A Spacetime Map of the Universe: Implications for Cosmology

John A. Gowan home page
(revised Jan,, 2011)

Table of Contents

Abstract

I present a 4-dimensional spacetime map of the cosmos showing our position in it and how we view the universe. We exist on the spacetime edge of the cosmos looking backward in time toward its beginning and "center" as we look outward in every direction in space. As we look deeper into spacetime we look into successively smaller and younger historical eras of our universe, all of which nevertheless surround us completely. Implications for cosmology (including the theory of "inflation") resulting from this (generally unappreciated) perspective are discussed.

PART I

Introduction

(The reader may wish to consult the "preface" or "guide" to this paper, which is found at "About the Papers: An Introduction" section V).

Reading cosmology often leaves me wishing I had a simple map of the cosmos for reference and orientation, just as I want a globe handy when reading the geography or history of Earth. As I have never found a suitable map for this purpose, however, I decided to attempt its production myself, proceeding on the generally held assumption that the universe has expanded to its present size from very small beginnings. The resulting map is therefore relevant to "Big Bang" and "Inflationary" cosmology, but does not distinguish between them. (I am assuming that inflation (if it exists) ends before it produces a large universe.) I found the mapping effort so illuminating and mind-stretching that I feel others interested in astronomy and cosmology generally will find the map and mental exercise it affords both stimulating and useful. The map also has a good deal to say about certain conceptual difficulties in cosmology - especially the "horizon" or "flatness" paradoxes, and hence also "inflation", a theory which was invented expressly to address these problems.

Producing a map of the universe is a problem - but not a straightforward problem - in the scalar representation of 3-dimensional space. For example, how does one represent the fact that we look backward in time to an ever-smaller universe as we look outward into an ever-larger region of space? And how should we indicate the central point of origin, or conversely, the outer boundary of our universe? A three-dimensional model gives us no adequate way to indicate the spatial limits of our universe because it lacks a crucial dimensional parameter: time.

The mapping problem presented by the time dimension is easily stated: as we look outward in space we look only backward in time. Because of the finite speed of light, we cannot look out in space into the present. We see our universe not as it is, but as it used to be, in an ordered regression of concentric spatial observational shells receding into the past as we look deeper into the heavens. Furthermore, the past universe that we see from Earth is a unique subset of the whole past, as we cannot see any of our own history, and we see only single moments in earlier samples of the history of our cosmos. To escape from the observational tyranny of the one-way character of time, the finite velocity of light, and the linkage of both with space, we must find a way to disentangle the spatial and temporal dimensions so that we can map what "is" as well as what we are constrained to see. Problems such as these are wholly unfamiliar to the Earth cartographer and require the use of a 4-dimensional spacetime map.

At this point we need to recognize that our mapping problem is not so much one of content (the number and positions of galaxies), as of finding an appropriate methodology for representing the universe of spacetime which the galaxies occupy. To state the problem in the more familiar terms of Earth's geography: cartographers needed to develop spherical models of the Earth before they could make realistic maps of continental positions. The spacetime map I present is analogous to a blank cartographer's globe of the Earth, containing only lines of longitude and latitude. Although for the present devoid of material content, I think the reader will find there is much to learn even from an (almost) empty map of our universe. In any case, it is a necessary beginning.

Constructing the Map

To construct a spacetime map, we must reduce not just scale but also dimensionality. All 3 spatial dimensions are collapsed into a single line, and *time and space are accorded equal status as mapping parameters*. The justification for this is that we are mapping space in units of "light time" or "light years" (ct), so we are essentially mapping t against ct, which are metric equivalents. Massive objects move in time with a "velocity" which is the metric equivalent of light's velocity in space: one second of temporal duration is metrically equivalent to ~300,000 km of spatial distance. The compression of dimensionality results in the loss of recognizable features - the universe does not "look like" the spacetime map. Nevertheless, the map allows us to represent our universe in a dimensionally correct manner and at the same time show what we see of it and what we don't. The map helps us to orient ourselves with respect to the spacetime structure of the cosmos, understand the cosmological redshift, and discover where we are with respect to the observable, as well as the invisible, universe. The deployment of the Hubble Space Telescope, and the construction of a new generation of giant land-based telescopes, with their exceptionally deep and clear views of space, has increased our need for such understanding.

Figure 1 shows a spacetime map of a universe 14 billion years old. New measurements by the Hubble and other telescopes suggest the universe is only 13.7 billion years old (*Sky and Telescope*, May, 2003). For our general purposes, however, the relative size of the map or age of the universe will not affect our discussion or understanding of the model (the geometric relationships of a sphere are not affected by variations in size).

Where it does matter, we use the new values.

The map consists of 14 concentric, evenly spaced circles which represent the increasing spatial volume of a uniformly expanding universe at billion-year time intervals. The map implies the validity of the modern notion that spacetime is not a void which preexisted the Big Bang, but is itself a product of the Big Bang. In this representation, the 3 spatial dimensions have been compressed into 1, hence the line of any circle contains all of the space of the universe at the particular historical moment indicated by its intersection with the time line. The center of the circles represents the Big Bang, or "time zero", and the outermost circle represents the spatial volume of the present-day universe. The circular shape of each space line represents an isometric time curve, that is, all the space in the line is of the same age, as it is equidistant from the Big Bang, the center of the diagram. The shape of the map does not reflect the physical shape of the universe, but indicates instead its uniform age and finite size. *Only the (presumed) fact that the universe had a specific and point-like beginning in space and time allows us to construct a map of this type*. An important consequence of our common beginning in the Big Bang is that all galaxies/observers in the cosmos are of the same age, and observational relationships between them are reciprocal in character.

The time dimension is the radius of the diagram and controls the development of the map. Uniform intervals between spatial circles indicate an even flow of time. Any number of radii could be drawn from the center of the diagram through the spatial circles, like spokes from a hub, to represent the time lines of other observers in galaxies distant from our own. The map represents the Einsteinian connection between time and space in three ways: 1) the time dimension is constructed at right angles to all three spatial dimensions simultaneously; 2) the spatial dimensions are measured in units of light years; 3) time and space are linked by the geometry of the map as the radius and circumference of a circle. Because this latter relationship is linear, the map represents only the change in the cube root of the volume of the universe per unit of time.

From the viewpoint of any observer, 3/4 of Fig. 1 is imaginary: as I have drawn the map, only the upper left quadrant is "real". There are two reasons for the large, imaginary map area: the asymmetry of the time dimension and mapping artifact. Because time runs in one direction, only the left or right hemisphere of Fig. 1 can be real. Secondly, because the lines of the circles contain all three spatial dimensions, either the upper or lower quadrant of the remaining hemisphere is redundant. (The right angle between increasing space and increasing time can be constructed either "above" or "below" the time line.) We are left with a map more nearly resembling the textbook 2-axis diagrams of spacetime. Nevertheless, I will continue to refer to the full figure because: 1) its full symmetry is helpful to generate and analyze the "real" portions of the map; 2) the full figure is more easily visualized; 3) it is helpful to understand the orientations of the space and time lines of other, distant observers (whose "real" map quadrants partially or wholly overlap our "imaginary" map quadrants).

Figure 1 is strictly appropriate only for a universe composed entirely of light. The map shows a universe whose radius in light years is equal to its age, indicating expansion at the maximum possible rate. The spatial circles are evenly spaced and the map is flat, illustrating an historically uniform rate of expansion. If we want our map to represent a universe containing matter, then we must show a gravitational deceleration of the expansion, that is, a reduced volume increment per unit of time. We can indicate a deceleration by bending the time line out of the plane of the paper (or bending the paper itself, either toward or away from the reader), producing a curved map. In a curved map, while the actual length of any time line increment remains constant, its effective length as the controlling radius of the map is shortened, reducing the rate of growth of the spatial circles.

The greater the gravitational deceleration, the greater the curvature of the map and the more strongly the growth of the spatial circles is suppressed. A change in the degree of curvature represents a change in the rate of deceleration. If the curvature of the map is great enough, it will begin to form a sphere, grow to the region of its "equator", and continuing beyond, start to shrink in size, allowing us to portray a contracting universe. Time does not "flow backwards" in this spherical representation, its forward motion simply drives a shrinking rather than expanding universe.

A gravitationally curved (or "closed") spherical map is simple to visualize as an overlay on a globe of the Earth. Place the Big Bang origin at the north pole, and the two major space and time axes become lines of longitude 90 degrees apart. The spacetime arcs between them consequently become "parallels of latitude" connecting the two longitude axes. As the longitude axes flow over the globe toward the equator, they gradually become parallel lines, "pulled together" by the contracting "parallels of latitude" as they approach the equator. Flowing past the equator, the longitude axes of space and time converge at the south pole, in the "Big Crunch" of a "closed" universe. Thus while the mathematics of "curved" (accelerated) metric surfaces may be obtuse (General Relativity), visualizing the result is not difficult, at least in simple cases. Everything we have said about the flat map may be overlaid upon an (appropriately) curved surface - at least in our imagination: transposing a flat map to a curved surface (or vice versa) cannot be done directly and requires special mathematical techniques.

The actual configuration of a gravitationally curved map should not be spherical, but egg-shaped or ovoid, with the poles on the ends of the oval. The ovoid shape reflects changes in the rate of expansion and contraction, changes which are greatest near the "Big Bang" and "Big Crunch", the "time poles" of the universe, where the spatial volume of the cosmos is the smallest and the gravitational energy is therefore the most concentrated and effective.

For a "closed" universe, which collapses, the full globe shape applies; for an "open" universe, one which expands forever, the appropriate shape is that of a widely flaring bell, gradually opening to a nearly flat rim. The third possibility is that of a universe balanced between the open and closed situations, barely changing as time passes. A map of the latter condition would look something like half of a large egg, continued indefinitely beyond its "equator" as a cylinder. (Recall that, as in the flat map, only one quadrant of the curved maps is real). To facilitate our discussion, I will not refer to any of these curved forms, but only to the flat map of Fig. 1. Anything said about the flat map can be converted to a curved figure by projecting or overlaying the flat map onto the appropriate 3-dimensional form. (Furthermore, all observations indicate the flat map is the appropriate shape anyway. Later, we will see why this is to be expected, and it is not necessarily because of "inflation".)

The Observer's Perspective

The present position of the Earth is indicated on the map by the dot at position "A" on the outermost circle (at the scale of the map, this dot is very much larger than our entire galaxy). Our view of the universe is from the perspective of the outermost circle, the very edge of the cosmos, looking back in time toward the center of the universe, its beginning in the Big Bang. Observers elsewhere in the universe must see the cosmos from the same perspective, and hence must also be situated on the outermost circle. (All observers live in their own "present moment", which, because we were all born together in the Big Bang, is exactly the same age as our own present moment - the same distance in spacetime from the origin of the cosmos or the center of our diagram.) The "edge of the universe" is not somewhere "out there in space", but is (for us) here and now on planet earth, which is at the furthermost possible remove in spacetime from the Big Bang. What is "out there in space" is the Big Bang itself, the spacetime center of the cosmos, a small beginning which nevertheless observationally surrounds us completely, and which we look toward in every direction as we look outward into space and backward into the past.

