A Space-Time Map of the Universe

John A. Gowan

Introduction

In an age of giant telescopes, deep space observations to early eras of our universe are becoming commonplace. A map of the whole cosmos is therefore helpful to understand what and how we see, and to ground our observations in reality. We routinely hear the term "the very edge of space and time" applied to the deepest observations of our astronomers. This phrase, however, encapsulates a common misconception harbored not only by the public and by journalists, but also by eminent scientists. Because we look only backward in time as we look outward in space, it becomes evident (upon reflection) that the "here and now" comprises the greatest current extent and age of our universe. The "edge of space" is not somewhere "out there" in deep space. As observers, we are actually standing upon the "edge" of the universe and look backward in time toward its beginning and center (the "Big Bang"); we look forward in time into the blackness of an unformed future. The ubiquitous "backwards" misconception as to how we see our universe might be harmless if it did not have serious consequences for cosmological theory when carried, often enough, into the literature by professionals in the field.

Mapping Space-Time

On a summer morning in 1981, I sat at my kitchen table in upstate New York and drew a space-time map of the cosmos, such as we see in Figure 1 (next page). It has remained unchanged in all essential details since that time.

The map shows a universe that is 14 billion years old (rounded), with billion-year intervals represented by circles concentric on a central "Big Bang." Obviously, a map of this type will only work for a "Big Bang" universe, one which has a discreet, small, and sudden beginning. As we will see, the map works for our universe, which suggests that we do indeed live in a "Big Bang" cosmos (an origin metaphorically similar to that in Genesis).

Notice first that only the upper left quadrant of this map is "real." If the universe contained only light, then the whole circular form would be appropriate. However, when we add a material astronomer, the symmetry of the light universe with its circular form is broken due to the one-way character of time, the

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unique perspective of the observer, and the consequent need to avoid mapping "negative" space. Hence, we must arbitrarily choose a single quadrant of the circle to represent our position ("mapping artifact"—the map is not simply a scale model of the universe).

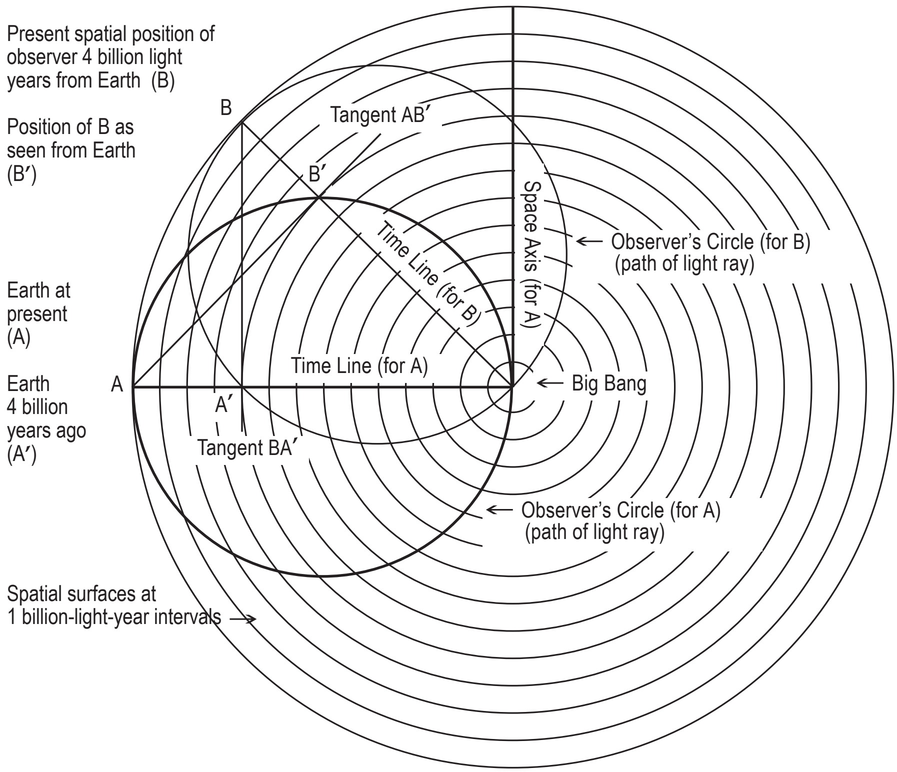

Figure 1. Space-Time Map of the Comos

There are two critical features of the map which must claim our attention: the first is the fact that all three spatial dimensions have been collapsed into a single line, with increasing space running vertically from the central "Big Bang." This allows us to construct the timeline horizontally, at right angles to all three spatial dimensions simultaneously, giving space and time equal importance as mapping parameters. The time dimension is one-way, increasing from the Big Bang to the left-hand margin of the map, where it ends in Earth's present position, our "here and now." Whereas the space line is marked off in units of billion light years, the timeline is marked off in units of billion years. This correspondence between time and space is the essence of Einstein's and Minkowski's space-time metric; notice that both space and time are increasing in lockstep as metric equivalents. Both expansions are primordial expressions of entropy in free versus bound electromagnetic energy. The intrinsic motion of light drives the spatial expansion, while the intrinsic motion of time drives the historical expansion, with gravity mediating between them (Gowan).

