Formalizing Theoretical Evolution

Abstract

There is a persistent trend in the human search for knowledge to resist the evolution of prevailing theories. In cosmology this trend is embodied in our resistence to the notion that the material hierarchy of the universe extends beyond the parts of it we can see even after we've extended it time and again througout our history. In the current Big Bang model this resistence to an extended hierarchy is formalized in the cosmological principal. Instead of an ongoing hierarchy, the cosmological principle presumes that the hierarchy stops at the scale of galaxy clusters. It preusmes the universe at that scale to be homogenious and isotrophic, even out to infinity if that's what it takes to encompass all of physical reality. Two alternative axioms are proposed and supported from a Bayesian analysis of both the material hierarchy across all scales and the historical succession of our cosmological models. The first axiom proposed is that all material phenomena are finite constituents of larger phenomena. The second axiom is that all physical phenomena are multiply manifest. The Bayesian conclusion is that the effort to make any physical phenomenon (i.e., galactic cluster recession behavior) a complete and sufficient description of all of reality, rather than a local phenomenon, is precisely where that model will be found weakest. Thoeretical evolution persists indefinitely. The value in this conclusion is in strategically identifying the most promising areas for evolving the current model. No specific claims are made against relativity or the standard model in general in that within the virtually infinite range of the Big Bang the cosmological principle remains an effective modeling tool, with no viable alternative yet in evidence.

1. Intro

While cosmology has always evolved throughout history, we have never formally expected it to do so. Each time we devise some new cosmological model we presume it could be for the last time. Currently we presume the Big Bang to be a perfectly plausible final candidate for a complete and sufficient description of the universe. One of the premises that enables this sufficiency is the cosmological principle, the first two axioms of which state that at the largest scales the universe is both homogeneous (matter is evenly distributed) and isotropic (the universe looks the same no matter where you are). The evidence for such presumption ranges from the consistency of the red-shift recession data from major observatories dating back to the early 20th century to the pronounced uniformity of the Cosmic Microwave Background (CMB) radiation from the WMAP satellite data (http://map.gsfc.nasa.gov/). While unambiguously true for many thousands of times the diameter of the visible universe, the idea that we can project the local disposition of the universe beyond a reasonable scalar limit is counter indicated by two fundamentally empirical criteria. One is the overall hierarchical structure of the universe across all observable scales, and the other is the historical tendency for each new cosmology to reassert the hierarchy over our prior presumptions of its termination.

While the ultimate context of physical reality may well be infinitely vast, any material structure within that context has always proven finite and hierarchical. Across better than 40 orders of spatial magnitude, the material structure of the universe is unambiguously hierarchical, with little pieces of the universe joining together to make bigger pieces and those bigger pieces joining in turn to make even bigger pieces, etc., etc. From quarks to galaxy clusters every material phenomenon we have ever encountered proved to be unambiguously hierarchical in nature.

Yet, every time we humans find some ultimately immense cosmic structure, we habitually imbue that structure with attributes that serve to terminate the hierarchy in psychological pursuit of a complete and sufficient description of reality. Instead of presuming that greater structures will always emerge beyond our view, we prefer to imagine that we have finally discovered the complete profile of the universe. Then each time the next larger structure is discovered, we characterize this structure however necessary to make it the new final discovery for the complete and sufficient description of reality.

The first remotely empirical cosmology humans devised was that of a totally dominating flat Earth universe with the Gods controlling the heavens, exhibiting a very minimal hierarchy of earth and sky. This was supplanted by the slightly more hierarchical, and considerably more imperial, Ptolemaic universe with greater consideration of the heavens and the ancillary astronomical objects beyond the Earth, all of which was terminated by a distant crystal sphere that hung the stars. This model was succeeded by the similarly terminated yet hierarchically adjusted, Earth subordinated, Sun-dominated Copernican model which was in turn succeeded by the first true scalar hierarchy of the "Island universe" galactic model.

Each cosmology was based on the largest observable physical phenomenon of the time, the influence of which was presumed to provide a unique and physically sufficient description of the entire universe. Finally, in 1929 Edwin Hubble noticed that the galaxies were all moving uniformly away from each other and thus postulated that the universe was expanding. As proposed, the expanding structure of the Big Bang is now considered to be a unique and sufficiently vast phenomenon to completely describe the universe, just like every theory before it without particular regard to the fates of those theories or the evolving structure they portray.