The "shape" of the universe is a four-dimensional concept, involving time as well as space. This "shape" is the sum total of the "present moment" as it is realized throughout the spatial volume of the cosmos (the outermost circle). If light had an infinite velocity, this is the universe we would see. This "shape" changes constantly due to the passage of time, the intrinsic motion of light, and the influence of gravity. The outermost circle of the map represents this instantaneous shape, which because of the combined intrinsic motions of time, light, and gravity is really a "happening" and not a fixed shape at all. At the grand scale of the map, of course, this moving boundary is relatively stationary.

From the Earth's position on the outer circle, I have constructed an interior circle which has the time line as its diameter. I call this interior circle the "observer's circle", or "light line". (For the present, the reader should ignore the second interior circle constructed from B). The observer's circle is the path of all light rays between Earth and the Big Bang; all that we can see of our universe lies on this line (recall that due to the dimensional compression of the map, the light line corresponds to our full 360 degree view of the heavens in ordinary space and experience).

The observer's circle is one-way, consisting of the paths of light rays received, not sent, by the Earth. Light rays sent from the Earth (or any other source), always move within the (current) outermost spatial circle, and their paths trace out the observer's circles of the positions which receive them. For example, the paths of light rays sent from Earth 4 billion years ago (arc A'B) to another observer who is now 4 billion light years distant, and the reciprocal exchange (arc B'A), are shown. These light paths result from the combined action of 2 intrinsic motions: the arc A'B, for instance, is the trace of: 1) the upward motion (with respect to the map) of the light ray as it moves within its current space line from A' toward B; 2) the radial, outward motion of that space line as it ages 4 billion years.

The observer's circle is constructed by drawing tangent lines from the Earth's present position to each of the interior spatial circles, then connecting the points of tangency. The reader may verify, with a straightedge, that these tangent points all lie on a circle which has earth's time line as its diameter. For the sake of clarity, only the tangent lines from Earth and observer "B" to the 12-billion-year spatial circle are included in the diagram.

What is the rationale for our method of constructing the observer's circle? The mapping problem to be solved is to determine the path of a light ray coming from the Big Bang (or any other part of the visible universe) as it is seen from Earth today. To do this we must understand how we see our universe when we look outward into space, then translate this understanding into a mapping procedure.

Any observer of the universe may be considered to occupy the center of an infinite set of nested, concentric, spherical observational shells. An observational shell is the 2-dimensional inner surface of a hollow sphere whose radius is determined by the depth of the observer's view into space. The observer sees the universe as a coherent, concentric, 3-dimensional nested stack of these shells. These shells are 2-D spatial subsets of the universe as it existed at a particular earlier moment in its 4-D history. They are unique to every observer's view. The chief *mapping* significance of the shells is that they are 2-dimensional surfaces. Because a 3-dimensional volume is represented in our map as a 1-dimensional line, a 2-D surface must be mapped as a zero-D point.

An observational shell of appropriate radius from Earth must intersect each of the interior spatial circles of the map (since we can see all the way to the Big Bang); our task is to find the geometric principle which allows us to identify these points of intersection. Connecting these points from the edge to the center of the map will represent the light path in question. Because the light line must intersect each space line at only a single dimensionless point (from the argument given above), there are just two possible geometric construction procedures which yield solutions to the problem, one of which produces the time line. We cannot see our own past, so the time line is obviously not the solution we seek. The only other possibility is the points of tangency, and it is these which I have used to define the light path of the observer's circle.

Readers should try to generate the following mental pictures to verify for themselves the intuitive logic of the preceding discussion: imagine looking out in space to the distance of our Moon. Imagine the complete observational shell that surrounds the Earth at this distance: a 2-dimensional spherical shell of radius (approximately) 240,000 miles, or about 1 1/3 light seconds. This particular observational shell is a 2-D spatial subset of the entire universe as it existed 1 1/3 seconds ago, but the only part of that past universe we can see is the slice that contains our Moon. Now repeat this imaginary flight to the larger observational shell that contains our Sun, which is a 2-D spatial subset of our universe as it existed about 8 minutes ago (the Sun being 8 light-minutes distant). Although we know the entire universe existed 8 minutes ago, the only part of it we can see *as it existed then* is the slice containing our Sun - since no other significant objects exist to be seen at exactly this distance. Finally, imagine the huge observational shell that cuts through our neighboring galaxy, Andromeda, at a distance of about 2.2 million light years. The Andromeda stars intersected by this large observational shell are the only objects we can see in the entire universe as it existed exactly 2.2 million years ago. Other visible objects are part of either younger or older historical subsets of our universe. (In all cases I have assumed that the remainder of these shells cut through empty space). Note that, in principle, we can make the "time thickness" (ct) of these shells as thick or as thin as we wish, right down to a true 2-D surface.

The exercise above demonstrates that we never see all of our universe as it existed at a single, past, historical instant of time, just as we cannot see all of the universe as it exists "now". Rather, we see successively larger, older, and always different portions of it in spacetime shells which recede further into the past as we look deeper into space. Each shell is a 2-dimensional surface which just "touches" the 3-D volume of its historically associated (isometric or even-aged) universe. It should be intuitively clear that these 2-D surface "touches" are simply the higher dimensional analogs of the tangent points on the spatial circles of the map. It is only the combined thickness of an infinity of such shells that gives us the impression of seeing spatial volume (recall that light is a 2-D transverse wave whose intrinsic motion "sweeps out" a third spatial dimension). The observational shells become very small as we approach Earth, finally reducing to the size of our own bodies. We see practically nothing of the universe as it exists "now".

Our "processional" view of the cosmos is realized on the map in the following way: as the spatial circles shrink toward the Big Bang, the observer's circle intersects them at progressively higher positions on their real quadrant arcs. No two spatial circles are seen at the same relative point on their circumferences. The necessity for this arrangement becomes obvious when we recall that each spatial circle contains the whole universe at a given time; if we are not to see objects in two or more positions at once, we must view these universes in a sequential spatial as well as temporal progression (contrast the path of the time line in this regard - this is why we cannot see our own past). Gravitational lensing is the exception which proves this rule, dramatically illustrating the structural connection between metric spacetime and the path of light. What we see in the heavens is only a "light show"; the actual solid bodies all exist in the outermost spatial circle, the invisible spacetime dimension of the "universal now". The fact that the light line cuts the spatial circles in exactly this orderly, sequential way is one indication that the map's geometry is valid.

Note in this regard that the more distant a galaxy or region of spacetime is from us today, the greater must have been its original separation from our own position (during and just after the "recombination event" of the "Big Bang"). Thinking in terms of divergent velocity vectors, as we are always tempted to do by virtue of our usual conception of explosive dynamics, doesn't work, since the recessional velocity of galaxies depends only on the amount of spacetime between us and them, never on their direction. Some portions of these earlier universes were, of course, near neighbors right from the beginning - Andromeda and our "local group", for example - close enough to become gravitationally coherent. Within the line of any given spatial circle of the map, our neighbors are located near earth's timeline; distant galaxies are located nearer the "spatial limit" line.

Because the time line is: 1) the radius of the outermost space line; 2) the diameter of the observer's circle; it follows by simple geometry that, within the map's real quadrant, the outermost space line and the observer's circle are equal in length. I interpret this to mean that the universe we see, even though it is a composite view of many earlier universes, is of the same spatial volume as the universe of the present day, which we cannot see. We do see portions of the whole universe, but (like our own history) only as a fleeting parade, for the most part well-ordered in time as well as in space (excepting gravitational lenses). Although the observer's circle was not constructed to represent space, it has space-like properties since it is composed of an infinite series of nested 2-D concentric spherical surfaces. In aggregate, these nested surfaces form the bulk "electromagnetic volume" of the visible universe, which, together with the much larger invisible universe, comprise an historical reservoir of light, gravitation, and information: matter's "causal matrix". Every event which has ever occurred in spacetime is stored as light and as a causal history within this 4-dimensional volume of historic spacetime.

The map shows a second observer's circle. The second observer (B) is situated (presently) 4 billion light years from Earth. We find B's map position, as seen from Earth, by counting back 4 billion years along Earth's time line, then following that spatial circle out to its intersection with Earth's observer's circle; their point of intersection represents our entire observational shell at that distance. We find the second observer's present position in space by constructing B's time line from the Big Bang to B's observed position and extending that time line to the outer spatial circle (this procedure assumes the second observer is not in significant "peculiar" motion with respect to Earth). When we construct B's observer's circle, we find that it intersects Earth's time line just 4 billion years in our past, as it should. This observational reciprocity between A and B is crucial further evidence validating our geometric mapping method.

(Note that only the area between the time lines of A and B is a valid map of the simultaneous view of both observers - see appendix. Note also that the half-circle of B's light line above B's time line is superfluous (not real); likewise, the half-circle of Earth's light line below Earth's time line is superfluous. Finally, the space line for B is not shown; it would have to be constructed (at right angles to B's time line and below Earth's time line), from the Big Bang to the outermost circle, meeting the perimeter below Earth's position.)

Reality and the Map

One of the striking features of the map is that it exhibits several different kinds of reality. For example, the Earth's observer's circle (light line) is what we usually think of as the "real world"; it is what we can see of our universe, and it is the path of massless energy forms which travel to us with intrinsic spatial motion C (electromagnetic radiation, gravity). Nevertheless, this line is clearly composed of nothing more than an ordered sequence of observational shells, defining a particular subset of the universe's history that is unique to Earth observers. There are in fact no material objects in this reality at all - they are all forms of light. We might call this reality the "visible past". Only a fleeting portion of our time line is visible to other observers, and conversely, we can only glimpse a fleeting portion of theirs.

The time line of the Earth is another sort of reality. It is the historical path along which the Earth and other massive objects (humans, our galaxy) travel, objects which have intrinsic motion in time, not space (see: "The Time Train". Although we cannot see our own past (except in mirrors), observers elsewhere in the universe can see some part of it, and influence certainly travels to them and to us from our past (part of the "causal matrix" of all bound energy forms). What we may refer to as our own "historic past" is part of the "visible past" of some other observer, and vice-versa, confirming the continuing reality of our causal history, even though it is quite invisible to us.

Still a third type of reality is illustrated by the outermost line of the present spatial surface of the universe. This represents a sort of "universal present moment" in which we continuously participate. We receive influence from this sector of the cosmos only by touch, for this part of the cosmos contains all material objects. We encounter them only in the present moment when we physically touch them. This is the part of the universe into which we send light signals, rather than receive them. (B's observer's circle is the trace of a light ray sent from Earth 4 billion years ago; it was invisible to us during its entire trip and its arrival "today" in B's "universal now" will not be seen (by us) for another 4 billion years.) Light travels always in the "present moment" of the "universal now" (light's "clock" is stopped). Even though we see the light from the ancient history of distant galaxies, we see that light only in our portion of the "universal now", our personal "present moment".

