physics has also evolved a great deal. Men like Newton, Galileo, Maxwell and Einstein have helped to give us a better picture of the laws which govern our universe.

Because of the ever extending horizons of science, men are constantly faced with more complex problems, each requiring a more complex and encompassing solution. Such is the field of cosmology. Modern cosmology deals with theories on the nature of the universe as it was, is and will be. Each cosmological theory which is put forth goes through years of testing, and is often impossible to verify or disprove with our present technology. That is not to say that theories are just made up, and have the credibility of ancient myths. There are certain known facts about the universe which must be accounted for by any cosmological theory which is put forth. They are: the universe is expanding,[2] the universe is amazingly symmetrical and isotropic,[3] and there is a uniform background radiation which floods the universe and gives it a temperature of 3.5°K.[4]

The Expanding Universe

The H and K lines (two dark and easily identified lines of the spectrum) are characteristic of galactic spectra.[5] As we observe galaxies farther away, these lines, along with all the other lines of the spectra, are shifted toward the red or long wavelength end. This is due to the Doppler effect on the light from the galaxies and it is called the red shift.

Hubble and Humason correlated the velocities of receding galaxies with their distances from us, using the red shift in the wavelength of the light to determine their velocities.[6] They discovered that as the distance to a galaxy increases, so does its recessional velocity. This is known as Hubble's law, and it is written: the velocity of recession of a galaxy equals Hubble's constant times its distance from our galaxy.[7] Hubble's constant has been measured many times, and its value is currently accepted as 50 Km./sec./megaparsec.[8] (figure 1 and 2)

In 1927 Georges Lamaitre, a Belgian astromoner suggested that at the beginning of time, all matter in the universe was condensed in one place.[9] This huge cosmic egg would have had a density of 10^{15} Kg./m^3 .[10] This egg, for some reason, exploded to form the universe as we know it today. This theory was elaborated by George Gamow, a Russain American physicist, and appropriately named the "Big Bang" theory.[11] Gamow also predicted that low level background radiation would be present throughout the universe as a result of the initial explosion of the cosmic egg and the high temperatures present in the early universe. This radiation was later discovered and is now accepted as strong support of the Big Bang theory.[12]