2. Bayes' Theorem

A pattern develops here that is Bayesian in nature. Bayesian probability theory formalizes the mechanics of human reasoning on uncertain issues.[i] Bayes' Theorem is a simple mathematical formula for updating our confidence in the probability of some uncertain phenomenon considering any new or recurrent evidence that may arise. Bayes' Theorem follows the logic that each time we observe the Sun rise we can be a little more confident that it will continue to rise. In the case of human cosmology, we see two things. The first thing we notice is that each new cosmology adds dramatically to our estimate of the size of the universe making it ever more probable that the universe is infinite in extent. And the second thing we notice is that each new cosmology adds to another stage in the physical hierarchy of the universe, where small pieces come together in profusion to make ever larger structures.

As our recent cosmologies began to incorporate the infinitesimal as well as the vast, this hierarchical prospect became even more apparent. From quarks to galaxy clusters the universe became mind-numbingly vast and unambiguously, uniformly hierarchical. Similarly, A Bayesian view of every cosmology we ever devised prior to the Big Bang shows us that each new cosmology was found not to be a complete and sufficient description of the cosmos, but merely a hierarchical subordinate of its successor.

Currently the standard model of the Big Bang attempts to completely describe the universe via the first two axioms of the Cosmological principle: the homogeneity of the universe (matter is evenly distributed at the largest scale) and the isotropy of the universe (the universe looks the same at the largest scale from any direction or location). These two axioms sever to terminate the hierarchy by extending the uniformity of the visible universe out to infinity if necessary to render complete and sufficient our description of the universe. While certainly prevailing far beyond the range of the visible universe, to presume the homogeneity and isotropy of the fullest extent of an unknown universe based on a hundred billion galaxies would be tantamount to presuming a universe made of water from a trillion molecule sample (smaller than a pinpoint) from the middle of the ocean.

From a Bayesian perspective the homogeneity of the universe is more accurately presumed as a mega-regional descriptor and not a universal property. The following section suggests two generalized axioms that might limit the ultimate scope of the Big Bang and thus restore a more probable Bayesian presumption of an ongoing, open-ended investigation of the character of the material hierarchy.

3. Rules of the Hierarchy

The first hypothesis we might derive from the structure of the universe is the Finite Rule. Seeing that every material structure or behavior ever discovered turned out to be finite in extent and elemental to a larger structure, we might formalize this trend with the following axiom:

1) *All material phenomena are finite constituents of larger structures*.

We can *never* categorically prove this assertion, but we can invest a significant amount of provisional faith in the Bayesian probability of this rule in that it has been true for every material discovery ever made.

The next hypothesis is the Plurality Principal. Seeing that every material discovery ever made was determined to be one of many of a class of similar, widely distributed phenomena, we might also formalize this consistent if unprovable trend with a second Bayesian rule of hierarchy

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2) *All material phenomena are multiply manifest.*

These two rules are irrefutably true for every material circumstance in the human experience. Given any material relationship smaller than the visible universe (i.e., small enough in scale to be verified), we can unequivocally assert these two rules. Yet, we historically ignore their obvious implication with respect to the *only* structures about which they are impossible to corroborate: the largest (and smallest) structures we can see. (While this paper is primarily concerned with the astronomical perspective its precepts apply as well to the hierarchy of the infinitesimal.)

The problem is one of scale-limited logic. Historically we restrict ourselves to a single category of evidence to characterize the largest structures we can observe. We interpolate whatever symmetry we recognize at the largest visible scale however necessary to define a complete and sufficient depiction of the universe in terms of that uniformity. Whether it is a closed structure like the Copernican crystal spheres, an open structure like the "Island Universe" of the Milky Way, or an infinite structure like the Big Bang, we assume the evidence at hand to be sufficient to model the entire universe. Currently we see a pronounced homogeneity in the distribution of mutually receding galaxy clusters and the CMB radiation profile at the limits of our instrumentation and presume that homogeneity to be universal even if the universe happens to be infinitely large.