A fourth type of reality is a composite, the triple intersection of time, space, and light, the reality of the observer's present moment. Our own present is unique in that it is the only type of reality in which we can both generate and receive influence. It is in the present moment that we receive effects from our historical past (consequences, "karma"), and produce causes for our future. Here we also receive influences from the light universe (information, gravitation, energy) and send signals into it (communications); finally it is also here that we physically contact and rearrange the present material universe in our interactions with other physical bodies.

The hemispherical area between our light line and time line is an area of spacetime (physically real) which consists of our "causal past", the domain of our own "causal matrix". For us, it contains all the history of the universe that we could potentially have interacted with (two-way interactions) if we had been there from the moment of the Big Bang onward to the present day. It is invisible to us now, but for others in the universe, all of it is in someone's light line, or "visible past", still sending influence and information. It contacts us through our light and time line, its upper and lower bounding surfaces, and through the triple intersection of time, space, and light which constitutes our experience of the "Universal Present Moment". However, one-way exchanges of light rays outside this area are possible, as is demonstrated by the reciprocal but one-way exchange of light rays between A and B, separated by 4 billion light years of spacetime.

The area shaped like a cornucopia between our light line and the outermost spatial surface is for us a "manifest future", already formed and quite real, of all events we will be able to see and receive influence from that have occurred from the Big Bang to the present moment, but whose light has not yet reached us. Both our "causal past" (below the light line) and our "manifest future" (above the light line) are (partly) in the real light line of some observer elsewhere on the outermost spatial surface, the universal "present moment" (note B's light line, for example). Simple geometry proves that these two areas ("causal past" and "manifest future") are equal in size (area) and must always remain so. The necessary reciprocity between all observers is the intuitive basis for this result (as we see them in their past, just so must they see us in our past).

Another way to state this necessary reciprocity is the realization that if we see B four billion years in his past, then there already exists, for B, a future of equal length (the last four billion years of our history) which will eventually be revealed to him; and vice versa. Hence the light line must split the map into equal areas of past and future, and the observer's circle is the shortest line which can accomplish this feat. Since light always travels the shortest path between two points, the observer's circle is the only line which can possibly represent the path of light between Earth and the Big Bang. Note that this evidence for the validity of the observer's circle as the true path of light is independent of the others given; it also provides a helpful criterion for the construction of the light line in the more geometrically complex gravitational models.

It is even possible to see our own past; we do so every time we look in a mirror. If we could look into a giant mirror in the Andromeda galaxy with a telescope, we would see the Earth as they saw us 2.2 million years ago, that is, 4.4 million years in our past!

The area above and below our light line is a 5th spacetime dimension composed of the summation of all light lines of all possible observers in the universe; in a real sense it is our light line "squared". Hence our universe is actually 5-dimensional, with past, present, and future spacetime ("bulk" spacetime) forming a 5th, large, (mostly) invisible spacetime dimension hidden beneath our noses. (See the further discussion of this idea in: "The "Spacetime Map" as a Model of a 5-Dimensional Holographic universe".) The fact that we see distant galaxies where they were, not where they are, demonstrates the existence of this 5th spacetime dimension, which resides in the invisible gap between where galaxies are "now", and where we actually see them.

The great historical body of the universe (historic spacetime) is the conservation domain and repository of matter's "causal matrix"; not just our own, but of all bound energy forms in the universe. This area (the bulk of the real surface area of the diagram both above and below Earth's light line, mostly invisible to us) is the causal domain or 5th dimension of spacetime, an area which must remain real because all of it is in some observer's light line or "active past" (or could be), and all of it continues to exert influence on various parts of the universe through the long-range effects of gravitation, electromagnetism, quantum entanglement, information, and other propagating physical, causal, and temporal linkages. (Because the historical/spatial gap between us and all distant galaxies apparently contains an extra full set of our usual 4 large dimensions, there is some reason to wonder if our universe actually has 8 dimensions rather than 4 or 5.)

Once an object enters the domain of our historic past, passing through the nexus of our present moment (where two-way interaction is possible), we are causally connected with that object, and therefore its associated universe can never disappear entirely from our light line, which bounds the area of our historic causal matrix. For example, Julius Caesar is causally connected with us historically, and stars 2,050 light years away, which are part of his associated universe, are obviously readily visible to us; moreover, we will forever remain able to see some part of his associated universe. The extension of this idea also means that we are causally connected, through our historic past, to every star and galaxy we can see in our light line, no matter how distant, because if for no other reason, we were all born together in the Big Bang, and we all passed together through the long plasma era of thermal equilibrium, mutual interaction, and causal entanglement.

The dismal notion that the future universe will, due to its continued expansion or even accelerated expansion, become "empty" and lonely is only partially true. It may certainly become more redshifted, but it will never become completely invisible, as causal connections, once formed, cannot be broken. Furthermore, our "naked eye" universe, to which we are gravitationally bound (our galaxy and its "local group"), will not change due to future cosmological expansion. We will always have many hundreds of billions of stars for nearby companions. (We should not worry too much about the fate of the human species a billion or more years from now; in that length of time evolution will have changed us unrecognizably - if any of our descendants still exist. Recall that a billion years ago our predecessors and relatives were still single cells.)

The Cosmological Expansion of Spacetime

The expansion of the cosmos from the moment of the Big Bang until "recombination" - when free electrons could take up orbits around protons and the cosmos was cool enough to change from an optically opaque ionized plasma to an optically transparent and electrically neutral gas - this early period of expansion was driven entirely by the primordial entropy drive of light (an entropic expansion which continues to this day). The expansion and cooling of spacetime is the result of the intrinsic motion of light, which is the primordial entropy drive of free energy. The intrinsic motion of light creates, expands, and hence cools spacetime. During the plasma phase of the cosmos, a period of approximately 300,000 years, photons outnumbered particles (protons, electrons, helium nuclei) by a factor of (about) ten billion to one - the plasma was overwhelmingly photons, which is why it was able to expand and become our universe rather than collapsing immediately in a black hole. (See: *The First Three Minutes* by Steven Weinberg).

The matter and radiation of the plasma era were in thermal equilibrium - they interacted freely and constantly, the matter was as hot and energetic as the photons, moving at nearly velocity c. The motion of the particles themselves was completely random and hence could have no net movement other than a uniform expansion, driven by the intrinsic motion of light. The particles were driven apart from each other because they were coupled to the one-way (expansive) and constant (entropic) intrinsic motion of light, which also caused an expansion of the space between them. Because the particles were coupled with light during the plasma era (due to their electric charges), they behaved like the light, moving apart from each other with the entropy driven expansion of the spatial universe. The entropic motion of free energy (light) was transferred to bound energy (particles) via the coupling between light and matter's electric charges. There was negligible gravitational coupling between particles during the plasma era as the kinetic energy and momentum of the particles was much too great.

The "Hubble Flow"

The consequence of this contest between two entropy drives, one of free energy (light's intrinsic motion and the expansion of space) and one of bound energy (gravity, time, and the expansion of history), is the standard model of spacetime expansion, in which discreet gravitationally bound clumps are embedded in a spacetime which expands (and cools) in every direction around them, giving observers everywhere the visual impression of galaxies receding from them in a spherical halo with an increasing velocity proportional to their distance (the "Hubble flow"). One addition my Spacetime Map makes to this standard view (besides the "light line" and the suggestions above), is to fix our position as an observer (and the position of every observer) at the furthermost "edge" of the cosmos (in the "universal present moment"), looking back in spacetime toward a center (the Big Bang) which completely surrounds us despite the fact that the universe becomes progressively younger and hence smaller as we look outward in space. It is just this difference in the size of the nested set of ever smaller universes we observe that produces the cosmological redshift of the receding galaxies.

Another factor contributing to the observational effect of the symmetric distribution in space of all receding galaxies is that the universe can have no visible spatial "edge", because all of space is contained within it (a "3-sphere"). There is no space outside it into which we can look. When we try to look "to the edge of the universe", which people (including many astronomers), generally seem to think is somewhere "out there" in deep space, we can only look backward in time toward the spacetime center and beginning of the universe (the Big Bang), which, paradoxically enough, completely surrounds us (at least visually). Since we can only look toward the center of the universe into more space, we, and all other observers, can only see a symmetric dispersion of galaxies in every direction (the consequence of the entropic dispersion of the primordial "gas"). All observers are receding from the central spacetime event of the Big Bang with the same velocity in time - all observers in the universe necessarily exist in a region of spacetime on its expanding edge which is exactly as old as the universe itself, and all see the universe as we do. The linkage between the spatial and temporal dimensions of the cosmos cannot be decoupled from the perspective of any material observer.

The "edge" of the universe, like its center, is 4-dimensional in spacetime, not 3-dimensional in space. Thus we see the center when we look outward but only backward (in time) to the Big Bang, and the "edge" when we try to look forward (in time) of our present spacetime position into the future, and discover we cannot. The anticipated blackness beyond the "edge" of spacetime is the blackness of the unknowable future. Our present position in spacetime is on the "edge" of the 4-dimensional universe, where we coexist with all other observers in the universal "now", and uniformly move with them into the future. It is the arrow of time, and the very curious fact that the universe has an actual beginning (apparently correctly intuited by every early indigenous society as expressed through "creation myths"), that allows us to discover our orientation in the otherwise confusingly symmetric domain of space. While in spatial terms our view of the heavens is symmetric and "static" (due to scale), in temporal terms we find a definite sense of asymmetry, direction, and motion. When we look forward into the future we look into the blackness of "no space" beyond the "present moment" edge of the cosmos, while behind us in the past lie all the galaxies, those nearby (gravitationally bound) hardly moving at all, those further and further away (in every direction) receding faster and faster, their recessional velocity proportional to the amount of expanding spacetime between us and them. Such is the view from the bridge of "Spaceship Earth", as we all move in time at metrically equivalent light speed toward an unknown, invisible, and (partially) unformed tomorrow.

It must be clearly understood that the observed symmetric dispersion and recessional velocity of the distant galaxies is not simply a perceptual consequence of our fortuitous position on the furthermost spacetime edge of the universe. Our view of the universe (and that of all material observers) is constrained by the metric relationship between time, space, light, and matter, including the fact that matter (including material observers such as ourselves) moves with an intrinsic motion in time which is the metric equivalent of light's intrinsic motion in space. We do not see objects in space; we see lights in spacetime (the multiple images produced by gravitational lensing demonstrates this point). The Spacetime Map emphasizes the difference between "being" and "seeing". We don't have a choice regarding how we do either one. The seemingly arbitrary constraints placed by the map upon our view of the cosmos are due to this metric (and gravitational) regulation of light, time, matter, and the spatial dimensions which their primordial entropy drives ("intrinsic motions") force upon us.

