

# The Big Bang - in Controversy

By

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## Foreword

The Big Bang has an interesting history [1].

The theory came *first*, beginning in 1916, thirteen years *before* the first confirmed experimental evidence that even suggested that the universe was in “some kind” of motion. A second camp arose, claiming that the universe was static, and they offered an alternative explanation, for the supporting experimental data, called “tired light”.

Approximately thirty years after the theory was formulated, around 1945, came some theoretical and experimental work that showed that the light elements like Helium were produced by fusion, meaning that there was a hot beginning “of some sort” to the universe.

It took another twenty years, until 1965, before the Cosmic Microwave Background (CMB) was discovered and “interpreted” as the afterglow of a large cosmic explosion. The Big Bang scenario was thus born, of a prior theory and three subsequent but disparate experimental supporting “facts”.

By the early 1970s, more than thirty years ago, scientific “consensus” was reached that the Big Bang was indeed the way it all must have happened. New theoretical ideas came along to support the details: *inflation*, to quickly move the explosion away from a singularity; *baryogenesis*, to initially make all the matter from the hot soup; *string theory*, to explain some of these details; and early *fluctuations*, to serve as seeds for galaxies.

Trouble appeared in the 1980s when it was discovered that galaxies didn’t have nearly enough visible mass to rotate as they did. In the 1990s, it was discovered that there was not even enough visible matter to support the experimentally measured expansion rate. More than 90% of the required mass was “missing”! The concepts of dark matter and dark energy were born to account for the discrepancy. Dark matter was also thought to be needed to help make galaxies form; even if the seeds were already there.

And quietly, in the background, astronomers were busy measuring and cataloging as many galaxies as they could find, and making maps of where they were found. This has led to the discovery of great walls and voids, clusters and superclusters, and interesting structural patterns that don’t neatly fit with the Big Bang scenario. It has also led to a

remarkable spherical symmetry in all directions from Earth that also doesn't fit with a uniform expansion.

Was “consensus” on the Big Bang reached too soon? Has new observational experimental data taken in the modern age of space observatories such as the Hubble telescope and the Chandra X-ray observatory, plus the use of computers and digital cameras, provided enough new evidence to reopen the controversy? If the Big Bang falls, what sort of a theory should take its place?

Let us examine some of this history in detail. Let us look at some of the latest data, and its implications for the Big Bang. Let us see what characteristics a new theory has to have to satisfy the constraints of the data now in hand. At a minimum, let us begin a new dialog on the subject of “where did we come from”?

## History

Of all the fields of science, Cosmology is unique for two very special reasons. First, it attempts to measure and calculate things on a scale from sub-nuclear particle sizes to the size of the universe. Curiously, human experience is approximately in the middle of that span, so we are reaching far away in both directions. Second, it is the only field where there are major experimental observations that have no satisfactory explanations (e.g., black holes, gamma bursts, quasars, how gravity works, etc.) and where there are major physical and mathematical theories that are unsupported or insufficiently supported by experiment (e.g., inflation, baryogenesis, string theory, nature of dark matter, galactic structure formation, relativity, etc.).

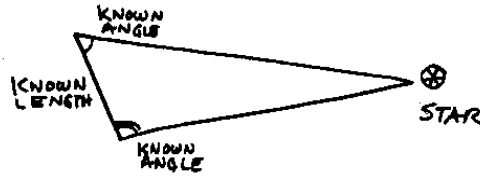
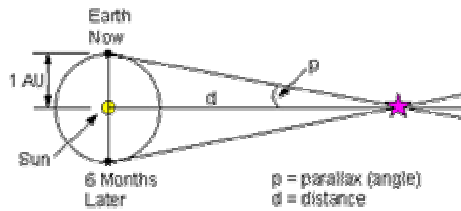
**Theory Behind the Big Bang** Einstein published his Theory of General Relativity (GR) in 1916. Soon after, Georges Lemaitre, Wilhelm de Sitter, and Aleksandr Friedmann investigated different theoretical models for the evolution of the universe. One class of potential solutions to Einstein's equations allowed for the possibility that the universe was expanding (or contracting). Einstein dismissed this possibility (as had all other scientists before him) because there was no evidence that the universe was in motion; the universe was, at that time, believed to be static.

Before the 1920s, nearby astronomic distance was measured by triangulation, using the Earth's orbital diameter as the known arc length. The process of making distance measurements, beginning from surveying techniques, and extended by the use of standard candles, is shown below in a slide from George Smoot's Nobel Prize lecture, where he was honored for measurements taken by the COBE satellite that “confirmed the Big Bang scenario”.

In a 1996 article in Science Spectra [2], Wendy Freedman summarized the status of experimental astronomy in terms of measuring distances between galaxies in the universe, and what that implied. This history is highly informative (***bold and italics added for emphasis***).

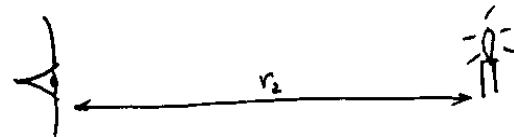
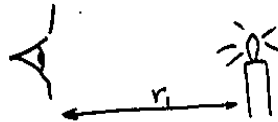
## Measuring Distance

### 1. TRIANGLES



### 2. STANDARD CANDLES

This technique enables measurement of enormous distances



$$\frac{\text{BRIGHTNESS}_1}{\text{BRIGHTNESS}_2} = \frac{r_2^2}{r_1^2}$$

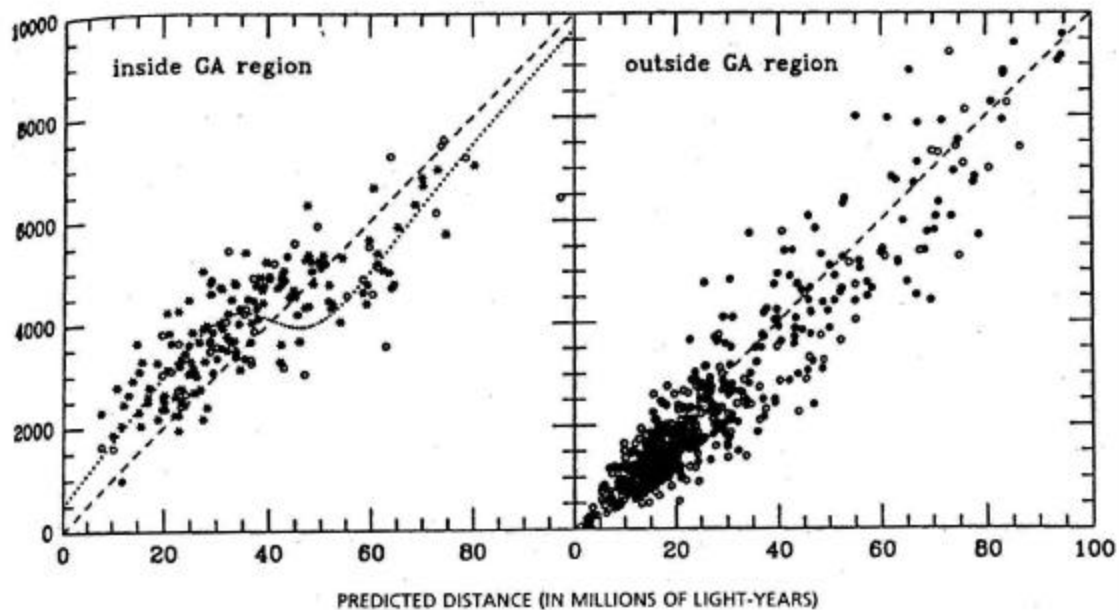
Freedman says, “Near the turn of this century (early 1900s), Harvard astronomer Henrietta Leavitt began work on measuring the brightness of a class of stars known as Cepheid variables in the Small Magellanic Cloud. Leavitt discovered an amazing property of Cepheids, namely that their periods were uniquely related to their intrinsic luminosities. This discovery led to the most accurate means that astronomers have for measuring cosmic distances.” The Cepheid became an absolute brightness candle.