We connect the equivalent units of time and space via circles representing space-time volumes of equal age: since all points on a given circle are equidistant from the Big Bang center, all the space within a given line is exactly the same age. Thus the spatial circles represent "3-spheres" of a specific age as indicated by their position on the time line. The first line represents the spatial volume of the universe (and all material objects within it) when the cosmos was precisely one billion years old, and so on for each succeeding line. The final spatial line represents the present spatial volume of the universe, including all the galaxies, as it exists now in the "universal present moment" of age about 14 billion years.

Because we are trying to understand how we see our universe, we next wish to indicate the path of all light rays coming to planet Earth from the cosmos. Any astronomer stands at the center of a nested, concentric set of observational shells—two-dimensional visual spheres that get larger as they recede. These 2-D spherical observational surfaces intersect the 3-D spatial circles of the map at some specific point on their arc, but how to identify this point? Since the spatial lines already represent 3 dimensions, a 2-dimensional intersection of their volumes would have to be represented as a point, and points on a circle can be designated by a tangent line—in this case drawn from Earth's location. We act upon this hunch and construct tangent lines from Earth's position to all the spatial circles in the real quadrant of the map (I show only one), and then connect the tangent points. We discover that all such points lie on another circle, which has Earth's time line as its diameter.

If this (one-way) "light line" is a valid representation of the path of (all) light rays coming to Earth from the cosmos, then we should be able to use the same principle of construction to indicate the position and "light line" of a second observer who is looking at Earth while we are looking at that observer, and note if this reciprocal exchange of observer's perspectives maps properly. We have indicated this second observer at "B," 4 billion light years distant, and we have constructed B's time line from the Big Bang through the position where we see him (4 billion years in his past), extending the timeline to his present position on the outermost spatial circle. We draw B's light line, which is a circle with B's time line as a diameter, and we discover that B's light line indeed intersects Earth's time line 4 billion years in our past, validating our mapping procedure for these "light lines."

Consider next a demonstration of the map's validity. Because the cosmological "redshift" is caused (according to Steven Weinberg 1977) by the difference in the size between the observer's universe as compared to the size of the observed universe (since we look backward in time to always smaller universes as we look outward in space), we can calculate directly from the map what we expect the redshift should be for any galaxy at a given distance. Simply substitute the map's radius in years for the wavelength of light. The formula is: wavelength observed minus wavelength emitted (or age/size of our universe minus age/size of observed universe), divided by wavelength emitted (divided by age/size of observed universe). Thus the redshift of a galaxy seen at a distance of 7 billion light years is 14 minus 7, then divided by 7, which equals 1. Redshift 1 is therefore halfway to the Big Bang. These calculations are for a universe expanding uniformly at velocity *c*, as indicated by our flat map. We would like to know what this map would yield in terms of redshift calculations if gravity were added, bending the map. Accordingly, I made another (approximate) calculation from this same map, but with gravity sufficient to halt its