Whether based on galactic cluster distribution and red shift data, like Martinez's *Searching for the Scale of Homogeneity*[ii] or the WMAP CMB data, such as *Scale of Homogeneity from WMAP,*[iii] these predictions are scale-limited by sample size and microwave detector resolution respectively. The WMAP CMB data is by far the more resolute of the two at around one part in 25 million, but the temperature variations across the sky range well over 1 part in 10,000.[iv] The universe is, in fact, not homogeneous at the largest scale. Its deviations are merely minute and evenly distributed, rendering inconclusive any projections beyond perhaps a million times the diameter of the visible universe and certainly not a billion. Considering our estimate of the size of the universe has expanded over a *trillion*-fold in just the past three hundred years, the prospect that the universe will prove to be another trillion times larger than the visible universe is not only possible, it is highly probable from a Bayesian perspective.[v]

The problem is one of using single-scale logic. Right now, we use only the distribution data gathered at the very largest scale we can observe to predict what might lay beyond. Using such single-scale Bayesian logic, we might watch the Sun rise for a million years and presume that it will rise forever. But a smaller scale Bayesian examination of the fusion process or a larger scale examination of the statistical lifetimes of G class stars, combine to provide a statistical limit to the prospects of the local sunrise. A Bayesian examination of a hierarchical universe is itself hierarchical. We need to employ as many scales in the examination of the extra-scalar disposition of the universe as we can. There are two distinct multi-scalar spectra of data which provide Bayesian rationales for characterizing the universe beyond the scale of the largest structures we can see.

4. Structural Analysis

The first spectrum we can apply to the broader characterization of the universe is, of course, the overall structure of the physical universe across all observable scales. Using the behavior of every material structure ever observed from quarks to galaxy clusters as a template, we can establish a consistent material pattern across all observable scales. We see the unambiguous picture of a universe that is fundamentally constructed of little pieces (Finite Rule) invariably joining in multiple profusion (Plurality Principal) to form larger pieces (Finite Rule) which in turn join again in profusion (Plurality Principal) to form larger structures, etc, etc, without exception, at every scale we have been able to observe.

In the same way we might calculate the probability of the Sun rising tomorrow based on having observe it rise for the previous eight days, the root form of Bayes'

Theorem can be applied to the likelihood that the Big Bang conforms to both rules of cosmology based on the following eight stages of trans-scalar structural conformity: Multiple quarks form neutrons, neutrons form atoms, atoms form molecules, molecules form planets, planets form star systems, star systems form galaxies, galaxies form galaxy clusters and collectively receding galaxy clusters suggest the form of a Big Bang for a total of nine stages of material hierarchy.

The root form of Bayes Theorem sets up as follows:

$$p(Hm|E) = \frac{p(E|Hm)*p(Hm)}{p(E|Hm)*p(Hm) + p(E|{\sim}Hm)*p({\sim}Hm)}$$

In its root form Bayes theorem is deceptively simple. In application, however, the variables can be complicated functions integrated across wide ranges of incidental data. In this analysis the variables are held to a minimum of complexity for clarity's sake, with **p(**x**)** being the probability of x, **Hm** being the contention that the **m**aterial universe is in **H**ierarchical compliance with the two rules, **E** being the hierarchical evidence at hand, and the "**|**" operator indicating that the left hand variable is evaluated "given" or "presuming" that the right hand variable is true.

Thus p(Hm|E) (the *posterior probability* or the answer we are seeking), is the probability that the material object under considerations is a *finite*, *multiply manifest* constituent of a larger object (Hm), *given* (|) the evidence that the current object is itself demonstrably assembled from a collection of finite, multiply manifest smaller objects (E). The remaining variables on the right side of the equation are collectively called the prior probabilities or the "priors." It is the initial, often wholly subjective, assignment of values to these variables that comprises the most controversial aspect of Bayes Theorem. In our case, however, the hierarchical evidence field is so consistent that we can adopt a fairly neutral, fairly simple doctrine for assigning values to the priors without much risk of inadvertent pro-Hm bias. The priors are defined and evaluated as follows:

p (E|Hm) = the *inverse conditional probability* or the probability of finding evidence E (the existence of smaller objects collectively assembled within the current object) assuming that phenomenon Hm (all objects are finite and multiply constituent to larger objects) is true as well for the current object as it relates to the next larger scaled material structures. We could say that since all objects we have ever been able to fully corroborate have complied with Hm that this value should be true or 1 or very close to it. But in consideration of the widely held subjective belief that the universe does not comply with Hm at the scale of the Big Bang, we will include the Big Bang as a non-compliant stage (Hm *not* true) among the 8 objectively compliant stages of material hierarchy (starting with the quark) for a frequentist's interpretation of 8/9 or 0.889 for p (E|Hm).

p (Hm) = The prior probability of phenomenon Hm being true *independent* of the evidence E, or *the prior probability of* Hm. For neutrality's sake we will ignore the evidence in favor of (Hm) and start with a 50/50 split between Hm (all objects are finite and multiply constituent to larger objects) and ~Hm (*not* all objects are finite and multiply constituent). This value is purely the initial value of the variable and not a fixed value.