“In the mid-1920s, Carnegie astronomer Edwin Hubble discovered Cepheid variables in several other nebulae and established that these objects were located far outside the confines of our Milky Way. Moreover, these results indicated that the nebulae he studied were systems not unlike our own Milky Way galaxy in size and structure.” The relative distance between two Cepheids could thus be related to their relative calibrated brightness. If the absolute distance to one was known by triangulation, then the actual distance to the other was obtained.

**First Experimental Confirmation for the Big Bang** “Hubble then proceeded, in 1929, to make an even more remarkable discovery. Slipher had been measuring the redshifts (Doppler velocities) of nebulae, which he found to be generally receding from our own galaxy. Hubble found that his distances to Cepheids were correlated *linearly* with Slipher's recession velocities. This relationship is now known as the ‘Hubble law’ and the constant of proportionality between distance and velocity is known as the ‘Hubble constant’. The consequences of this relationship for our understanding of the evolution of

the universe, which was *obviously* in a condition of overall expansion, were enormous.” Hubble’s law allowed the *approximate* distances to other galaxies to be interpolated or extrapolated from the Cepheid distance calibrations.

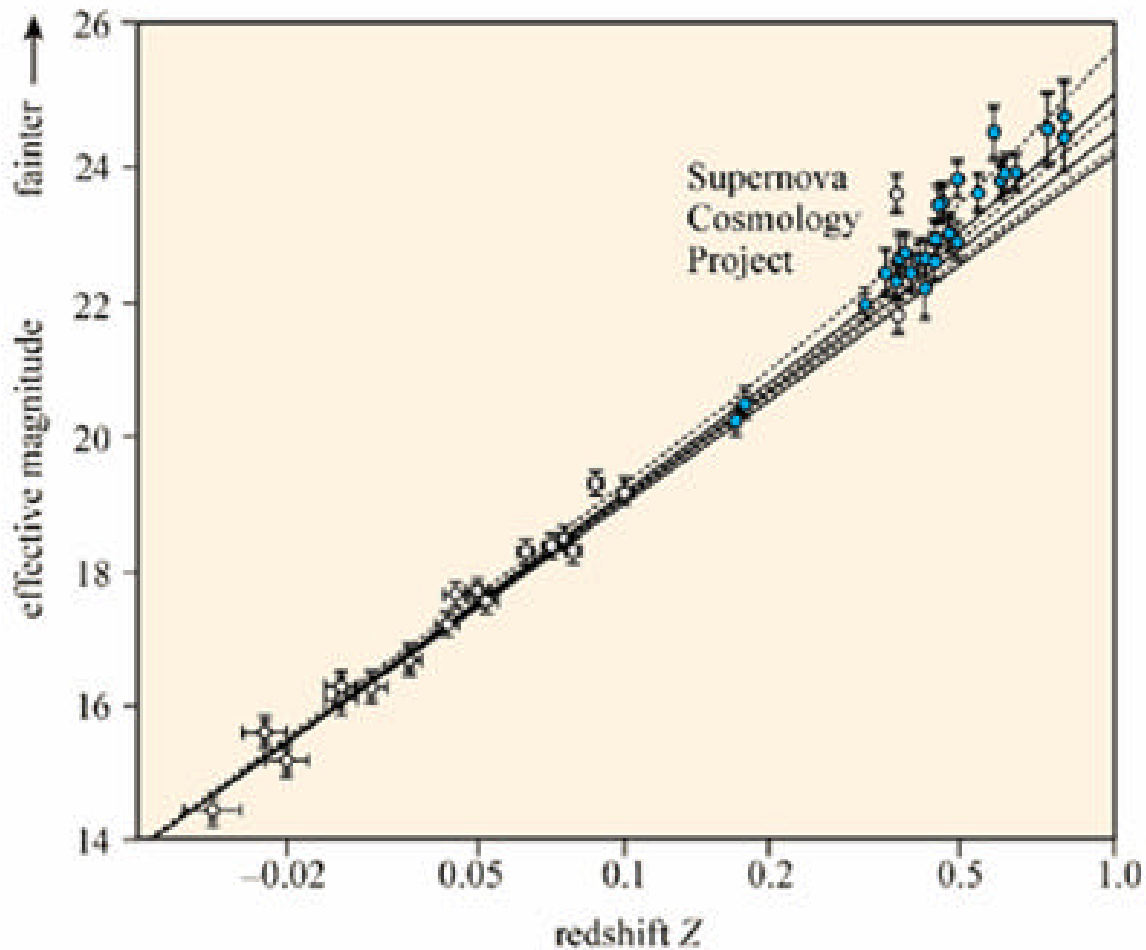
A typical Hubble’s law derived plot for galaxies within 100 million light years from Earth is shown below, along with a presumed anomaly in the direction of Virgo that has led to what is known as “The Great Attractor [3]”. What it shows is a linear correlation, but with a considerable statistical spread that leaves room for questions about exactly what the data means!



Freedman continues, “If it were feasible, Cepheids would be used to measure distances out into the uniform Hubble flow directly. Unfortunately, to date it has not been possible to detect Cepheids in galaxies so distant that they are known to be principally participating in the pure Hubble expansion. However, several other methods have been developed for measuring the relative distances between galaxies on vast scales, well beyond the range of the Cepheids alone. Carnegie astronomer Alan Sandage and his collaborators are undertaking to determine the Hubble constant based on the Cepheid calibration of a category of supernovae, classified as type Ia. Once direct Cepheid distances are measured to a sample of nearby galaxies in which type Ia supernovae have been well observed, then the relative distance scale for distant supernovae can be converted to an absolute scale.”