The iron linkage between time, space, light, and matter established by the electromagnetic metric of spacetime as "gauged" or regulated by "velocity c", means that the intrinsic motion of massive objects in time (such as galaxies) is metrically equivalent to the velocity of massless light. These intrinsic motions (c, t) are the primordial entropy drives of free and bound electromagnetic energy, respectively. This metric equivalence is regulated by the electromagnetic constant c, and is a necessary basis for energy conservation in interactions between light and matter within their shared dimensional domain of spacetime. The map reflects this metric equivalency by according space and time equal mapping parameters at right angles to each other, mapping "t" against "ct". We are aware of our temporal motion but not our spatial motion, whereas light's "clock is stopped" and light is "aware" of only its spatial motion. The map "works" because it reflects the natural relationship between time, space, light, and matter established by the electromagnetic constant c as the *spacetime metric*, in which "velocity t" of massive objects (bound electromagnetic energy) is recognized as the metric equivalent of "velocity c" of massless energy forms (free electromagnetic energy).

Conclusion

Having addressed our original question concerning the construction of a map of the universe, we can now orient ourselves with respect to our position in, and view of, the cosmos.

We live on the edge of the cosmos in the "Universal Present Moment" of spacetime, as do all other material observers. As we look outward in space, we look in every direction backward in time toward the center of our cosmos, its beginning in the "Big Bang". We cannot see beyond the spacetime edge of our universe into the future, nor beyond its center into a past preceding its origin.

Neither space nor time can be seen in their pure forms, for otherwise we could see the present spatial universe and our own past. We see only light, an electromagnetic vibration of spacetime, whose finite velocity constrains our view to a personally unique sequence of spherical spacetime shells receding to the "Big Bang". We are fortunate, nevertheless, to be able to see a sample of the developmental history of our universe, as this information will ultimately be more important for our understanding of the cosmos than a complete view of its present state.

[For a corresponding diagram and text of relativistic time dilation as it affects our view of very distant galaxies, see: Dr. Richard D. Stafford's "Spacetime Map".]

PART II

Appendix: Mapping Artifacts

Due to their inappropriate topology, and the loss of a single spatial dimension, flat maps of the whole Earth contain discrepancies of representation called "mapping artifacts": the poles are stretched into lines, Greenland is disproportionately large, the eastern and western hemispheres do not join, etc. Due to the loss of 2 spatial dimensions, our spacetime map contains even more severe mapping artifacts (the "spatial limit" line, for example). The most obvious problem was emphasized early in this article: the universe does not "look like" the map. Four other artifacts, some already mentioned, are discussed below:

1) Because of the joint effects of the one-way flow of time and the loss of 2 spatial dimensions, only one quadrant of the full circular map can be real for a specified observer. Furthermore, the map is strictly valid from the viewpoint of only one observer at a time. If interactions between two observers are considered, only the area between them (their "shared angle") is a valid map of what both see. The simultaneous view of three observers cannot be represented at all. (I am speaking here of observers widely separated on astronomical scales of distance.) The crux of the problem is that increasing distance from an observer must be represented only in one mapping direction; to do otherwise would recognize positive and negative spatial volumes. When a second observer is placed on the map, the same distance rule must be applied, but the direction of increasing distance for the second observer can only be back toward the first, because the observers must appear in each other's view of the cosmos. Hence regions of the map which do not lie between the two observers are excluded from mutual mapping interactions (such as the joint sighting of a third external position), because such positions must lie in the "negative space" of one or the other observer.

Although the full symmetry of the spatial circles generates the map conceptually, once we specify the position of the primary observer, 3/4 of the map immediately becomes unreal. However, the full circular map symmetry is appropriate for a universe composed only of light, because without the presence of matter it would be quite impossible to choose a specific point of reference on the outer circle from which to orient either time or distance. We can therefore think of the quartered (and curved) map as reflecting the broken symmetry of spacetime occasioned by the presence of matter, and the fully symmetric (and flat) map as representing the primordial generative form.

2) If we construct time lines from the Big Bang through all the intersections of the Earth's observer's circle with the 15 inner spatial circles, and project these time lines to present-day positions on the outer circle, we find that although these positions are separated by equal increments of time, they are not separated by equal distances on the outer circle. The unequal spacing is a consequence of the decreasing size of the inner spatial circles, and reflects the fact that objects were closer together in the early universe. Projecting these positions to the outer spatial circle produces a mapping artifact analogous to that causing Greenland to appear inappropriately large on flat maps of the Earth.

3) As we look outward in space, the surface area of our observational shell (the total area of observed sky at a particular distance) increases as the square of the radius of our depth of view. This increase in area is not reflected by the map. Because the observational shell is 2-dimensional, and we have lost 2 of the 3 spatial dimensions in the map, these shells, regardless of size, appear only as the dimensionless points of intersection of the observer's circle with the spatial circles. This brings up another point related to the fact that we see progressively smaller universes as we look out in space, but these are progressively "inflated" by observational shells that increase in proportion to the square of the radius of our depth of view. Our "inflated" view of the distant universe has the effect of flattening out any curvature of space due to gravity - similar to the observational effect claimed by Alan Guth's "inflation" theory. In this case, however, the inflation is due to the enlarged observational shells, not to spacetime itself. See the further discussion of this point in the postscript below.

4) Some readers may suppose that the arcs of the space lines and observer's circle represent "curved space",

or curved paths in space, even in the flat map of Fig. 1. This is not the case. The space lines are curved because they represent space of the same age (and hence the same distance from the Big Bang point of common origin), and the observer's circle is curved only because the space lines are curved. "Curved" spacetime is caused by gravitation, whose effects are illustrated by the spherical, egg, and bell-shaped maps discussed earlier. Gravitationally "curved" or "warped" spacetime can be represented by bending the paper upon which the map is drawn.

5) The "Redshift". Although not a mapping artifact, it seems convenient to discuss the "redshift" in this section (and see above and below). There are three types of "redshift": one is due to the effect of strong gravitational fields (gravitational redshift); a second is due to the effect of retrograde relative velocity (Doppler redshift); and a third is due to the expansion of spacetime, the difference in size between the universe of light's source vs the universe of light's observer (cosmological redshift). Due to the operation of the cosmological redshift, all distant galaxies appear "redshifted" in proportion to their distance: the greater their distance, the smaller the size of the universe in which we see them as compared to our own, and hence the greater their redshift. From the redshift observations of distant galaxies, first attributed to Vesto Slipher, Edwin Hubble, and Milton Humason (Mt. Wilson, 1929), we have concluded that the universe has expanded from very small beginnings to its present immense size.

We imagine the initial ("Big Bang") expansion of light and particles as wholly entropic, driven by the overwhelming preponderance of photons compared to particles (in a ratio of about 10 billion to one, the aftermath of the primordial annihilation event between matter and antimatter). During the first 300,000 years (the "plasma era"), photons and particles are coupled and in thermal equilibrium, and both expand entropically as if the particles were also photons. After "recombination", when atoms formed and the cosmos became transparent to light, light and particles decoupled, but particles kept right on dispersing entropically as before, due to the conservation of their considerable momentum (they would otherwise have formed a cosmic black hole).

Evolution has not prepared our minds to think about or intuit at either the microscopic scale of quantum mechanics, or the macroscopic scale of cosmology. Consequently, all attempts to describe the cosmological expansion of spacetime leave us (at least) vaguely dissatisfied and we must resort to abstractions and "hand waving". What we can say is that the process is driven by entropy in the primordial form of the intrinsic motion of light. The standard model of "raisins embedded in a rising bread dough" or "dots painted on the surface of an expanding balloon" seem to be about the best we can manage for a mental image of the process. Leaving aside (for the moment) the speculative issue of "inflation", we note that the expansion is (at least) 4-dimensional, taking place in one-way time as well as 3-D space. Furthermore, the particles and photons are in thermal equilibrium (during the "plasma era"), with the particles moving and expanding as if they were light. From the point of view of any one particle, wheresoever it may be situated, all other particles will appear to be moving away from it as the entire mass expands and disperses. And this apparent (or actual) motion will be in proportion only to the distance between them and the observer - particles further removed will appear to be moving away faster because there is more intervening, expanding space. And all particles will "see" those furthest removed from themselves as moving at (very nearly) velocity c: all such views will be reciprocated among all particles. This is probably the best we can manage for a visual image. It ends up today with our (reciprocal) views of far-flung galaxies receding in proportion to their distances, deep sunk in time because of the finite velocity of light and the fact that they are all continuing to expand away from us, the most distant at (nearly) velocity c. Exactly how the galaxies and galactic clusters managed to form and cohere within this expanding "gas" of photons and particles is still being actively debated; it is currently thought that "dark matter" must have been involved as gravitational "seed" material.

Notice that there are two effects possibly contributing to the redshift of these distant galaxies: 1) the actual motion of the galaxy itself, which is proportional to the amount of empty space expanding between us and them; 2) the size difference between the present universe and the observed universe, obviously a consequence of this motion. In addition, there is a relativistic time dilation (and space contraction) effect ("moving clocks run slow", etc.), as Dr. Stafford" points out, which disproportionately affects our view of the more distant and faster-moving galaxies. Remember, however, that all such effects are reciprocal - they see us as we see them, and therefore, in a certain sense, "cancel out". This reciprocity also reminds us that we, too, are participating in the spatial expansion of the cosmos, although the red shift of the distant galaxies is the only way we discover this fact. Our actual experience of this motion is restricted to its metric equivalent in the temporal dimension - the march of time.

All this means the interpretation of the luminosity and redshift of very distant galaxies and supernovas may be fraught with hidden pitfalls and uncertainties, so we should not rush to judgment concerning the fate of an "accelerating" universe. (The universal expansion is in fact accelerating, as we will see later, but by how much and why is the issue.) My plotting of the data (see graph) suggests that the size difference parameter is the crucial factor in determining the "redshift", summing up the effects of all other contributing factors. (See: Delsemme pages 23 - 32); (See: "Gravity, Entropy, and Thermodynamics".)

6) Finally, I wish to point out the remarkable fact that we are able to construct a four-dimensional map of (flat) spacetime while still adhering to Euclid's rules for geometric constructions, using only a straightedge and a draftsman's compass.

Cosmological Redshift (Z) Values for the Spacetime Map

Values for the Redshift and the Hubble Constant

The redshift parameter (Z) is calculated by the procedure: wavelength observed minus wavelength emitted, the remainder then divided by the wavelength emitted = Z. In other words, the change in wavelength divided by the original wavelength - the part divided by the whole - equals Z, the redshift, the % change in wavelength. Z can have any value from zero to infinity. The 2.7 degree Kelvin cosmic background radiation is thought to have a Z value of about 1100.

Assuming the *cosmological redshift* has its origin only (or equivalently) in the size difference between the universes of observer and observed, we can directly calculate the redshift we "should" see for each of the billion year intervals of the Spacetime Map, simply substituting the map's radius in years for the wavelength of light. For example, a very distant galaxy observed at the intersection of our light line with the 4-billion-year spacetime arc (that is, seen when the universe was only 4 billion years old), should have (in a 12 billion year-old cosmos) a redshift or Z value of (12-4)/4 = 2; in a 13.7 billion year-old cosmos the equivalent calculation yields Z = 2.425.