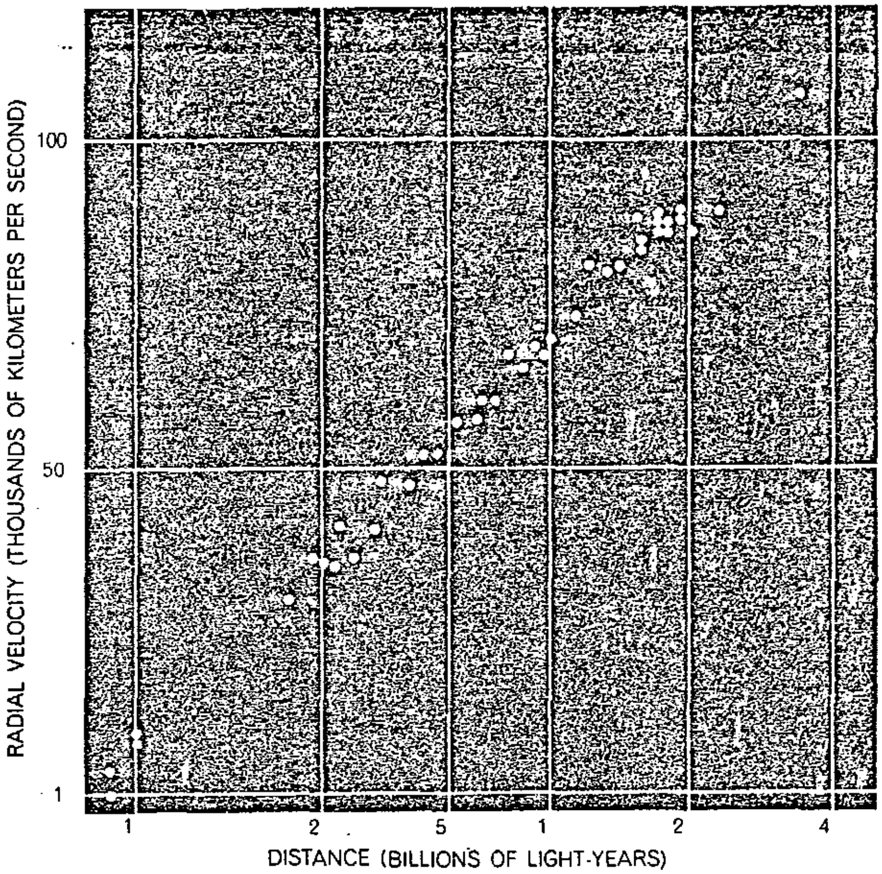


fig. 1

RECESSION VELOCITY OF A GALAXY is obtained by measuring the amount by which the radiation it emits is shifted to the red end of the spectrum. The velocity is directly proportional to the galaxy's distance, as judged by its apparent luminosity. In this diagram, adapted from a recent study by Allan R. Sandage of the Hale Observatories, the ratio of recession velocity to distance is shown for brightest galaxy in each of 41 clusters of galaxies. 13

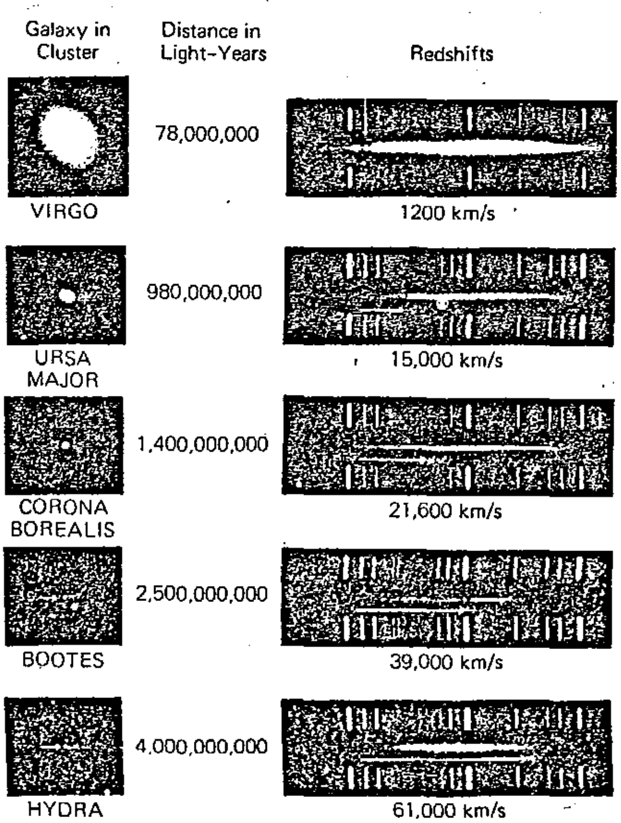


fig. 2

14 (*Left*) Photographs of individual galaxies in successively more distant clusters; (*right*) the spectra of those galaxies, showing the Doppler shift of two strong absorption lines due to ionized calcium. The distances are estimated from the faintness of galaxies in each cluster, and are provisional. (*Hale Observatories*)

The Cosmological Principle

The discovery of the backround radiation (also called black body radiation) has also had other important effects on cosmology. One such effect is due to its remarkable isotropy and is called the cosmological principle. It states that the universe appears isotropic from any reference point in the universe.[15] The cosmological principle was first developed from the apparently random distribution of matter throughout space, but before the background radiation was discovered it was mainly a philosophical idea. This principle and the expansion of the universe are the basis for most prominent modern cosmological theories.

A New Cosmological Theory

I would now like to propose a theory based on the idea that space is expanding. This is an important part of cosmology which is due more attention than it recieves.

When the universe began to expand, it could have done so in one of two ways--it could have expanded into three dimensional space or with three dimensional space. Using the cosmological principle, we can analyze, vectorially, the velocities of all objects in the universe, assuming that they were all ejected from a common point. Any reference point not at this common point of ejection, and the point from which the universe began to expand determine a line. All bodies along this line would appear to have greater recessional velocities (proportional to distance) than bodies not on that line (relative to the reference point not at the center of the universe). To accept this we must place ourselves at the center of the universe. To reject it, we need only accept the fact that space is expanding and picture the universe as an expanding balloon or a rising raisin cake, with the galaxies represented as points on the balloon or raisins in the cake and space as the stretching rubber or expanding cake.