The results of these measurements are shown below, which led to the *curious* conclusion that the universe was expanding at an *accelerating* rate because the 20 or so data points were systematically above the Hubble line! Please note that the propagation of statistical errors for such a bootstrap process is both complicated by the governing relationship and *cumulative* because of the underlying primary surveying standard! Nevertheless,

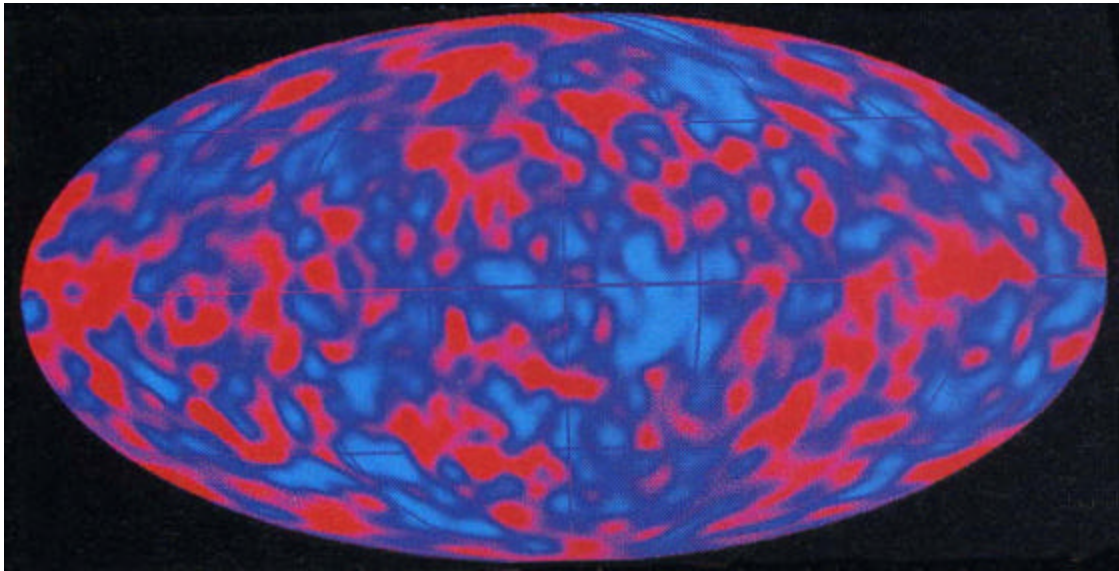
astronomers seem to be comfortable *assigning* 10% error bars to this data, perhaps because that is all they need to come close to Hubble's law!



The primary conclusion that can be made from the above discussion is that methods of measuring galactic distances are robust but have an uncertainty of at least 10%. These experimental methods are independent to first order on whether or not the Big Bang model is valid at all! However, astronomers such as Freedman truly believe in the correctness of the Big Bang theory, and to them any experimental deviations from the exact uniform Hubble Flow are *peculiarities* that need to be explained and/or *corrected* for.

**Second Experimental Confirmation for the Big Bang** It was not until the mid 1940s that George Gamow, who was working on fusion-produced isotope chains, proposed a series of reactions, beginning from neutrons, which produced the light elements in reasonably correct proportions relative to the Big Bang. With his colleagues, Alpher and Herman [4], he also made some predictions on the residual background temperature of the universe based on this process. Thus the idea of a hot beginning from a *possibly* small original volume for the universe was born. Wheeler coined the phrase, Big Bang, for this beginning, since it corresponded to the theoretical GR scenario.

**Third Experimental Confirmation for the Big Bang** In 1965, Penzias and Wilson, while attempting to improve microwave antennas at Bell Labs, discovered that there was a constant background noise level that was independent of antenna direction, which apparently originated in the cosmos. This became known as the Cosmic Microwave Background (CMB). It was interpreted as the residual radiation from the hot beginning of the universe. This radiation was subsequently shown to exhibit a black body spectrum at  $2.73^0$  K. The COBE satellite measurements subsequently confirmed the uniformity of this radiation to a millionth of a degree. Theorists celebrated the fluctuations in this data map as confirming the possibility that these were sufficient to foster the formation of structure in the universe. Smoot's plot is shown below.



By 1970, the Big Bang had won out over the Steady State model proposed by Hoyle and Bondi [5]. The steady state model had no answer for the CMB data. Scientific consensus was attained.

Of course, the correct question was not *which* of *two* models was best, but whether or not *either* of them was correct!

## **Seeds of New Controversy**

If the battle is over, then why are some people still unhappy with the result? The answer to that question is that a lot of new experimental data has come in over the past twenty years that throws doubt on the very *assumptions* that went into the theory that GR describes the universe.

**One Viewpoint** The flavor of some of this has been summarized from a website on a *fractal* theory of the universe. It begins, “10 March 2007 - From New Scientist Magazine by Amanda Gefer: Written across the sky is a secret, a hidden blueprint detailing the

original design of the universe itself. The spread of matter throughout space follows a pattern laid out at the beginning of time and scaled up to incredible proportions by nearly 14 billion years of cosmic expansion. Today that pattern is gradually being decoded by analyzing maps of the distribution of the stars, and what has been uncovered could shake modern cosmology to its foundations". *The 14 billion years refers to the Big Bang estimated age of the universe, which could be wrong on the low side by as much as 10 times if estimates of how long it takes to form superclusters of galaxies hold up.*

"Cosmology is founded on the assumption that when you look at the universe at the vastest scales, matter is spread more or less evenly throughout space. Cosmologists call this a "smooth" structure. But a small band of researchers, led by statistical physicist Luciano Pietronero of the University of Rome and the Institute of Complex Systems, Italy, argues that this assumption is at odds with what we can see. Instead they claim that the galaxies form a structure that isn't smooth at all: some parts of it have lots of matter, others don't, but the matter always falls into the same patterns, in large and small versions, at whatever scale you look. In other words, the universe is fractal."

"It is a controversial view, and one that sparked an intense debate over a decade ago. Since then, astronomers have surveyed ever-greater numbers of galaxies, taking larger and larger samples of the universe. Now the biggest galaxy survey ever and a brand new *calculated* map of the universe's *dark matter* are adding fuel to the fire!"

"At stake is far more than the way galaxies cluster. A fractal universe could undermine cosmology's most basic assumptions. "All of the observations we make depend to a greater or lesser extent on the idea that the universe is *homogeneous*," says David Hogg of New York University, who leads a team of physicists that disputes Pietronero's view."

"This idea that matter is spread more or less *evenly* throughout the universe is embodied in Einstein's Cosmological Principle. Einstein formulated it after publishing his general theory of relativity, which describes how the distribution of mass bends space-time and creates gravity. It allows cosmologists to use the equations of general relativity to describe the geometry of the whole universe. As a result it has led to a picture of a universe expanding *uniformly* in a *center-less* manner from the Big Bang, and in which cosmological measurements have defined meanings." *Note that bent space-time is also a theoretical idea that has not been proven by experimental evidence!*

"Certainly the universe does not look smooth. Some regions contain clusters of matter; others are virtually empty. Hundreds of billions of stars group together to form galaxies, and galaxies congregate in clusters. Clusters assemble into colossal structures called superclusters that can stretch out for 100 million light years and look uncannily like fractal patterns." *Of course, these patterns are subject to other interpretations as well.*"

"Even superclusters string together in long filaments and sheets that stretch like ghostly cobwebs across an otherwise empty sky. The Sloan Great Wall, for example, spans more than a billion light years. These filaments and sheets seem to encircle huge *voids* of empty space. The voids range from 100 to 400 million light years in diameter, making the

entire assemblage appear as an immense, glowing lattice punctuated by wells of darkness.”