The "Hubble Constant" (velocity of recession per unit of distance) is the velocity required per unit of distance to collapse (or expand) the universe in the time available (the assumed age of the universe). The Hubble constant is calculated in this paper simply by dividing velocity c by the size (radius or age) of the universe, then multiplying that result by some distance unit of choice, such as a million light years, or a megaparsec (3.26 million light years). The rationale for this procedure is the assumption that the cosmological expansion is primarily driven by the entropy of free energy, the intrinsic motion of light. Therefore, our baseline or first estimate of the expansion rate is founded upon the assumption that it converges upon velocity c. Gravitational inputs, of course, will somewhat reduce this velocity, "curving" the map, "warping" spacetime. Unfortunately, we do not yet know how much gravity to add to our model - we do not know by how much the spacetime map should be "bent". However, as these calculated Hubble constant values for expansion at velocity c (in the 14 billion year old universe) are almost exactly the same as the recent observational data from the NASA WMAP satellite, it appears there is in fact very little gravitational slowing of the universal expansion, at least currently (the Hubble "constant" changes as the universe evolves, due to the cosmos' changing size, age, and gravitational environment). (See *Sky and*

Telescope May 2003 page 16). (See the discussion in appendix point 3) (above) regarding the "flatness" of the observed universe.)

In the table below, note that the value of Z rises sharply as the universe becomes young and small. The deeper we look, the more the increasing size differential between the universe of observer and observed seems likely to complicate the interpretation of high-redshift data. The problem is surfacing now only because the new generation of large and space-based telescopes can, for the first time, see into the region of "exploding" Z values.

Below I list the redshifts or Z values as calculated for universes 12 -18 billion years old, using only the billion-year integers as inputs. In the 16 billion-year universe, recessional velocities have also been calculated from the Z values, and are presented after the Z value in units of thousands of kilometers per second.

For purposes of comparison, in the 15 billion year universe column the second entry is calculated for a closed universe which at 15 billion years is halfway to its maximum expansion (designated "closed 30", or "Zc30"); the third entry in this column is for a closed universe ten times larger than Zc30 (designated "closed 300", or "Zc300"). Note that the size differentials, and hence the Z values, of these closed universes are changing much more slowly than the open case, which has no gravitational input. Note also that it might be difficult to distinguish between the two closed cases observationally, at least in their present assumed early stage of development (both only 15 billion years old). We expect observed values for our actual, present day universe to fall between the open and closed examples. Z values for the "closed 300" universe example will be approximately the same (during the first 15 billion years of its development) as for a universe which is poised between open and closed, the "critical density" universe, which is the reason for its inclusion.

The "closed universe" entries were calculated using the relative lengths of the "latitude" lines on a sphere with radius 30 or 300 units (representing 30 or 300 billion light years), beginning from the zero point, Big Bang, or "North Pole", and working "south" 15 units toward the "equator", or region of maximum expansion (see diagram, and the discussion of gravitationally curved 4-dimensional metric surfaces in earlier parts of this paper).

The formula for converting Z values into velocities is (5):

{[(Z+1)sq -1] divided by [(Z+1)sq +1]} times c = recession velocity

(where sq means squared, and c is the velocity of light (300,000 km/sec)

The table assumes no gravitational input (other than "Z30" and "Z300", see above). Gravity exactly equal to the "critical density" (a universe balanced between open and closed) would reduce the age associated with a given Hubble constant by about 33% (8).

Currently the best estimate for the age of the universe suggests it is 13.7 billion years old, give or take 200 million, and evidence indicates the universe is flat and near critical density, with a Hubble constant around 71 (plus or minus 4) kilometers per second per megaparsec (Sky and Telescope May 2003 page 17); the observed Z data should conform roughly to the scale listed for the 13-14 billion year columns. However, the calculated Z values in these columns are maximum values, as they assume uniform expansion at light speed, without any gravitational deceleration (except "Z30" and "Z300", see above). It is obvious that a modest gravitational input is required to bring the bottom values of the table into reasonable agreement with the higher observed values of Z (see the table footnotes and column "Z300" values). First values in the table columns are interpolations.

While the approximations of the table and the data inputs are very "rough", they are good enough to confirm that the map "works" empirically and operationally (see graph) - it is properly constructed in that observational data can be sensibly plotted on it, and likewise, reasonable approximate expected values can be calculated from it. Finally, we can fairly assume that the Map would work even better if we knew how to "bend" it gravitationally. Note in this regard that the value of the Hubble constant calculated for our 14 Gyr Map universe (69.8) is almost exactly the same as the observed value (71) obtained (at considerably greater expense) by the recent NASA WMAP satellite (Sky and Telescope May 2003 page 17). It must be understood that the graph only intends to demonstrate the general validity of the model and our mapping method. It is not intended to show the finer details of Cosmic "acceleration" or "deceleration", etc. Nevertheless, all things considered, there is a remarkably good fit between the (averaged) observational data and the values calculated from the bare map parameters.

Redshift (Z) Values as Calculated From the Parameters of the "Spacetime Map" (no observational data)

ASSUMED AGE OF UNIVERSE (top of table is present moment; bottom is Big Bang origin)													
18 Billion Year Age Hub. Const. = 54.3 km/sec/Mpc		17 Billion Year Age Hub. Const. = 57.5 km/sec/Mpc		16 Billion Year Age Hub. Const. = 61.1 km/sec/Mpc		15 Billion Year Age Hub. Const. = 65.2 km/sec/Mpc		14 Billion Year Age Hub. Const. = 69.8 km/sec/Mpc		13 Billion Year Age Hub. Const. = 75.2 km/sec/Mpc		12 Billion Year Age Hub. Const. = 81.5 km/sec/Mpc	
Age Bil Yrs	Z	Age Bil Yrs	Z	Age Bil Yrs	Z=redshift; R=recess. Velocity (1000 km/sec) Z; R	Age Bil Yrs	Z open; Z closed 30; Z closed 300 Zo; Zc30; Zc300	Age Bil Yrs	Z	Age Bil Yrs	Z	Age Bil Yrs	Z
18	0.03	17	0.03	16	0.03; 9.5	15	0.04; 0.01; 0.01	14	0.04	13	0.04	12	0.05
17	0.06	16	0.06	15	0.07; 19	14	0.07; 0.02; 0.03	13	0.08	12	.08	11	.09
16	0.13	15	0.13	14	0.14; 39	13	0.15; 0.05; 0.07	12	0.17	11	.18	10	.2
15	0.2	14	0.21	13	0.23; 61	12	0.25; 0.08; 0.12	11	0.27	10	.3	9	.33
14	0.29	13	0.31	12	0.33; 83	11	0.36; 0.12; 0.16	10	0.40	9	.44	8	.5
13	0.38	12	0.42	11	0.45; 107	10	0.50; 0.16; 0.22	9	0.56	8	.625	7	.71
12	0.5	11	0.55	10	0.6; 131	9	0.67; 0.21; 0.28	8	0.75	7	.86	6	1
11	0.64	10	0.7	9	0.78; 156	8	0.88; 0.27; 0.36	7	1.0	6	1.16	5	1.4
10	0.8	9	0.89	8	1.0; 180	7	1.14; 0.35; 0.45	6	1.33	5	1.6	4	2
9	1.0	8	1.13	7	1.29; 204	6	1.50; 0.44; 0.57	5	1.8	4	2.25	3	3
8	1.25	7	1.43	6	1.67; 226	5	2.0; 0.57; 0.72	4	2.50	3	3.33	2	5
7	1.6	6	1.8	5	2.2; 247	4	2.75; 0.73; 0.92	3	3.67	2	5.5	1	11
6	2.0	5	2.4	4	3.0; 265	3	4.0; 0.98; 1.22	2	6.0	1	12	0	--
5	2.6	4	3.25	3	4.3; 279	2	6.5; 1.41; 1.71	1	13	0	--	.	.
4	3.5	3	4.7	2	7.0; 291	1	14; 2.38; 2.82	0	--	.	.	.	.
3	5.0	2	7.5	1	15.0; 298	0	--	.	.	.	.	.	. .
2	8.0	1	16.0	0	--	.	.	.	.	.	.	.	.
1	17.0	0	--	.	.	.	.	.	.	.	.	.	.

Observational Data - Z Estimates From Various Sources - for Comparison with Above Table of Map Calculated Entries (Gyr = billion years age, or billion light years distance); (Note that 1+Z = factor of expansion); (See also graph of 13.7 Gyr cosmos. The references below are the data inputs to the graph.)

1a) Z = 0.04 = 0.4 Gyr distant; *Nature* Vol. 410, 8 Mar 2001, p. 153.

1b) Z = 0.145 = 2 Gyr distant; *Science* Vol. 301, 29 Aug 2003, p.1218.
1c) Z = 0.158 = 1.96 Gyr distant; *Sky and Telescope* March 2006 page 70.
1d) Z = 0.1685 = 2 Gyr distant (*Sky and Telescope* July 2003 page 18).

2a) Z = 0.25 = 3Gyr distant (*Sky and Telescope* Dec. 2003 page 19).

3a) Z = 0.3 = 3.5 Gyr distant; *Science* 293(5533):1273-8 17 Aug. 2001.
3a1) Z = 0.31 = 3.4 Gyr ago; *Sky and Telescope,* Oct. 2007, page 21.

4a) Z = 0.5 = 5 Gyr distant; *Science* 293(5533):1273-8 17 Aug. 2001.

4b) Z = 0.57 = 5.5 Gyr distant; *Sky and Telescope* March 2006 page 70.

5a) Z = 0.6 = 6 Gyr distant; *Science* 293(5533):1273-8 17 Aug. 2001.
5a1) Z = 0.68 = 6 Gyr distant; Sky and Telescope Oct. 2006 page 22.
5a2) Z = 0.702 = 6 Gyr distant; *Einstein's Telescope*, Evalyn Gates, Norton, 2010, page 155.

6a) Z = 0.8 = 7 Gyr distant; *Science* 11 April 2003 page 270 - 4.
6a1) Z = 0.82 = 6.8 Gyr ago; *Sky and Telescope,* Oct. 2007, page 21.

7a) Z = 1.0 = 8 Gyr distant. *Science* 293(5533):1273-8 17 Aug. 2001.

7b) Z = 1.33 = 8.9 Gyr distant; *Sky and Telescope* March 2006 page 70.
7b1) Z = 1.4 = 9.1 Gyr distant. *Sky and Telescope* Nov. 2005 page 38.

7c) Z = 1.44 = 9.2 Gyr distant; *Sky and Telescope* March 2006 page 70.

7d) Z = 1.69 = 9.8 Gyr distant; *Sky and Telescope* March 2006 page 70.
7d1) Z = 1.7 = 10 Gyr distant (supernova); *Sky and Telescope* July 2001 page 20; (fits 16 bil yr. cosmos, or younger with gravity).
7d2) Z = 1.74 = 10 Gyr distant (quasar); Sky and Telescope Oct., 2006 page 22.