p (E|~Hm) = the *normalizing conditional probability* or the probability of evidence E (the existence of smaller objects collectively assembled in the current object) being true presuming that phenomenon Hm (all objects are finite constituents of larger objects) is *not* true of the current object as it relates to the next larger scale material structure. We will assign p (E|~Hm) = 0.5 allowing that the evidence of the current object exhibiting smaller constituents has an equal chance of being somehow unrelated or contrary to our phenomenon (Hm), even though the current accumulated evidence is 8 out of 8 that (E) is both related to and corroborative of (Hm). We conservatively allow this value to remain fixed at 0.5 to even though it can be argued that this refuting probability should decrease when the phenomenon tends towards true as we accumulate the evidence.

p (~Hm) = The *normalizing alternative probability* or the prior probability that Hm is *not* true for the object under considerations, independent of E. Since there is not third possibility to our problem statement of compliance to the hierarchy (i.e., it is or it isn't compliant) this value is necessarily 1 – (Hm) = 0.5.

With the priors thus established, we start with the smallest object we can currently detect (the neutron) that we know contains yet smaller, multiply manifest constituents (3 quarks to a neutron) and calculate the following Bayesian probability of neutrons being finite constituents of yet larger objects.

$$p(Hm|E) = \frac{0.889 * 0.5}{(0.889 * 0.5) + (0.5 *(1- 0.5))}$$

$p(Hm|E) = 0.64$ (neutron constituent to a larger object)

Which is a modest improvement over the initial subjective assignment of p(Hm) = 0.5. As is often the case in Bayesian analyses, we will now use the last calculated value of the *posterior probability* as the new *prior probability* for consideration of the next new manifestation of evidence. Thus, $p(Hm)_n = p(Hm|E)_{n-1}$ in the next calculation, Substituting $p(\sim Hm)_n = (1-p(Hm))_n = (1-p(Hm|E)_{n-1})$, we establish a Bayesian *sequence* for examining an ongoing spectrum of hierarchical structure data updating our confidence in the two Bayesian rules of hierarchy as we go.

In this manner, the Bayesian equation,

$$p(Hm|E)_0 = \frac{p(E|Hm)*p(Hm)}{p(E|Hm)*p(Hm) + p(E|\sim Hm)*p(\sim Hm)}$$

produces the Bayesian sequence,

$$P(Hm|E)_n = \frac{p(E|Hm)*p(Hm|E)_{n-1}}{p(E|Hm)*p(Hm|E)_{n-1} + p(E|\sim Hm)*(1-p(Hm|E)_{n-1})}$$

Starting with the initial priors and the root from of Bayes equation we have an initial posterior probability of:

$p(Hm|E)_0 = 0.64$ (neutron constituent to the atom)

From there we substitute and proceed with the sequence:

$$P(Hm|E)_1 = \frac{0.889 * 0.64}{(0.889 * 0.64) + (0.5 *(1-0.64)}$$

$p(Hm|E)_1 = 0.76$ (atom constituent to the molecule)
$p(Hm|E)_2 = 0.85$ (molecule constituent to planet)
$p(Hm|E)_3 = 0.91$ (planet constituent to star system.)
$p(Hm|E)_4 = 0.9\underline{5}$ (star system constituent to galaxy)
$p(Hm|E)_5 = 0.97$ (galaxy constituent to galaxy clusters)
$p(Hm|E)_6 = 0.98$ (galaxy clusters constituent to Big Bang)
$p(Hm|E)_7 = 0.99$ (Big Bang constituent to a larger structure?)

Thus, we have a consistent trend and a plausible Bayesian probability that the Big Bang, in conjunction with an indeterminately broad class of immense Big Bang phenomena, is constituent to a larger, mind numbingly immense, yet ultimately finite, superstructure.

5. Historical Analysis

The second spectrum we can apply to a Bayesian assessment of the Finite Rule and Plurality Principle is the history of the human perception of the universe. For the last 2000 years our cosmological expectations have been in consistent disharmony with our subsequent discoveries in concise resistance to the above two rules of hierarchy. Using the pattern of each of our five main cosmological models, we have a consistent pattern of succession. Instead of being the largest, unique universal structure terminating the hierarchy, each model was in its turn discovered to be subordinate to a more extensive material context.