“No one disputes that the universe is far from smooth on relatively small scales - by which cosmologists mean thousands of light years. But Hogg's team is convinced that if you zoom further out, smoothness reigns. "When you're looking at the size scales of galaxies, groups of galaxies, clusters, superclusters and filaments, it looks like a fractal," says Hogg. "But once you get larger than all of that, then it starts to look homogeneous." "Galaxies, groups of galaxies, clusters and superclusters all appear fractal, but at larger scales the cosmos is smooth”

“What has convinced him is his team's analysis of the latest data from the Sloan Digital Sky Survey, the largest 3D map of the galactic universe so far. His team insists that the map is proof of smoothness. The fractal camp, however, are skeptical. In fact, they say the Sloan observations confirm what they've been claiming all along. It might appear to be deadlock, but at least with the Sloan survey the two sides can agree on what they're disagreeing about.”

“The usual story runs something like this. In the tiny fluctuations of the nascent universe, matter began to collect in denser regions, setting off a chain reaction of gravitational collapse that has given us the large-scale structure we see today. Gravity has worked from the bottom up, building galaxies first, then collecting galaxies into clusters, then clusters into superclusters and so forth. But while the matter has been clumping together, the universe has been expanding, and thus a battle has ensued: gravity versus expansion.”

“According to Pietronero, there simply *hasn't been enough time* since the universe came into being 14 billion years ago for gravity to sculpt structures larger than about 30 million light years across: expansion would have prevented anything larger from forming. "The existence of structures much larger than this implies a crisis of the present view of structure formation," he says.”

“Recall that Einstein's fiendishly complex equations of gravity *can be solved exactly* only if we assume that the Universe on the large-scale is *homogeneous* - that is, it looks the same from every place.”

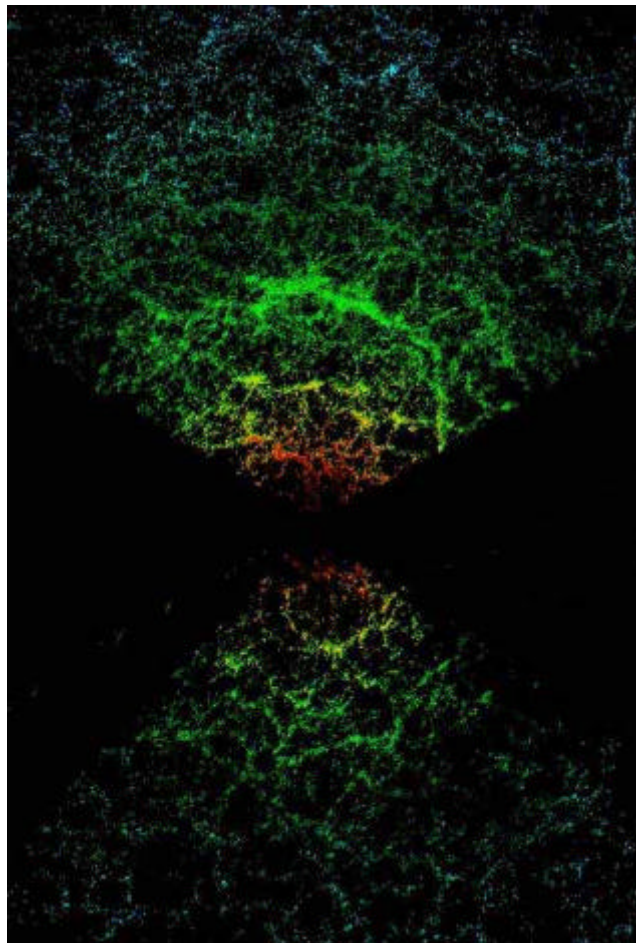
“This assumption, enshrined in the Cosmological Principle, leads to the Friedman-Robertson-Walker solutions, the Big Bang models. Abandon that assumption and everything we thought we knew about the Universe gets *jettisoned*, as New Scientist has pointed out (21 August 1999, p 22).”

“No one can deny that the galaxy distribution is fractal in our cosmic neighborhood. The "geometry of chaos" is apparent from scales of about 300,000 light years up to at least 300 million light years. But what can be said about the region beyond this range? Here lies the battleground”, *at least between these two groups*.

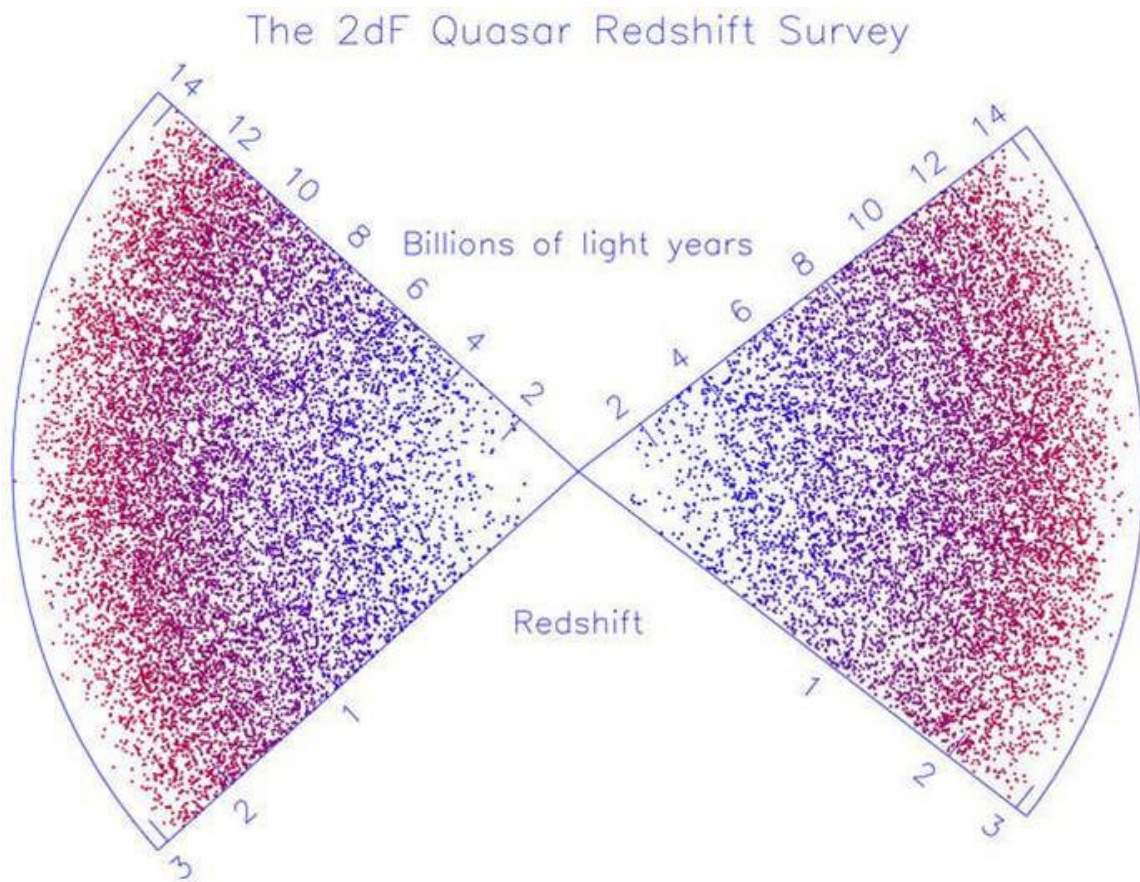


**A Second Viewpoint** This is not the only controversy possible. There is indeed more experimental data that argues that the very *assumptions* of the Cosmological Principle do not apply to the evolution of the universe; i.e., General Relativity has *nothing* at all to do with the distribution of matter in the universe! We will examine some of this data now.