8a) Z = 2.0 = 10.3 Gyr ago; *Sky and Telescope,* Oct. 2007, page 20.
8a1) Z = 2.01 = 10.3 Gyr distant;*Sky and Telescope* March 2006 page 70.
8a2) Z = 2.07 = 10.4 Gyr distant; *Sky and Telescope* March 2006 page 70.

8b) Z = 2.15 = 11 Gyr distance (fits in 16 bil yr. cosmos; fits younger cosmos with gravity); *Sky and Telescope* 103(6):19.
8c) Z = 2.515 = 11 Gyr distant; *Einstein's Telescope*, Evalyn Gates, Norton, 2010, page 156.

9a) Z = 3 = 2 Gyr old universe (fits at about 3 Gyr old) (*Science* 23 Jan 1998 page 479).
9a1) Z = 3.16 = 11.6 Gyr distant; *Sky and Telescope* March 2006 page 70.

9a2) Z = 3.36 = 2 Gyr old cosmos; *Science* 7 Nov. 2003 page 951-2.

9b) Z = 3.7 = 12.0 Gyr ago; *Sky and Telescope,* Oct. 2007, page 20.
9b1) Z = 4.0 = 12 Gyr distant or 11 % of present age (fits 15 bil cosmos) (*Sky and Telescope* 102(3):44).
9b2) Z = 4.10 = 12.1 Gyr distant; *Sky and Telescope* March 2006 page 70.

9b3) Z = 4.35 = 12.2 Gyr distant; *http://cerncourier.com* April 1, 2009 (GRB 080916c).

10a) Z = 4.75 = 12.4 Gyr distant; *Sky and Telescope* March 2006 page 70.

11a) Z = 5.0 = 1Gyr after Big Bang (*Nature* Vol. 421 page 329 Jan. 23, 2003).
11a1) Z = 5.0 = 1.2 Gyr after Big Bang; *Sky and Telescope,* April 2006, page 20.

11b) Z = 5.576 = 12.6 Gyr distant; *Einstein's Telescope*, Evalyn Gates, Norton, 2010, page 156.
11c) Z = 5.58 = 4% of age of cosmos (about 0.56 Gyr; requires gravity to fit anywhere); *Sky and Telescope* 103(1):17.
12a) Z = 5.7 = 12.6 Gyr distant. *Sky and Telescope* Nov. 2005 page 38.
12a1) Z = 5.8 = 13 Gyr distant quasar in 14 billion year old cosmos (fits at about 2 bil years old; better fit with gravity) (Sloan Digital Sky Survey).

12a2) Z = 6 = 13 Gyr ago; Data from Chandra X-ray Observatory - *Sky and Telescope* Aug. 2002.
12a3) Z = 6.2 = 12.8 Gyr ago; *Sky and Telescope,* Oct. 2007, page 20.
12a4) Z = 6.28 - Quasar; cosmos less than 1/7.3 present age and 800 million years old (fits at about 2 bil years old; better fit with gravity) (Sloan Digital Sky Survey: *Nature* 27 June 2002 page 905).
12a5) Z = 6.29 - gamma ray burst (GRB 050904) - cosmos less than 1 Gyr old - SPACE.com 12 Sept. 2005
12a6) Z = 6.42 = 870 million years after Big Bang. *Sky and Telescope,* Feb. 2005, page 19 (QSO J1148 + 5251).

12a6a) Z = 6.43 = 12.83 Gyr distant; *Sky and Telescope* Sept. 2009 p. 27 (CFHQS J2329-0301).
12a7) Z = 6.5 = 800 million years after the Big Bang. *Sky and Telescope,* Feb. 2005, page 18.
12a8) Z = 6.65 = 0.780 Gyr after Big Bang; (requires gravity to fit anywhere); *Sky and Telescope* 103(6):28.
12a9) Z = 6.7 = 12.9 Gyr distant; *www.scientificblogging.com* April 28, 2009 (GRB 080913).
12a9a) Z = 6.7 = 12.8 Gyr distant; *Einstein's Telescope*, Evalyn Gates, Norton, 2010, page 157.
12a10) Z = 6.96 = 12.88 Gyr distant; *www.scientificblogging.com* April 28, 2009 (galaxy 10k-1).
12a11) Z = 7 = 800 million year after Big Bang. *Sky and Telescope,* Feb. 2005, page 19.

13a) Z = 7.6 = 650 to 800 million years after Big Bang. *Sky and Telescope,* Feb. 2005, page 18.
13a1) Z = 7.9 = 650 million years after Big Bang. *Sky and Telescope,* Feb. 2005, page 18.
13a2) Z = 8 = 650 million years after Big Bang. *Sky and Telescope,* Feb. 2005, page 19.

13a3) Z = 8.26 = 13.1 Gyr distant; *www.scientificblogging.com* April 28, 2009 (GRB 090423).

14a) Z = 10 = few hundred million years after BB. *Science* 293(5533):1273-8 17 Aug. 2001.
14a1) Z = 10 = 500 million years after Big Bang. *Sky and Telescope,* Feb. 2005, page 19.
14a2) Z = 10 = 1 Gyr after Big Bang. *Science* 18 Aug. 2006 page 926.
14a3) Z = 10 = 500 million years after Big Bang. *Sky and Telescope,* Oct. 2007, page 16.

15a) Z = 11 or 12 = 400 million years after Big Bang. *Sky and Telescope*, June, 2006, page 22. (first stars appear)

15a1) Z = 17 = 400 million years after Big Bang. *Science* 18 Aug. 2006 page 926.

16a) Z = 18.3 = 13.4 Gyr distant. *Sky and Telescope* Nov. 2005 page 38.

17) Distant supernovae are unexpectedly dim, hence more distant (brightness/redshift); expansion rate is 15% greater now than when universe was 1/2 its present age (data from 7 billion light year distant supernovae) (supernova redshifts in these observations range from Z = 0.18 - 0.83) (*Science* 18 Dec. 1998, page 2156). (For a luminous discussion of the "accelerating universe" see pages 164-165 in: Robert P. Kirshner: "*The Extravagant universe*". Princeton University Press, 2002. See also: Richard Panek: "Going Over the Dark Side". *Sky and Telescope* Feb. 2009, pages 22-27.)

18) Because the universe is constantly converting its original mass into light (via nuclear fusion/fission and gravity, especially quasars), but no known process adds to the original mass, we expect the total gravitational field of the universe to decrease with time (since light moving freely in space produces no gravitational field). Hence a small "acceleration" of the Cosmic expansion (actually a small reduction in the rate of gravitational deceleration) is to be expected from this mass and gravity loss. However, if the early universe converted mass to light at a much higher rate than today (vigorous star formation, galaxy mergers, quasar and black hole formation, etc.), a significant reduction to the total gravitational field during that era could result. Black holes, for example, can convert a considerable percentage of a particle's rest mass into free energy as it falls toward and through the "event horizon".

It has been objected that the conversion of bound to free energy in stars is not sufficient to account for the observed acceleration of the cosmos; however, if the conversion of bound to free energy also occurs in the non-baryonic "dark matter" presumed to be five times more abundant than the ordinary baryonic matter of the stars, then such universal processes, driven by the conservation of the symmetry of free energy, whether that energy is "dark" or "light" (as demanded by "Noether's theorem"), might well be sufficient to account for the observed lessening of the gravitational deceleration. Evidence that such processes are indeed occurring has recently been found: see: *Science* Vol. 322, 21 Nov. 2008 page 1173; see also: *Science* Vol. 324, 8 May 2009 page 709. Also, the contribution from black holes and quasars may be more significant than has been realized. Finally, the existence and decay of a fourth, heavy "leptoquark" neutrino might even account for the deceleration within the limits of "ordinary" baryonic matter. (see: Entropy, Gravitation, and Thermodynamics).

If a "cosmological constant" is postulated as either the cause of, or a contributing factor to, the recently observed "acceleration" of the cosmos, it should be in the context of some conservation law or function, such as entropy. If the "cosmological constant" were an entropy function of the spacetime metric, causing an "intrinsic" expansion of the metric over time, then we could more readily understand and accept its role in the expansion of the metric during the early moments of the "Big Bang", and its contributions to the accelerated expansion of the cosmos in later times, as recently observed.

19) The graph of the 13.7 Gyr cosmos demonstrates empirically that the map is correctly constructed - observations reported in the literature (above) fall on or between "limit lines" calculated directly from the bare parameters of the map - as they should (see also the table of data inputs for this graph).

Postscript: The Cosmological "Horizon" Problem

Note to readers: This postscript has been added to the original paper in response to a recent *Scientific American* article in which an inappropriate illustration of spacetime was used to demonstrate the "cosmological horizon problem". While this postscript does directly point up the general need for a better spacetime map, it is not necessary to a reading of my original paper. This postscript will be most useful to those with the Sci. Am. illustration in hand (unfortunately, apparently not available from their website.)

The "cosmological horizon problem" consists of the notion that widely separated regions of our universe cannot have had enough time, given the finite velocity of light and the age of our universe, to communicate with each other since their common origin in the Big Bang. Although "their common origin" makes this notion seem ludicrous on first encounter, it apparently has an observational basis, as illustrated in a recent *Scientific American* article (January 1999, vol. 280 no. 1, page 69). In this example, two galaxies, each 12 billion light years distant from Earth, but seen in opposite directions, cannot have had enough time since the beginning of the universe to "see" each other, since the universe is less than 24 billion years old. This supposition, however, is at odds with data regarding the cosmological background radiation, which is uniform to within one part in 100,000. If widely separated regions of the universe have never been in communication with each other, how could the great uniformity of the background radiation, which implies a period of general cosmic and thermal equilibrium, have been established? The "inflation" theories of Alan Guth and others have been proposed to resolve this paradox.

Considerations stemming from a properly constructed four-dimensional "Spacetime Map" however, suggest the "horizon" problem is bogus, resulting from a misinterpretation of how we see the cosmos generally and at great depths particularly.

The Sci. Am. illustration is a typical example of this common misperception, even among highly placed professionals. Here, the two galaxies are shown at the "edges" of the universe, while observers on Earth are shown at the center. This is exactly the reverse of the actual situation: as the Spacetime Map makes clear, we view the universe from its edge, looking backward in time toward its center. We can only look backward in time as we look outward in space, to a center which apparently surrounds us (at least observationally), the background thermal radiation of the Big Bang itself. The universe has a center in spacetime, not in space. The spacetime center of the universe is its beginning in the Big Bang.

When we construct a geometrically correct four-dimensional spacetime map, it at once becomes obvious that our common perception that faraway objects lie at the "edge" of the universe is completely wrong: we are at the "edge" of spacetime, since our present moment is at the furthermost remove possible in time and space from the Big Bang (the proof of which is that we can only look backward in time as we look outward in space). The observed galaxies of the Sci. Am. illustration should be placed toward the center of the universe, sunk in the past, much closer than we in time and space to the origin of the cosmos. Placing the observed galaxies at the edge of the universe rather than the center of the illustration is the reason why the expansion of the universe appears to cause the "horizon" problem, whereas in fact the expansion solves the problem. Of course, it is impossible with the type of diagram utilized by Sci. Am. to portray the actual four-dimensional situation.