Accepting the expansion of space means accepting the premise upon which this theory is based, and that is: that any two particles in space which are initially at rest relative to one another , with no net forces acting on them, will move apart due to the expansion of space. This phenomena could easily be observed in both the balloon and raisin cake models of the universe. Also accepting Newton's law of inertia, we can say that there must be some repulsive force which is acting on these two masses and is driving them apart. Since there are no known forces acting on these masses, there must exist some unknown force which drives these bodies apart, and since the only reason these masses separate is because of the space between them, which is expanding, we could say that this force is due to space.

The Force

The purpose of this portion of the paper is to show that the existance of a repulsive force due to space is consistent with what is now known about the universe, and can even explain a few puzzles presented by existing models of the universe.

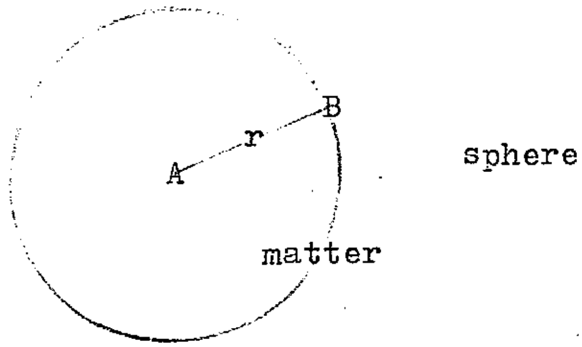
By using classical mechanics and Hubble's law, a formula can be derived for the average acceleration of any galaxy away from us due to this repulsive force. The Big Bang theory shows us that at the beginning of time all bodies were at rest. And Hubble's law gives all galaxies a present velocity away from us which equals rH, where H is Hubble's constant, and r is its distance away from us.[16] Using these two velocities, the average acceleration of any body away from us can be derived.

1. $a=\frac{\Delta V}{t}$	; definition of average acceleration
2. $r=\frac{1}{2}at^2$	; distance in terms of acceleration and time
3. $V_i=0$	; extrapolate present velocities of all bodies
4. $V_f=rH$	; Hubble's law
5. $a=\frac{V_f}{t}$	; 1,3
6. $V_f^2=2ar$	; 2,5
7. $r^2H^2=2ar$	; 4,6
8.* $a=\frac{rH^2}{2}$	; 7

*This is the acceleration away from us of a galaxy located at a distance r. If this acceleration is constant, then 'a' is the acceleration at any time, but if this acceleration is changing 'a' is the average acceleration over a distance of r.

Since the acceleration is directly proportional to r, whatever force is causing this acceleration must increase with r. Unless we choose to attribute this force to matter and make it a reversal of gravitation at a distance (such as Einstein's cosmic repulsion force which he first introduced into his field equations in order to create a static model of the universe[17]), it would most logically be attributed to space. Because space, like this force, increases with distance. It is also possible for this force, like gravity and electromagnetism, to be a $\frac{1}{r^2}$ force. Such a force would be much easier to accept than a mystical force which increases with distance.

The inverse square relation of this force to distance could never be observed simply because we could never move away from a volume of space without encountering more space. To clarify this point let us analyze the effect of gravity, an inverse square force, on a universe consisting of infinitely homogeneous matter with a uniform density.

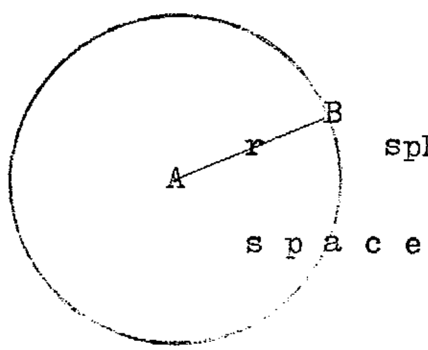


A and B are insignificant test masses.