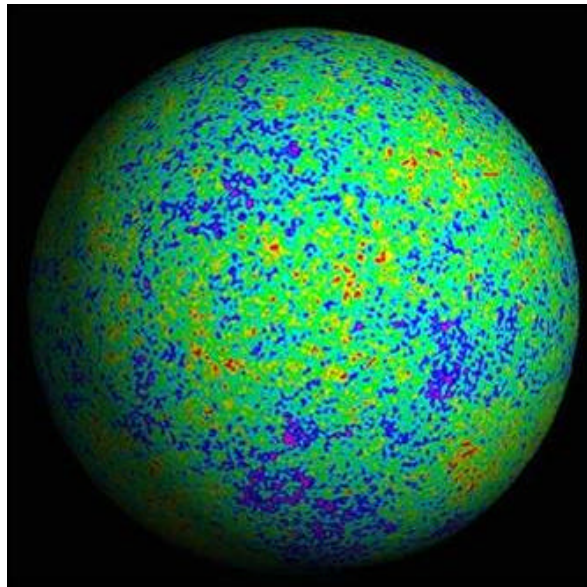
Charles Sven [6] made a presentation at a meeting of the Natural Philosophy Alliance (NPA) at U. Conn. in 2005, where he presented NASA data showing that various phenomena were distributed *spherically* about a center about 50 million light years from Earth. He argued that the Sloan Survey, shown below as a pie diagram, summed over all angles in and out of the page, is remarkably symmetric spherically in all directions from our location. It can also be argued that the density of galaxies as a surrogate for the density of matter seems to *decrease* radially from the center if the false colors are meaningful.



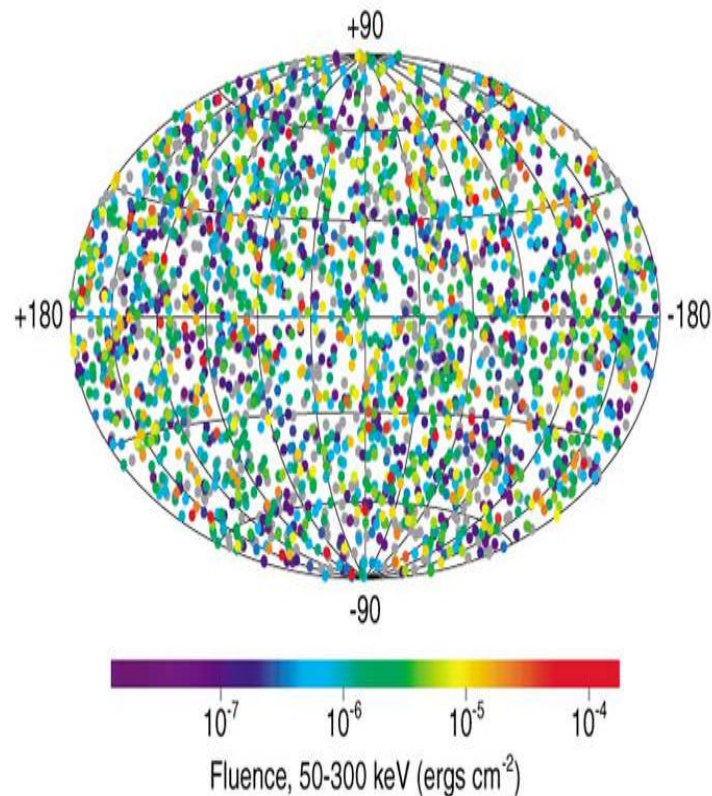
Sven then shows that Quasars also obey the same pattern, albeit with a pie structure that resembles a doughnut with a hole in the middle. This can *only* be a spherically centered pattern! Arp [7] has argued that some Quasars appear to be associated with galaxies that have smaller redshifts, and therefore argues that they have a bias that makes them seem farther away than they really are. This will be discussed again later.



Sven then adds the fact that the CMB pattern is remarkably symmetric, as shown in a separate diagram without the false colors and polar distortion shown above. He also shows that the occurrence of gamma ray bursts is also symmetric.



## 2704 BATSE Gamma-Ray Bursts



The thrust of Sven's arguments is that a *spherically* symmetric distribution of matter around the position of the Earth *is at odds with a uniform expansion as produced from Einstein's GR!* In other words, the distribution is not the one predicted by the Big Bang!

**A Third Viewpoint** The arguments given above ignore the *most significant* data available that throw doubt on the Big Bang.

A series of measurements known as Deep Pencil Surveys has been done in the past decades by a team of astronomers generally headed by Broadhurst and Koo [8-14]. A pencil is a narrow cone ~40 arc minutes in diameter, which gives a manageable few thousand galaxies to count and measure their redshifts over a depth of about 4 billion light years. This was done for a series of narrow cones pointed in the directions North and South of the plane of the Milky Way, along a direction 45 degrees from the Milky Way plane known as the SA68 and anti-SA68 directions, and at another 45 degree position approximately 90 degrees from the former known as the Hercules and anti-Hercules directions. No mention was made of restricting the survey to any particular type of galaxy, so it can be assumed that all types were counted. Dressler [3] has shown that in regions of sparse density, spiral galaxies predominate, whereas in dense regions, elliptical and SO galaxies are more abundant.