Applying Bayes' Theorem to the succession of our five major models we see the mythological Flat Earth was found to be hierarchically subordinate as one of many celestial objects in a much larger Ptolemaic structure. The Ptolemaic Earth was then found to be hierarchically subordinate as one of many smaller planets orbiting a much larger Copernican Sun. The Copernican Sun was found to be one of many stars subordinate to a vastly larger Milky Way galaxy. And the Island Universe's was found to be one of many Galaxies subordinate to a staggeringly large Big Bang system. Thus, we might define the posterior probability of the Bayesian succession of cosmologies, p(Hc|E), as the probability that the next cosmology will relegate the current **c**osmology into conformity with the physical **H**ierarchy of the universe (**Hc**) given (|) the evidence (**E**) of the previous cosmology being hierarchically relegated in the same fashion.

Since both the succession of our cosmologies and the succession of the material universe are dependent upon the same structural hierarchy, our historical analysis sets up identically to the structural analysis, with the sole exception of number of stages through which we may iterate our sequence. Since we have only 5 roughly identifiable cosmologies in our history, with 4 known to have failed in general resistence to the presumption of a greater hierarchical context, we allow for the possibility that the Big Bang could indeed terminate the hierarchy at one out of five yielding the lowest reasonable value for p (E|Hc) = 4/5 = 0.8. Following identical rationales used in the structural analysis above, we assign the initial values to the priors as follows:

p (E|Hc) = The inverse conditional probability = 0.8. (fixed) p (Hc) = The prior probability = 0.5.

p (E|~Hc) = The normalizing conditional probability = 0.5 (fixed)

p (~Hc) = The normalizing alternative probability = 1 – p(Hc) = 0.5.

So we take the Flat Earth, the Ptolemaic the Copernican, the galactic "Island Universe" and the Big Bang cosmological models and calculate the odds that each one turned out to be a lesser constituent of the subsequent more contextually diverse model. The Flat Earth was found to be subordinate to a much larger, more diverse Ptolemaic system, so we first calculate the root form of Bayes Theorem for the first iteration of human cosmology:

$$p(Hc|E)_0 = \frac{P(E|Hc)*p(Hc)}{p(E|Hc)*p(Hc) + p(E|\sim Hc)*p(\sim Hc)}$$

$$p(Hc|E)_0 = \frac{0.8 * 0.5}{(0.8 * 0.5) + (0.5 * (1-0.5))}$$

$p(Hc|E)_0 = 0.62$ (Flat Earth subordinate to the Ptolemaic model)

And then substitute into the sequence:

$$p(Hc|E)_1 = \frac{0.8 * 0.667}{(0.8 * 0.64) + (0.5 *(1-0.64)}$$

$p(Hc|E)_1 = 0.72$ (Ptolemaic subordinate to the Copernican model)

$p(Hc|E)_2 = 0.8$ (Copernican subordinate to the Galactic model)

$p(Hc|E)_3 = 0.86$ (Galactic subordinate to the Big Bang)

$p(Hc|E)_4 = 0.91$ (Big Bang subordinate to the next hierarchical model?)

While the first two models do not digress in as distinct non-conformity to the rules of hierarchy as might the last three, they nonetheless represents a scalar relegation of both spatial primacy and object plurality, with the Earth being twice relegated in scope and class as a lesser constituent in a larger context.

These analyses offer a rational provocation to presume that, ultimately, the Big Bang is a local description of an ongoing hierarchical structure, the homogeneity of which will eventually prove to be scale-limited. Both the structural analysis of the known universe and the historical analysis or our cosmologies offer compelling rationales that not only is the universe intrinsically hierarchical, but that we humans tend to falsely terminate that hierarchy in pursuit a complete and sufficient description of the universe based on the data at hand. We now have a sufficient data field to make and altogether different presumption that any unconfirmed termination of the material hierarchy of the universe is more psychological artifact than logical conclusion.

6. Bayesian Caveats and Advantages

The value of presuming the ongoing hierarchy of the universe is not so much in refuting the cosmological principle as in refining the direction of our investigations. We must admit to that the homogeneity we see in the large scale universe may indeed remain forever beyond our ability to confirm or deny. Comparing the homogeneity of the billions of galaxies in the visible universe to the untold trillions of molecules in a single drop of water lends perspective to the staggering potential for any single-scaled homogeneity to range in mind-numbing uniformity, particularly considering our hypothetical drop of water to be surrounded by an ocean. Even though the mind-numbingly vast symmetry of an ocean of water molecules eventually must come to an end, it would be virtually impossible to determine that prospect from a hundred billion molecule sample (smaller than a pinpoint) at its center. Thus, we may never be able to objectively determine the limits of the homogeneity of the Big Bang.