1. $F=\frac{Gm_a m_b}{r^2}$; law of universal gravitation
2. $F=m_b a$; Newton's second law
3. $m_b a=\frac{Gm_a m_b}{r^2}$; 1,2
4. $a=\frac{Gm_a}{r^2}$; 3
5. $D=\frac{m}{V}$; definition of density
6. $V=\frac{4\pi r^3}{3}$; volume of a sphere
7. $m=\frac{4\pi D r^3}{3}$; 5,6
8. $a=\frac{-G4\pi r^3}{3\ r^2}$; 4,7, the negative denotes attraction
9. $a=\frac{-G4\pi r}{3}$; 8
10. *$a=-Kr$; 9, $K=\frac{G4\pi}{3}$

In this universe of infinite matter, a body would appear to accelerate toward any other body proportionally to distance, even though this acceleration is dependent upon gravitation, a $1/r^2$ force, and more specifically upon the volume of matter surrounding each of the masses.(i.e. the amount of matter surrounding point A in the diagram above is what gives B its acceleration toward A). Because this force is a $1/r^2$ force, the acceleration caused by this force will increase as time passes and the matter becomes more dense under its own influence.

Returning to the real universe, it is evident that space, not matter, is infinite and homogeneous. A force exerted by this space, since it is infinite and homogeneous, would appear to be solely dependent upon r, but it would have to be dependent upon r^3 and time because space has three dimensions, not one, and it expands with time.



A and B are insignificant test masses.

1. $a=\frac{rH^2}{2}$; derived from Hubble's law
2. $r=\frac{r^3}{r^2}$; division of exponents
3. $a=\frac{\frac{1}{2}r^3H^2}{r^2}$; 1,2
4. $V=\frac{4\pi r^3}{3}$; volume of a sphere
5. $a=\frac{3VH^2}{8\pi r^2}$; 3,4
6. *$a=\frac{KV}{r^2}$; 5, $K=\frac{3H^2}{8\pi}$
7. $F=ma$; Newton's second law
8. #$F=\frac{KmV}{r}$; 6,7

* This is the acceleration that any body in our universe would have away from the center of a volume of space.

\# This is the force necessary to give a mass an acceleration of $\frac{KV}{r}$.

Now we must confront the question of the nature of this force, and how it effects all bodies in the universe. First, since it is a force, any mass can be said to possess both a gravitational field and an opposing repulsive field which is inherent in the volume of space surrounding the mass. Any body in this repulsive field would have a potential energy and kinetic energy related to the reference body at the center of the field. As this volume expands and a body moves farther from the center of force of the space, it would have a lower potential energy and higher kinetic energy relative to the repulsive field (this is the opposite of what happens in a gravitational field because the forces are opposite). The kinetic energy + the potential energy + the rest energy of any mass must remain constant to stay within the limits of the law of conservation of energy and mass. This means that as this body moves farther from the reference body at the center of the field due to the expansion of space, its acceleration decreases, because if its acceleration were to remain constant or increase with time, eventually the kinetic energy of the body (with relation to the repulsive field) would surpass the potential energy and its velocity would surpass the speed of light.

Thus we must modify the equation $a=\frac{KV}{r^2}$, where $K=\frac{3H^2}{8\pi}$ to include the relationship of V and H to time and to say that the value of VK is constant regardless of time to stay within the limits of the law of conservation of energy and mass. Therefore the acceleration of any ONE body away from us is inversely proportional to the distance to that body squared because KV is constant.

Thus far I have referred to the phenomena which causes this acceleration as a force, and by using Newton's second law (F=ma), I related this force to the law of conservation of mass and energy. For that purpose the use of Newton's law is necessary and valid, because only changing velocities and distances are being dealt with. Using differing masses, however, presents a problem, because as the mass of an object increases, and the force on it remains the same, its acceleration should decrease (F=ma). But it doesn't, because all objects that we observe obey Hubble's law, regardless of their respective masses.

So, at this point in the paper, I find it necessary to change the equation $F=\frac{mVK}{r^2}$ because the force only acts on the volume of space surrounding the mass, and not directly on the mass. So the mass in the equation should actually be a volume. A formula for the interaction of two volumes of space, however, would be meaningless, because such a situation would be purely mathmatical in nature and could never exist in the universe as we know it. Since two isolated volumes need not be dealt with, simply adding the radii and computing a new volume from that sum is sufficient (unless a very massive body is being dealt with, and space is sufficiently warped to necessitate the introduction of a correction factor). This reduces the force equation to $F=\frac{KV}{r^2}$ where $V=\frac{4\pi(r+r)^3}{3}$.