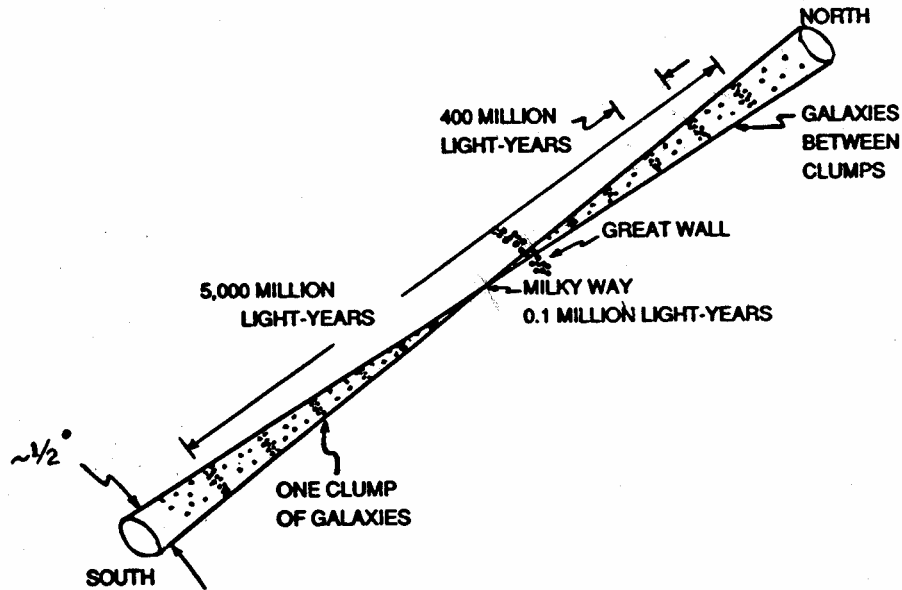


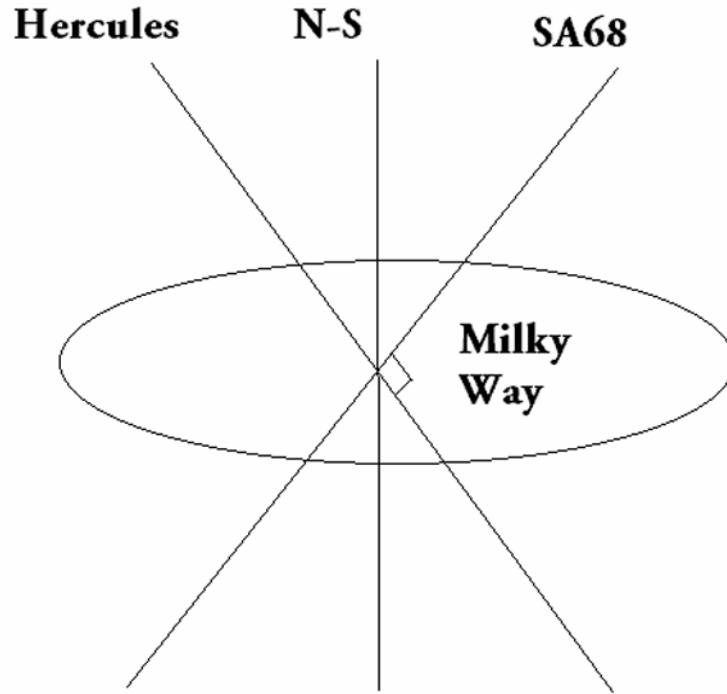
Figure 1. Cartoon of experimental setup where dots in cone represent galaxies. Note that the first clump of galaxies to the North Galactic Pole is due to the intersection of our observing cone with the Great Wall.

The cones have a small angular diameter. Of important significance is that the cones spread in area as  $r$ -squared, so they sample an ever increasing volume of space in a radial interval as distance is increased. Hence, the galaxy count data from these surveys should be *divided* by  $r$ -squared to obtain the true density. Astronomers count data for increasing time periods as distance increases in order to obtain sufficient counting sensitivity.

There is an argument that there is a selection function at work here due to decreasing brightness, which accounts for some counting losses at large distances. In an e-mail exchange with a Cosmologist who had given an interview on NPR, I asked for a definition of the selection function and was told that it is the ratio of what we can see to the total number. When asked how we find out the total when we don't know how many we do not see, I was told that the total is obtained from some *very deep field* measurements taken theoretically near the beginning of the Big Bang. *The apparent inconsistency in these two statements is mind-boggling!* If we have trouble counting things that are far away, then how can we possibly use as an accurate standard a measurement taken at the far limit of our sight!

The pattern of the pencil surveys is sketched below. This level of sampling in six related, but independent directions, should give us an excellent picture of how the universe looks on the large scale. Each of the pencil surveys covers a depth of about  $4\frac{1}{2}$  billion light years, so that a significant fraction of the "accepted" age of the universe is covered.





Typical pencil survey data from Koo et al [14] are shown below for the N-S direction.

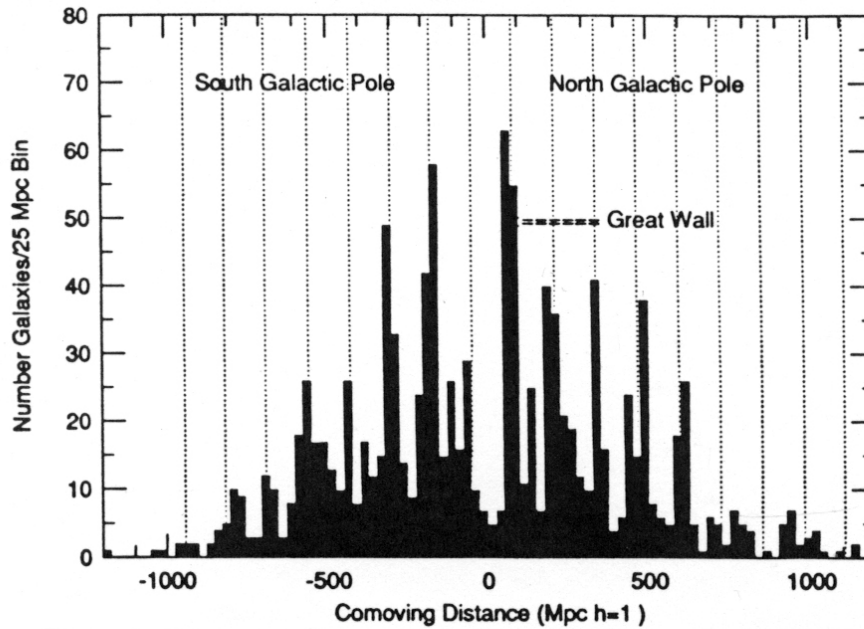


Figure 1. Co-moving distance histogram of 1182 galaxies towards the Galactic Poles. The data were acquired on 4-meter class telescopes with multi-optical-fiber spectrograph systems at Kitt Peak National Observatory and the Anglo-Australian Observatory. The dotted lines show equal co-moving spacings of  $128 h^{-1}\text{Mpc}$ .

Even without correction for cone spread, several features can be observed: 1) the data are remarkably *symmetric* about Earth, being at most off-center by about 70 million light years; 2) the data are *periodic*, with a period of about 400 million light years; and 3) the data are strongly *damped* with distance from Earth. The SA-68 survey shows a similar behavior, but is not as clean. I have been told that, with recent new measurements, the data is now much better. I do not have data for the Hercules survey as yet.