The more practical, more immediate value in presuming the Bayesian probability of an ongoing hierarchy is in directing our attentions to the most probable areas for our model's theoretical evolution. While no one can deny that what we humans strive to acquire with the scientific method is a complete description of all of physical reality, almost everyone will concur that sooner or later all our theories are subject to future evolution. Asking ourselves what the human vision of the universe will be in a thousand years presumes a wealth of new discoveries and dramatic successions to our theories similar to those in the past. The presumption of such evolution begs the question: Which aspect of our current model is most likely to be the next to evolve?

It is strongly suggested by our Bayesian analysis that it is precisely those aspects of our paradigm that serve to terminate the hierarchy that are historically the most probable resources for the current model's evolution. While it is beyond the scope of this paper to specify that evolution, the two aspects of the standard model that are most involved with terminating the hierarchy are the cosmological principle and inflation theory. Both of these theories serve to terminate the hierarchy by extending what know at the limits of our investigations to an infinite and infinitesimal degree. Rather we should anticipate that there will be more scalar diversity below the quark and beyond the visible universe than the prevailing data can convey. Thus, the most valuable prediction this paper suggests is that these two theoretical aspects of our cosmology (inflation and the cosmological principle) are potentially rich resources for theoretical evolution of the standard model.

Keeping in mind that the local homogeneity of the universe may range forever beyond our ability to encompass, we might nonetheless examine the data we do have for some extremely attenuated evidence of its limits. It is trivially suggested that the WMAP CMB data might be examined for faint asymmetry. If the Big Bang is ultimately a finite expanding structure then the most probable profile it might manifest would be a faint dipole in the overall temperature of the CMB radiation.

With respect to inflation theory, it's a much more difficult question. Ostensibly we might examine the potential for the Big Bang to have an initial finite mass. To this end, presuming some substantial structural initiator of yet unknown origin (black hole, worm hole) may be fruitful in modeling the Big Bang as the transition phase of a finite material structure and not the creation of all of reality, as may be more compatible with the Bayesian perspective of an ongoing material hierarchy. In this manner, inflation could be occurring behind the veil of an event horizon where our uncertainty is significant enough to presume further investigation. Once again, this paper's prediction is only identifying the areas of our cosmology that are most likely to evolve. The specifics of that evolution are beyond the scope of this paper.

7. Conclusion

The universe has always been larger and more diverse than any of our previous cosmologies could encompass. While the data in this analysis are relatively few, they are unambiguously consistent in the Bayesian suggestion that our current cosmology is but a hierarchical subordinate of our next cosmology. In the past our inadvertently false presumptions of sufficiency were comparatively moot. The data told the tale, no matter our presumptions. But, as we reach further and further from our native scale, only the most prohibitively expensive, massively sophisticated orbital observatories and enormous particle accelerators can offer us much more in the way of hard data. As such, we may want to discipline our theoretical expectations to make the best possible use of the data we do manage to acquire that mitigates our psychological propensity to oversimplify the universe.

If the material hierarchy persists, the presumption of an infinitely diverse, open-ended context within which the human body of knowledge interstitially resides will be equally important to our understanding the true nature of the universe as our best efforts to locally characterize it. This paper offers an empirical provocation for moving away from a complete and sufficient model of the universe to a more probable Bayesian model in which there will always be the intrinsic expectation of theoretical evolution.

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[i] Bayes, Thomas (1763): "An essay towards solving a problem in the doctrine of chances." *Philosophical Transactions of the Royal Society.* **53**: 370-418.

[ii] Martinez, Vincent, Pons-Bordería, María-Jesús; Moyeed, Rana A.; Graham, Matthew J. (1998),"Searching for the Scale of Homogeneity." Monthly Notices of the Royal Astronomical Society, Volume 298, Number 4, August 1998 , pp. 1212-1222(11), Blackwell Publishing

[iii] Patrícia G. Castro, Marian Douspis, and Pedro G. Ferreira, (2003) Physical Review D., Volume 68, Issue 12, 3 pages.

[iv] http://map.gsfc.nasa.gov/universe/bb_tests_cmb.html

[v] http://www.thegodofreason.com/infinity.pdf