The relevant question is not simply how far these galaxies are from us (which we can measure directly if we know their true luminosity), but how far they are from each other (which we cannot directly measure but can only infer), in their much smaller universe of 12 billion years ago, the era in which we now see them (according to the parameters of the Sci. Am. article). The fact that these galaxies are distant from us does not mean they are distant from each other; in actuality, given the same angle of observed separation (in this case, the maximum possible, 180 degrees), the further they are from us, the closer they will be to each other, since more distant universes are smaller.

Presumably, we know both galaxies are 12 billion light years distant because of their comparable "redshifts". The redshift is telling us that the spatial radius of the universe from which their light comes is significantly smaller than our own. On principle, the light from their smaller, early universe must nevertheless uniformly fill the larger radius of our present-day cosmos, stretching its wavelength, which produces the "redshift". Hence these galaxies cannot possibly be separated from each other by 24 billion light years (as the authors suggest), since the universe in which both reside is only about three billion light years in diameter (if our current universe is fifteen, as the authors assume). The perceptual paradox is that the further out into space we look, the wider becomes the radius of our spherical observation shell, but the smaller becomes the universe we actually observe.

However, if we know the redshift of the galaxies in question, and if we know the present age of the universe, then we can at least infer their maximum spatial separation. The only problem with the redshift is that it simply gives us a ratio between sizes, not the sizes themselves. We must know by some independent means the size of either our universe or that of the observed universe, before we can translate the redshift ratio to actual sizes and distances. Here we use the estimated age of the universe (15 billion years, according to the authors) and assume it has expanded uniformly at velocity C, without taking gravitational deceleration into account. The redshift of these galaxies ($Z = (15 - 3)/3 = 4$) would have to indicate that our present universe is 5 times larger than their own (factor of expansion = $Z + 1$), for this particular choice of numbers (and assumed conditions) to agree.

Another misrepresentation in the Sci. Am. illustration which contributes significantly to the illusion of a horizon problem is that the Earth is shown (in the top panel) receiving light from the galaxies as if all three were in the same present moment of our time. Clearly this is impossible, and directly contradicts the stated conditions that these galaxies are 12 billion light years from Earth. This explicitly means that we see them where they were 12 billion years ago, not where they are "now" (our time). Where they are now will not be revealed to us until 12 billion years in our future. We see them "now" in their 3 billion-year-old universe (if ours is fifteen); hence as we see them, their maximum separation from each other is 3 billion light years, not 24 - resolving the "horizon" paradox.

Thoughts About the Map and the "Horizon" Problem

A. The question of the maximum possible separation of two objects in spacetime - is this parameter related to the radius, diameter, or circumference of the universe? - is something of a brainteaser. The radius of the Earth is approximately 4,000 miles, its diameter 8,000, its circumference 24,000, and the maximum separation of objects upon its surface 12,000. None of this math works in 4-dimensional spacetime. The question is most easily resolved by considering our own situation. Assuming our universe is 14 billion years old, and has expanded at the speed of light, we are currently 14 billion light years from the Big Bang, the origin and center of spacetime. This is (currently) the maximum separation between any two objects in our universe - nothing can possibly be further from us than the Big Bang and still lie within our universe. Therefore, the length of the time line determines the maximum separation between objects in any of the smaller universes we observe - if they have a time line of 3 billion years, then 3 billion light years is the maximum separation between any two objects in that universe. Hence there is always enough time in any universe for all its constituent parts to reassemble at their point of common origin, if they move at velocity C.

As noted earlier, all distant galaxies, wherever they may appear in our night sky, are in fact much closer together in a younger and smaller universe whose visual display and image (paradoxically) surrounds us completely. The observational spheres corresponding to our view of these smaller and younger universes nevertheless continue to grow in size as they recede into space, producing for us the "red shift" of deep space observations, the dark sky of "Olber's Paradox", and the impression of an "inflated" spacetime. We live at the outermost edge of spacetime (the oldest position) and look in every direction backward in time to younger and smaller historical eras of our universe, as we look outward in space to the Big Bang and the common beginning of space, time, light, and matter.

B. Since the size of our observational shells increases with distance, one might suppose the observed density of galaxies would decrease with depth of view. However, the increasingly large observational shells intersect increasingly densely populated regions of space, since the smaller, distant universes nevertheless contain the same total number (approximately) of galaxies as the larger, nearer ones. The two effects counterbalance each other, so that the density of galaxies does not appear to diminish with distance - as observed. There will, of course, be some visible evolutionary effects, especially in the early universe.

The peculiar way we are forced to observe our universe - we see successively smaller universes as we look deeper into space, but these are nevertheless seen in progressively larger observational shells which completely surround us - not only produces (or contributes to) the red shift of the distant galaxies, but reproduces some of the observational effects and "benefits" attributed to the "inflation" theory - specifically, the flattening of the geometry of space while simultaneously providing a solution to the "horizon" problem. Apparently, it is our view of the universe that is "inflated", not the universe itself. Since the "inflation" theory was invented specifically to solve these two problems, one must wonder about the theoretical foundations of this theory. How is the "inflation" theory related to, or required by, the conservation laws? Is inflation a type of entropy? If not, what is it - beyond an idea with an ad hoc utility, solving what is apparently a bogus problem? Perhaps inflation is useful or necessary to the "Multiverse" theory?

C. The very early universe expanded at (slightly) less than C since light (the driving force of the expansion) was in thermal equilibrium with matter. This is the plasma period of mixing and thermal equilibrium. Expansion at C occurred only after "recombination", about 300,000 years after the Big Bang. The uniformity of the background radiation, and the symmetric distribution of galaxies, is the consequence of this long period of thermal equilibrium, when all parts of the cosmos are in contact with each other.

D. As diagrammed in the Map, due to the finite velocity of light, in effect we "peel" the electromagnetic images of the galaxies away from their spatial positions on the outer circle of the Map. Beginning at the triple point of contact between light, space, and time in the observer's "present moment" (Earth's position), as we proceed into the past the light line falls progressively further and further away from the actual spatial position of the galaxies (the outer circle), until at the opposite pole of the universe, light, space, time, and matter meet again in the Big Bang.

E. Recent Thoughts Concerning "Inflation" (July 2010): Although the early "inflationary era" of the Cosmos (Alan Guth et al.) has nothing to do with the Spacetime Map as presented in this paper (the map is a representation of *how* we see the Universe, not *what* we see, and treats only the post-inflationary era), it is nevertheless appropriate to comment on this important cosmological topic, as it may set the stage for the map.

I have always been suspicious of the concept of "inflation" because of the bizarre concepts and language used to explain it (supercooled "Higgs field", "false vacuum", "negative" gravity, etc.). Nevertheless, recently it has occurred to me that inflation might be the evidence that our 4-D spacetime metric was simply torn apart by the violence of the initial energy input to the "Big Bang", resulting in a runaway, unregulated vacuum state characterized as "inflation". This chaotic quasi-dimensional state allowed the initial energy input to expand and cool until our ordinary 4-D spacetime metric could cope with the extreme energy density, at which point inflation ceased and the usual 4-D metric expansion of spacetime took over. This scenario seems to me to be a sensible interpretation of the inflationary era, including how it came to an end. How it began is another matter, but in this scenario it could not have begun in our 4-D spacetime, since our metric couldn't cope with such an intense energy density, and therefor certainly couldn't have created it. Hence the origin of the "Big Bang" energy must lie outside our dimensionality and Universe, evidently in the "Multiverse" and/or higher dimensional reality (or a-dimensional reality), the primal source of all energy for all Universes.

Links

Cosmology

- A Spacetime Map of the Universe (short text of conference talk)
- A Spacetime Map of the Universe (updated pdf diagram)

Gravitation

Entropy

References:

(1) Adams, C. and Shapiro, J. Sept-Oct 2001. The Shape of the Universe: Ten Possibilities. *American Scientist* Vol. 89(5):443-53
(2) Bahcall, N. A., et al. 28 May 1999. The Cosmic Triangle: Revealing the State of the Universe. *Science* 284 (5419): 1481-88
(3) Davis, M. Weighing the Universe. 8 March 2001. *Nature* 410(6825): 153-4
(4) Delsemme, A. *Our Cosmic Origins*. Cambridge University Press 1998.
(5) Emiliani, C. 1988. *The Scientific Companion*. John Wiley and Sons, Inc.
(6) Goldhaber, G. and Perlmutter, S. 1998. A study of 42 Type Ia Supernovae and a Resulting Measurement of Omega(M) and Omega(lambda). *Physics Reports* 307: 325-31
(7) Goobar, A., et al. 2000. The Acceleration of the Universe: Measurements of Cosmological Parameters from Type Ia Supernovae. *Physica Scripta* T85, 47-58
(8) Gribbin, J. 1999. *The Birth of Time*. Yale University Press.
(9) Guth, A. 1997. *The Inflationary Universe*. Helix Books, Addison-Wesley, Inc.
(10) Kirshner, R. P. 2002. *The Extravagant Universe*. Princeton University Press.
(11) Peacock, J. A., et al. 8 March 2001. A Measurement of the Cosmological Mass Density from Clustering in the 2dF Galaxy Redshift Survey. *Nature* 410(6825): 169-73
(12) Perlmutter, S., et al. 1 June 1999. Measurements of Omega and Lambda from 42 High-Redshift Supernovae. *The Astrophysical Journal* 517:565-86
(13) Perlmutter, S., Turner, M. S., and White, M. 26 July 1999. Constraining Dark Energy with Type

Ia Supernovae and Large-Scale Structure. *Physical Review* Letters 83(4) 670-3
(14) Silk, J. 2001. *The Big Bang* W. H. Freeman and Co.
(15) Weinberg, S. 1977. *The First Three Minutes*. Basic books, Inc.
(16) Sloan Digital Sky Survey, New Mexico Apache Point Observatory (www.sdss.org/)
(17) Two-Degree Field (2dF) Galaxy Redshift Survey, Anglo-Australian Observatory New South Wales (www.aao.gov.au/2df/)