This force can no longer be represented in newtons because the mass portion of the equation has been removed. Therefore even a point with a mass of zero would be repelled by this force, and it would experience the same acceleration as an entire galaxy at the same distance (r) from any reference point.

Testing This Theory

Since this force can only be noticed at great distances, it is difficult to obtain conclusive experimental confirmation of its validity or invalidity. This force would not be strong enough to effect the orbit of Pluto, but it could possibly effect the orbits, and periods of periodic comets which travel a great distance from the Sun.

Because this force is repulsive it places a limit on the size of any gravitational system, because as a body moves farther away from a mass the effect of gravity on it decreases and the effect of the repulsive force due to space increases. This could be the reason why all galaxies are approximately the same size.

The above two ways of testing this theory involve classical mechanics. Using Einstein's general relativity, two other more feasible methods can be used to test this theory.

In his theory of special relativity, Einstein showed that there is no such thing as an absolute frame of reference, and that all motion is relative.[18] From this theory he developed the principle of equivalance which led to his general theory of relativity. The principle of equivalance states that an inertial frame of reference cannot be favored over a frame of reference which is moving arbitrarily because motion is always relative.[19] He then showed that any laws which hold true for one frame of reference must hold true for a similar frame of reference. Since a frame of reference at rest in a gravitational field is similar to an accelerating frame of reference in empty space, any law which holds true for one frame must hold true for the other. Using this argument Einstein proceeded to show that light would bend around a gravitational field.[20]

Light describes as straight a line as can exist in our universe. Because the light bends around a gravitational field, Einstein chose to describe the space in the gravitational field as being curved, with a positive or spherical curvature (figure 3).[21] By explaining gravity as a warp in space and time, Einstein was able to develop a theory of gravitation which is similar to Newton's theory but explains phenomena like the irregularities in Mercury's orbit, something which couldn't be explained using classical mechanics.[22]

Light bends toward a massive body because gravitation is an attractive force. Were gravitation repulsive, light would bend away from a massive body. Since the force which I have described in this paper is repulsive, it would cause the universe to possess a negative overall curvature. This curvature could be recognized on one of two ways. First, a triangle constructed in negatively curved space would have angles whose sum is less than 180° (figure 3).[23] This was the method used by Einstein to prove his general theory of relativity.[24] Secondly, the volume of a sphere in negatively curved space would be less than $\frac{4\pi r^3}{3}$.[25] Utilizing the triangle theorem to test this theory would be difficult to impossible. But the second can, and has been used to determine the curvature of the universe. By counting the galaxies at differing radii and using the galaxy count to determine volume (the cosmological principle) it is possible to determine the curvature of the universe. The curvature of the universe has not yet been determined conclusively, but in the aricle entiled 'The Evolutionary Universe' by George Gamow, and the article entitled 'Will the Universe Expand Forever?' by Gott, Gunn, Schramm, and Tinsley, all evidence points strongly toward a universe which is negatively curved.