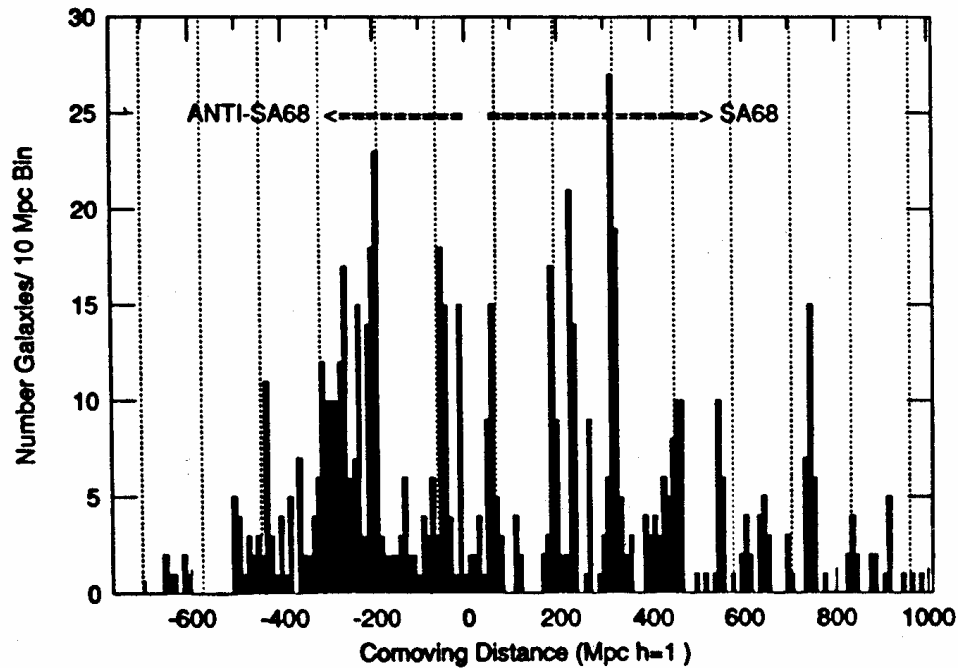
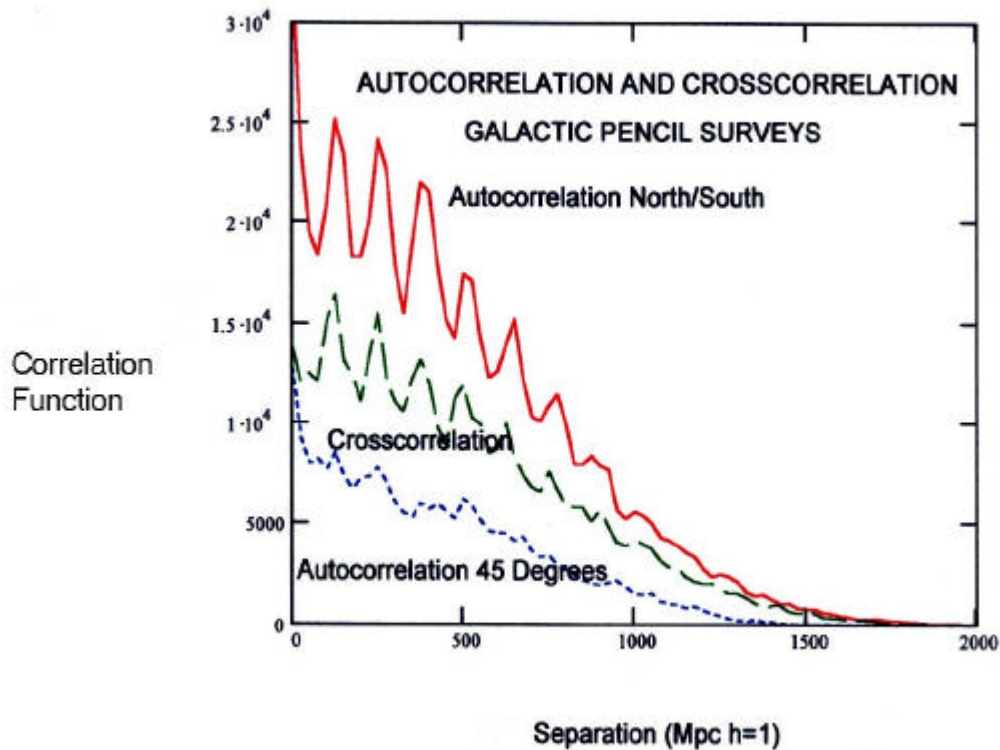


Figure 5. Co-moving distance histogram of 684 galaxies towards SA68 and anti-SA68. Dotted lines are spaced  $128h^{-1}\text{Mpc}$  apart and phased so that the Milky Way is centered.

The same authors did a series of shallower mini-slice surveys [15, 16], 4 degrees by 49 minutes, to see if the above features washed out. The general conclusion is that the periodicity was still observed. Rydin [17] has digitized some of this data and performed auto and cross correlations between the surveys, where the North and the South, etc. surveys can be considered to be independent of each other. This was presented at the 2003 NPA meeting at U. Conn. One of these correlations is shown below, where the normalizations are different in order to spread out the results.

The general conclusion is that all of the surveys are *highly correlated*, have the *same* periodicity and hence have a *common* source. Furthermore, the data *can only be* consistent with a *spherical* distribution of galaxies emanating from an origin about 70 million light years from Earth in the general direction of Virgo [18]. *The universe is not expanding at all, but the galaxies are each moving in space in a radial direction away from the origin!*



A similar 400 million light year periodic situation exists for Quasars, as shown by Arp [7], who nevertheless refuses to convert redshift to velocity, preferring instead to stick with a Static universe. This data is shown below. In fact, Kirilova and Chishov [19] have done an extensive literature search on large scale structure in the universe. Besides the pencil surveys and the Quasar data, indications of a characteristic scale of  $120 - 130 h^{-1}$  Mpc (around 400 million light years) exist for peculiar velocity information and Lyman- $\alpha$  break galaxies. Similar spacing occurs for IRAS galaxies and clusters of galaxies, X-ray clusters of galaxies, and the supercluster-void distribution. This spacing is so ***prominent*** that Big Bang theorists are now trying to find theoretical mechanisms that might generate such a distribution. But they still think in terms of a uniform expansion, so their thoughts go to regular lattices such as Voronoi foam (soap bubbles).

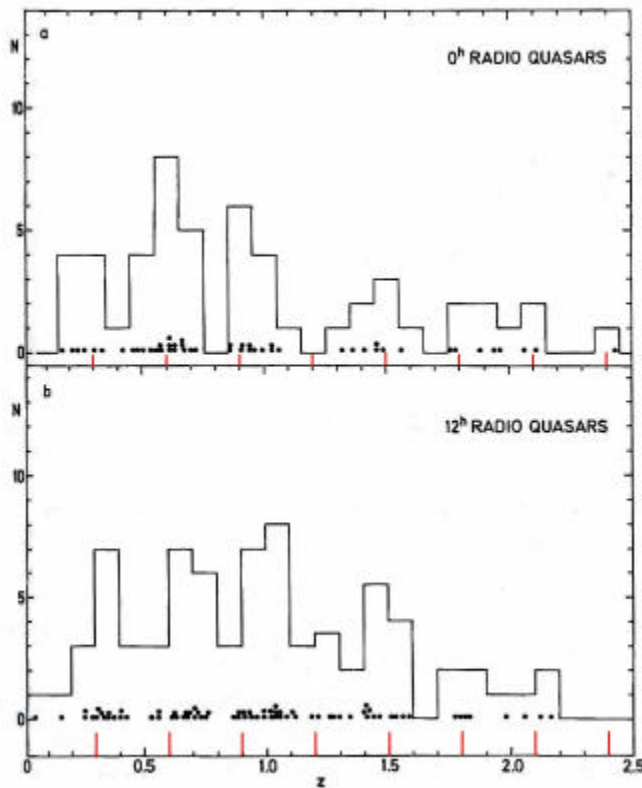
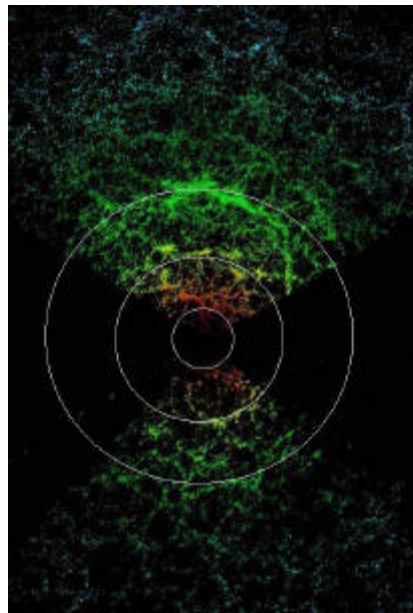


Fig. 8-8. Catalogued quasars found by radio emission with greater than 1 Jansky flux at 11 cm. Quasars in Local Group Direction ( $0^h$ ) and Local Supercluster direction ( $12^h$ ). Latter are shifted by  $(1+z) \times (1 + 0.03)$ .