Fig. 1: A Spacetime Map of the Universe

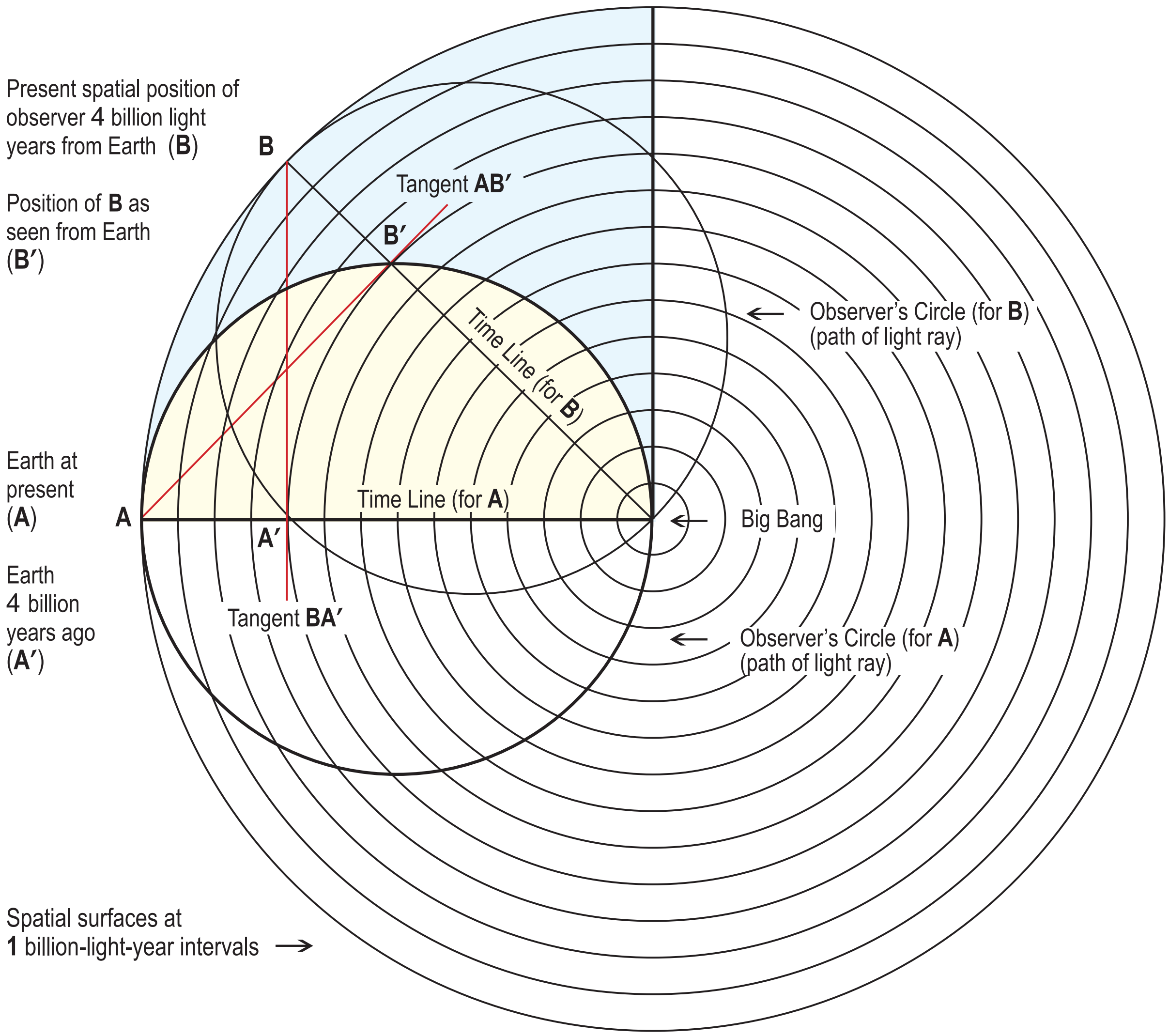
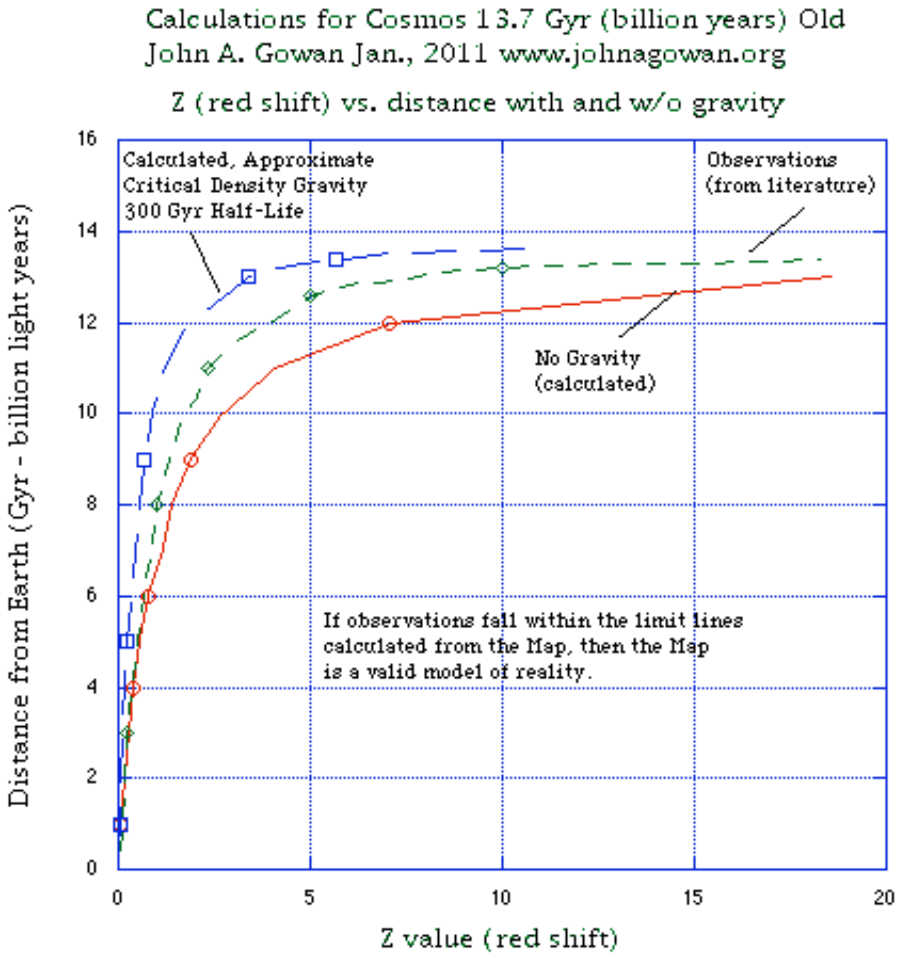


Figure 1: The Spacetime Map Diagram

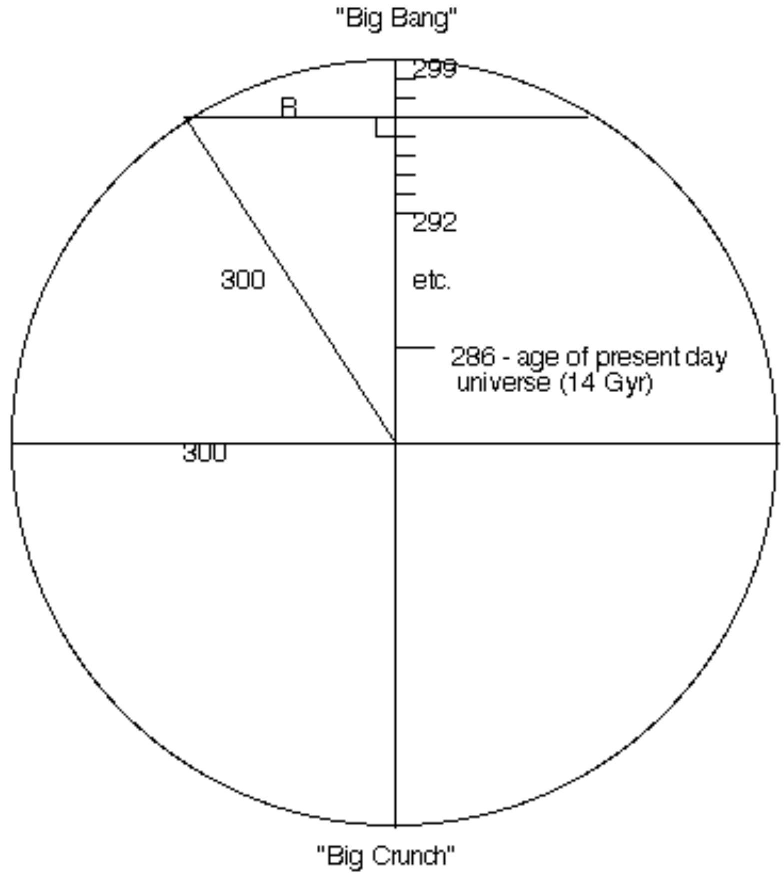
John A. Gowan www. johnagowan.org

Graph of Galaxy Positions: Calculated vs Observed



Graph of Galaxy

Positions: Calculated vs Observed



Closed Universe with 300 Billion Year (Gyr) "Half Life"

300 Gyr closed universe - diagrammatic. Vertical scale exaggerated for clarity. Visualize the top of the diagram as the "North Pole" of a sphere (in longitudinal cross-section); the cords (R) are the radii of circles lying on the surface of the sphere ("latitude circles") which represent the size of the expanding universe as it ages. (The "North Pole" is the "Big Bang" origin.) These circle lengths are in linear relationship to their radii, so all we need to known is the ratio between the lengths of the radii to calculate the Z values (red shifts) of the several universes relative to the fixed value of the present-day universe at 14 Gyr age (286).

Data Input Table to 13.7 Gyr Graph
for Spacetime Map (Spacetime Map see main text for sources)

Billion Light Years (distance from Earth) (Gyr)	Open Cosmos (no gravity) (calculated Z)	Closed Cosmos (~ critical gravity) (calculated Z)	Observations (from literature) (Z = "red shift")	Number of Observations
0.4	0.0224	0.0152	0.04	single
1.0	0.056	0.038	-	-
2.0	0.171	0.080	0.1572	average of 3
3.0	0.29	0.129	0.25	single
3.5	-	-	0.30	average of 2
4.0	0.412	0.184	-	-
5.0	0.575	0.25	0.50	single
5.5	-	-	0.57	single
6.0	0.78	0.33	0.661	average of 3

6.9	-	-	0.81	average of 2
7.0	1.154	0.42	-	-
8.0	1.404	0.54	1.0	single
9.0	1.915	0.69	1.356	average of 2
9.2	-	-	1.44	single
10.0	2.703	0.91	1.71	average of 3
10.35	-	-	2.04	average of 3
11.0	4.076	1.23	2.332	average of 2
11.66	-	-	3.17	average of 3
12.0	7.059	1.81	3.9	average of 3
12.2	-	-	4.35	single
12.4	-	-	4.75	single
12.6	-	-	5.0	double
12.76	-	-	5.75	average of 4
12.880	-	-	6.240	average of 5
12.876	-	-	6.706	average of 7
13.0	18.571	3.37	7.8	average of 3
13.1	-	3.72	8.26	single
13.2	-	4.17	10.0	average of 4
13.3	-	4.79	14.0	average of 2
13.4	-	5.68	18.3	single
13.5	-	7.18	-	-
13.6	-	10.56	-	-
15.0	-	-	-	63 total obsv.

John A. Gowan Jan., 2011

homepage