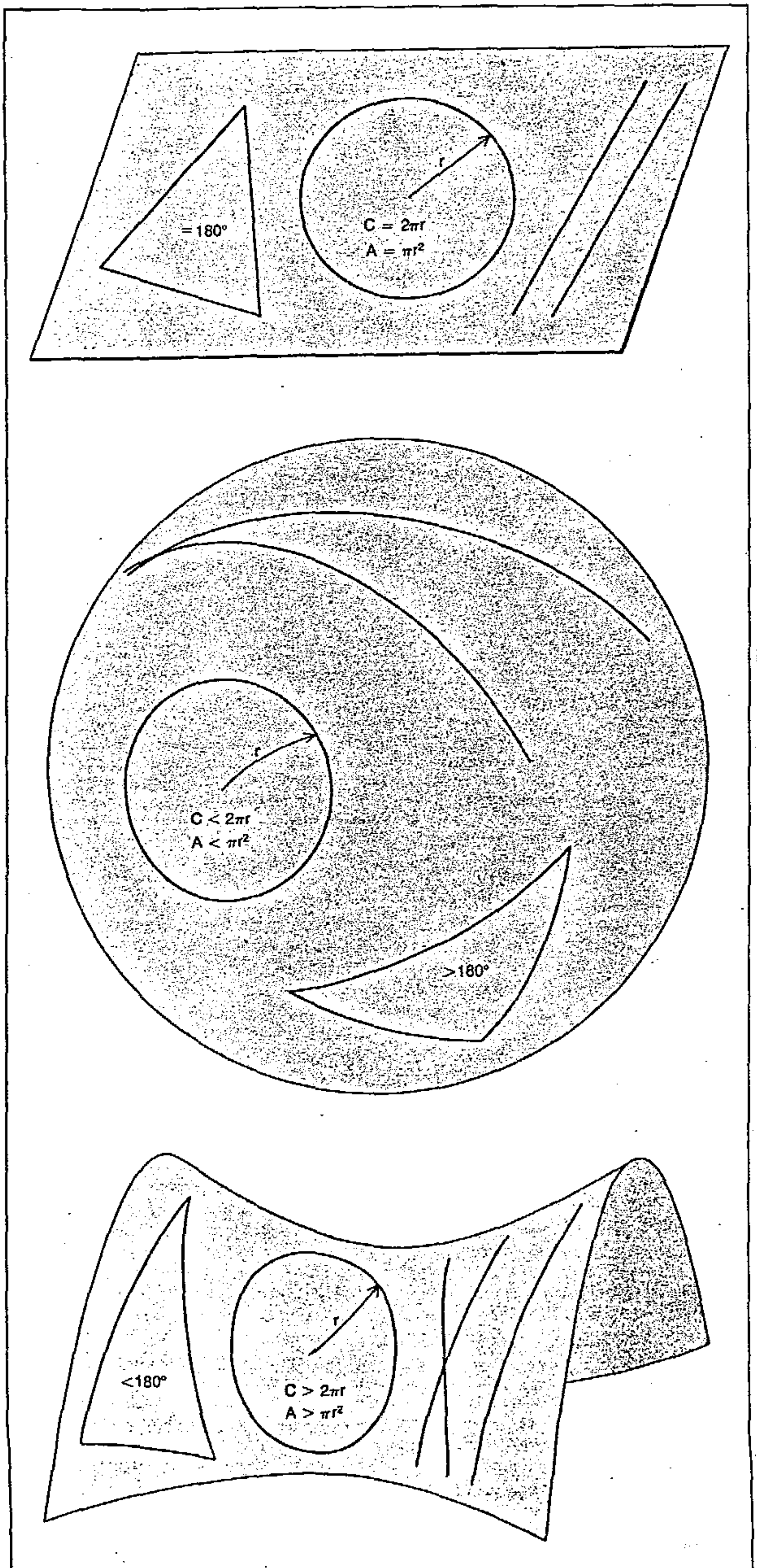


fig. 3

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GEOMETRY OF SPACE characteristic of each model universe has an analogous surface. The properties of the surfaces are defined by the Euclidean axioms and theorems on parallel lines, on the included angle of a triangle and on the circumference and area of a circle. The flat space of a critical universe is represented by a plane, and the positively curved space of a closed universe corresponds to the surface of a sphere. Some of the properties of the negatively curved space of an open universe can be demonstrated on a saddle-shaped surface, but the saddle is an imperfect analogue because it has a center. The best representation of an open universe is an infinite surface called a pseudosphere, which cannot be constructed in a three-dimensional space.

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Galaxy counts and the curvature of space. *Galaxies are randomly distributed in space. If space is flat, when we plot the locations of galaxies on a piece of paper, we will find that the points are evenly distributed over the paper. If space is positively curved, then when we plot the locations of galaxies, we will find that there seem to be more galaxies nearby than far away. Finally, if space is negatively curved, the plot would suggest that there are excess numbers of galaxies at great distances.*