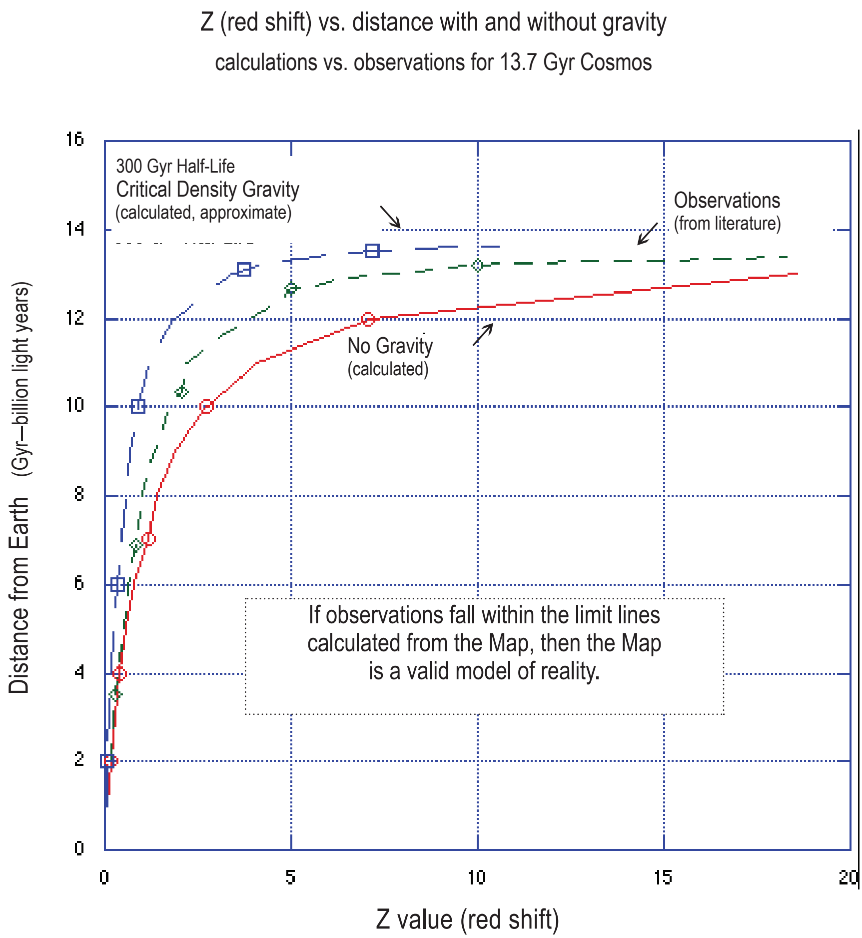

Figure 2: Expansion Calculated vs. Observed

expansion in 300 billion years (see Figure 2). These two sets of numbers gave me an upper and a lower boundary (expansion with gravity versus expansion without gravity) to compare with real-world observations (taken mostly from *Sky and Telescope* and *Science*).

The graph on Space-Time Map (Figure 2) shows three lines: the lower line is the "no gravity" curve, the upper line is the "with gravity" curve, both calculated from the raw parameters of the map, flat in one case and spherical in the other. Redshift values increase toward the right on the horizontal axis; distance increases toward the top on the vertical axis. The third line is the observational data line, which falls just between the top and bottom calculated lines, as we must expect if the map is a valid representation of space-time. This is the "hard" observational evidence that the map actually "works" as constructed.

Explaining the "horizon" paradox to myself was the original motivation for drawing the map, and we turn to it now. Most people, apparently including some professional astronomers, think the "edge of the universe" is somewhere "out there" in deep space, whereas the map clearly shows that "here and now" is the true edge of the universe. What is "out there" in deep space is the Big Bang, the center of the universe in the sense of its beginning in space-time. We are poised on the edge of space-time, looking backward in time (along our light line) toward ever-smaller universes as we look outward in space—in every direction. The common failure to appreciate this point has led to the perceived paradox of the "horizon problem" (among others), in which hard data (from the cosmic microwave background radiation) shows the universe to be a causally unified whole; but that evidence is at odds with what we think we see in the sky.

A typical example of the "horizon problem" (as commonly misconceived) is found in an article in *Scientific American* in a special issue on cosmology and the theory of "inflation" (Bucher and Spergel 1999). In this article, the authors claim that two galaxies, both seen at 12 billion light years distance, but 180 degrees apart as we see them in the sky (one east and the other west), must be separated by 24 billion light years of space and therefore cannot have exchanged light signals in the lifetime of our cosmos, which is only 14 billion years old (they are therefore beyond each other's visual "horizon"). A glance at the map reveals the fallacy of this argument: at 12 billion light years distance, both these galaxies occupy a universe which is only 2 billion light years in diameter. Their maximum separation in space-time is therefore 2 billion light years, not 24, and they have had ample time to exchange light signals. Similar arguments apply to the "smoothness" and "flatness" problems (the background radiation is too homogenous; the overall geometry of space-time is not gravitationally warped). The theory of inflation was developed specifically to address such problems. It seems, however, that it may be our view of the universe that is "inflated" rather than the universe itself. The cosmic microwave background radiation, for example, is thought to be redshifted (or "inflated") by a factor of about 1100.

Our Own View of the Cosmos

In summary, we look at several types of reality represented in the map. Almost the entire universe is invisible to us; we cannot see our historical past, which is fully ½ of the "bulk" universe, the area between our time line and our light line. Also, we cannot see the other half of the universe, the area above our light line, which is a sort of "manifest future" consisting of light signals from the universe which are "in the pipeline" but which have not yet reached us. Our light line is our only view of the cosmos, which neatly separates these two areas into equal halves of past and future (as required by the reciprocal perspectives of observers everywhere), both unseen (by us) but both perfectly real (insofar as light and space-time are real), and both currently visible to observers elsewhere in the cosmos. All the galaxies that currently occupy the cosmos are likewise invisible to us, as they all lie in the outermost spatial circle, the "universal present moment" (which we contact only by touch). We do not see objects where they are, we see them where they were at various times in the past, depending on their distance from us. We see only as and what the space-time metric allows us to see (as the phenomenon of gravitational lensing demonstrates). The advantage of our map is that it shows us what we do see as well as what we do not see.

The special significance of our "observer's position" is that it is the 4-way intersection of space, time, light, and matter, the only point in our personal universe where two-way interactions are possible. From "here and now," we receive and send light signals from and to the universe and mould our future with a mixture of "karmic" influence from the past, physical contact with present matter, and free-will action embedded in the ever-moving entropic flow of time and space.

Author's Note

Visit John A. Gowan's website "General Systems, Gravity, and Unified Field Theory" at: http://www.johnagowan.org/index.html. See the e-book "Essays in Physics and a "Theory of Everything" at: http://www.johnagowan.org/bookcontents.html. Contact John at jag8@cornell.edu or at johngowan@earthlink.net.

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