Adapted from H. Arp  
Seeing Red

Ticks are at 400 million light years, Showing Periodicity for Quasar Distributions

One can ask, are these results repeated in general? A look at the Sloan Survey, with a few concentric circles drawn in, suggests that the answer to this question is yes! Several additional circles are strongly suggested to the eye beyond the ones sketched in.



Sloan SDSS Survey of Galaxies with Annular Walls Sketched In



Does the Sloan data tell us anything else? Rydin [18] made an analysis of the meaning of pie diagrams such as this, and presented it at the 2006 NPA meeting at OSU in Tulsa. The density of galaxies shown on *any* portion of such a diagram can be derived. The differential volume element in spherical coordinates is

$$dV = dr(r \sin \mathbf{j} d\mathbf{J})(rd\mathbf{j}) = r^2 dr d\mathbf{J} \sin \mathbf{j} d\mathbf{j} . \quad (1)$$

Hence, the number seen in any volume element assuming  $\mathbf{r}(r, \mathbf{J}, \mathbf{j}) = \mathbf{r}(r)$  = radial only is

$$dn = \mathbf{r}(r) dV = \mathbf{r}(r) r^2 dr d\mathbf{J} \sin \mathbf{j} d\mathbf{j} . \quad (2)$$

When integrated over the declension angle in and out of the paper,  $\mathbf{j}$ , the number seen in any area element  $dA = rd\mathbf{J}dr$  on a segment of the pie diagram is

$$dn = \mathbf{r}(r) r^2 dr d\mathbf{J} \int_{-p/2}^{p/2} \sin \mathbf{j} d\mathbf{j} = 2r\mathbf{r}(r) rd\mathbf{J}dr = 2r\mathbf{r}(r) dA. \quad (3)$$

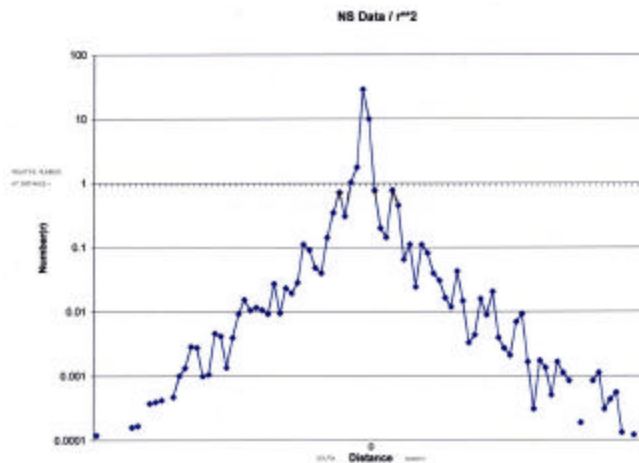
Now, if we simply choose a constant differential area,  $dA$ , we see that the number found in any fixed area element in our pie slice varies as  $dn/dA \sim r\mathbf{r}(r)$ .

This means that for a truly *uniform* GR density distribution,  $\mathbf{r}(r) = \text{constant}$ , the brightness of the count data should *increase* directly with radius  $r$  from the origin. The data shown in the above figure are completely *inconsistent* with this condition, which means that the Big Bang model assumption of uniformity is *violated*! On the other hand, if the brightness appears to be constant, then the actual density must be decreasing as  $1/r$ . And if the brightness appears to be decreasing as  $1/r$ , then the actual density is decreasing as  $1/r^2$ . The brightness shown in the figure appears to fall off with radius, although there is an obvious periodicity superimposed upon it. A portion of this radial behavior, which is clearly annular because it survives after the  $\mathbf{j}$  integration, is known as the Great Wall.

The above result *violates* the *primary assumption* of GR as applied to the Big Bang, namely that the universe is homogeneous with constant density! The observed spherical pattern of galaxies *violates* the conclusion that the expansion is *uniform and center-less*, because it is *clearly spherical* from an *origin* near Virgo! And *nowhere* in any of the proposed alternative theories is *periodicity* predicted!

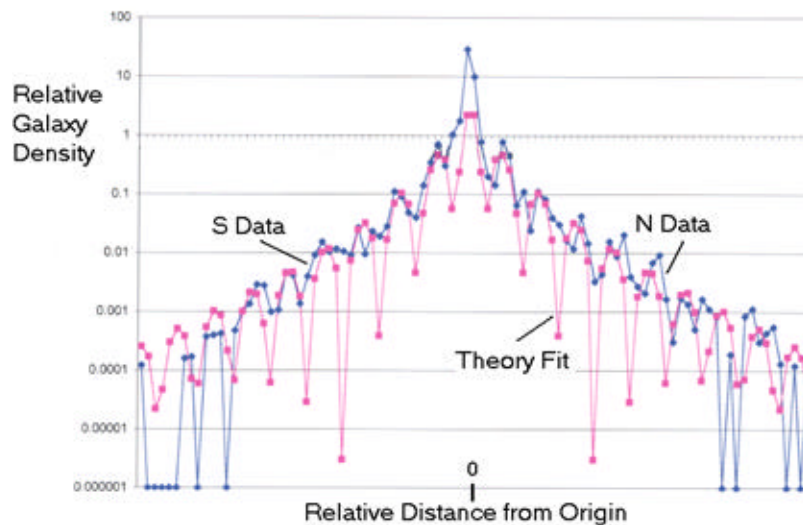
## Where Do We Go From Here?

What does the pattern of the distribution of galaxies look like when the 1-over-r-squared correction is added to the pencil data? We obtain a pattern that seems to be *spreading geometrically from the origin like a spherical explosion*, but it is damped beyond that spread by an exponential factor. And superimposed upon all of that is a fixed periodic behavior of great walls and great voids. This is a significant burden for any theory to explain, and a reminder that perhaps the experimental data should be examined carefully *before* a theory is proposed rather than 90 years later!



North-South Pencil Survey Data Corrected for Cone Spread (log-linear plot)

The pattern suggests that a damped **wave** solution might fit it. From a simple quantum mechanical standpoint, this data corresponds to a decaying exponential function times a  $J_0^2$  spherical Bessel function with a phase offset. The spherical Bessel function naturally spreads as 1-over-r-squared. The exponential corresponds to matter deposition from a spherical energy wave traveling at  $c$  that contains the characteristic period. The spherical Bessel function also has minimums of zero that correspond to voids! The fit is shown below.



Experimental N-S Data vs. Damped Spherical Bessel Function Fit

The final step is to figure out what all this means and come up with a new scenario for how the universe might have formed. I have my own idea as posted on my website, <http://home.earthlink.net/~rarydin/>, but you are welcome to try your ideas on this data to see what you come up with.

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