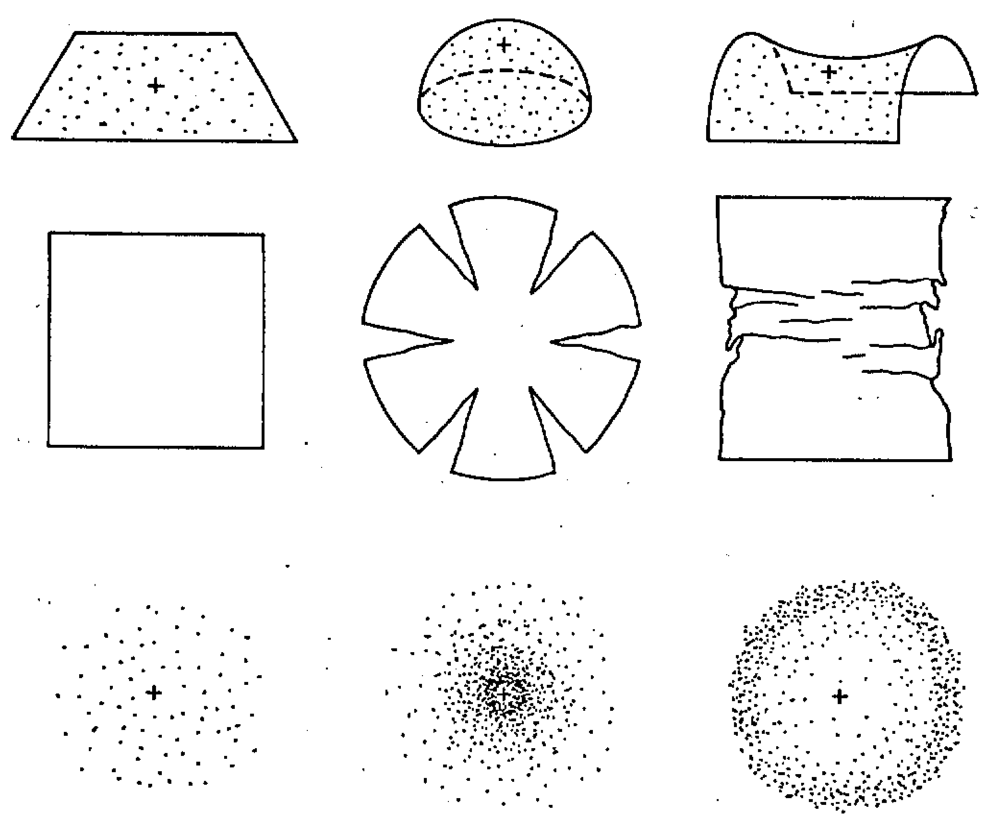

fig. 4

Einstein also predicted, in his general theory of relativity, that time would slow down in a gravitational field due to the force acting on any clock in the field.[28] Since time is a measure of frequency, he showed that a strong gravitational force could decrease the frequency of light and thereby increase its wavelength. This is called Einstein's red shift, and it plays an important role in the research on black holes because, according to this theory, black holes could stop time (this is called the event horizon).[29]

The force due to space, which is proportional to distance, also causes light to have red shifts proportional to distance. Such a shift would be the result of the relatively slow passage of time on the distant galaxies due to the force of space, not the Doppler effect. This would mean that Hubble's constant is not truly accurate at great distances, and a correction for it due to this force has to be introduced. This correction for the red shift would reduce the actual size of the universe to less than it is thought to be today. This correction in the size of the universe has also been used to explain super-luminal objects,which are objects in the universe which appear to move apart at many times the speed of light.[30] It could also be used to account for distant objects which seem to be moving away from us at speeds which approach that of light.

Because of this red shift, a correction must be added to the equation $F=\frac{VK}{r}$ where K and V are both measured at the same time. K would have to equal $\frac{3(H-\phi)^2}{8\pi}$ and ϕ would be the correction of Hubble's constant due to the change in the wavelength of light because of the force of space. The only theory which has sufficiently explained superluminal objects gives ϕ a value of about $\frac{1}{2}$H.[31]

Conclusion

As I stated before, the existance of a force due to a volume of space is a purely theoretical idea (although the curvature of space could be considered a proof for this theory). I have constructed this theory because it can be used to account for many existing phenomena which have not, as yet, been satisfactorily explained. First, it gives a reason for the expansion of the universe other than a mighty and uniform explosion which would have had to combat the infinitely great force of gravity which was then binding the universe. Secondly, it provides an explanation for the apparently great velocities which are measured by the red shifts. Thirdly, by shrinking the actual size of the universe, this theory proposes that the energy output of quasars and other distant objects need not be as great as it is thought to be, because they are not as far away as they seem. It also is in accordnace with the only theory which has, as yet, explained superluminal objects.

Footnotes

[1] Albert Einstein, Out of My Later Years (New York: Philosophical Library, 1950), p. 54.

[2] Allan Sandage, "The Red-Shift," Cosmology + 1, 1977, 8.

[3] Steven Weinberg, The First Three Minutes (New York: Basic Books, Inc., 1977), p.23.

[4] ibid., chapter 3.

[5] George Abell, Realm of the Universe (New York: Holt, Rinehart and Winston, 1976), p.354.

[6] Fred Hoyle, The Nature of the Universe (New York: Harper and Row, 1960), p.114.

[7] Harry Shipman, Black Holes, Quasars, and the Universe (Boston: Houghton Mifflin Company, 1976), pp.247-8.

[8] Frederic and Baker, An Introduction to Astronomy (New York: D.Van Nostrand Company, 1974), p.403.

[9] Lincoln Barnett, The Universe and Dr. Einstein (New York: Harper and Row, 1966), p.101.

[10] Isaac Asimov, The Universe (New York: Avon Books, 1971), p.224.

[11] Barnett, p.101.

[12] Adrian Webster, "The Cosmic Background Radiation," Cosmology + 1, 1977, 37.

[13] Reese and Silk, "The Origin of the Galaxies," Cosmology + 1, 1977, 56.

[14] George Abell, p.354.

[15] Asimov, p.234.

[16] ibid., p.211.

[17] Georges Lamaitre, "The Primeval Atom," Theories of the Universe, 1957, 344-53.

Footnotes (cont.)

[18] Max Born, Einstein's Theory of Relativity (New York: Dover Publications, 1965), p.312.

[19] ibid.

[20] William Kaufmann,III, Relativity and Cosmology, (New York: Harper and Row, 1973), p.28.

[21] ibid.

[22] ibid., p.29.

[23] J.J. Callahan, "The Curvature of Space in a Finite Universe," Cosmology + 1, 1977, 27-8.

[24] Kaufmann, p.28.

[25] Gott,Gunn,Schramm and Tinsley, "Will the Universe Expand Forever?" Cosmology + 1, 1977, 88.

[26] ibid.

[27] Kaufmann, p.111.

[28] ibid., pp.31-2.

[29] Shipman, p.75.

[30] Frank Drake,"Faster Than the Speed of Light?" Natural History, February 1978, p.28.

[31] ibid., p.32.

Bibliography

Abell, George. Realm of the Universe. New York: Holt, Rinehart and Winston, Inc., 1976.

Asimov, Isaac. The Collapsing Universe. New York: Walker and Company, 1977.

Asimov, Isaac. The Universe. New York: Avon Books, 1971.

Barnett, Lincoln. The Universe and Dr. Einstein. New York: Harper and Row, 1966.

Born, Max. Einstein's Theory of Relativity. New York: Dover Publications, Inc., 1965.

Callahan, J.J. The Curvature of Space in a Finite Universe. Ed. Owen Gingerich. San Francisco: W.H. Freeman and Company, 1977.

Drake, Frank. "Faster Than the Speed of Light?". Natural History, February 1979, 28-34.

Einstein, Albert. Out of My Later Years. New York: Philosophical Library, 1950.

Frederick, Laurence, and Robert Baker. An Introduction to Astronomy. New York: D.Van Nostrand Company, 1974.

Gott, Richard, et al. Will the Universe Expand Forever?. Ed. Owen Gingerich. San Fransisco: W.H.Freeman and Comapany, 1977.

Hoyle, Fred. The Nature of the Universe. New York: Harper and Row, 1960.

Kaufmann, William. Relativity and Cosmology. New York: Harper and Row, 1973.

Lamaitre, Georges. The Primeval Atom. Ed. Milton Munitz. Illinois: The Falcon's Wing Press, 1957.

Rees, Martin, et al. The Origin of Galaxies. Ed. Owen Gingerich. San Fransisco: W.H.Freeman and Company, 1977.

Shipman, Harry. Black Holes, Quasars, and the Universe. Boston: Houghton Mifflin Company, 1976.

Webster, Adrian. The Cosmic Background Radiation. Ed. Owen Gingerich. San Fransisco: W.H.Freeman and Company, 1977.

Weinberg, Steven. The First Three Minutes. New York: Basic Books, Inc., 1977.