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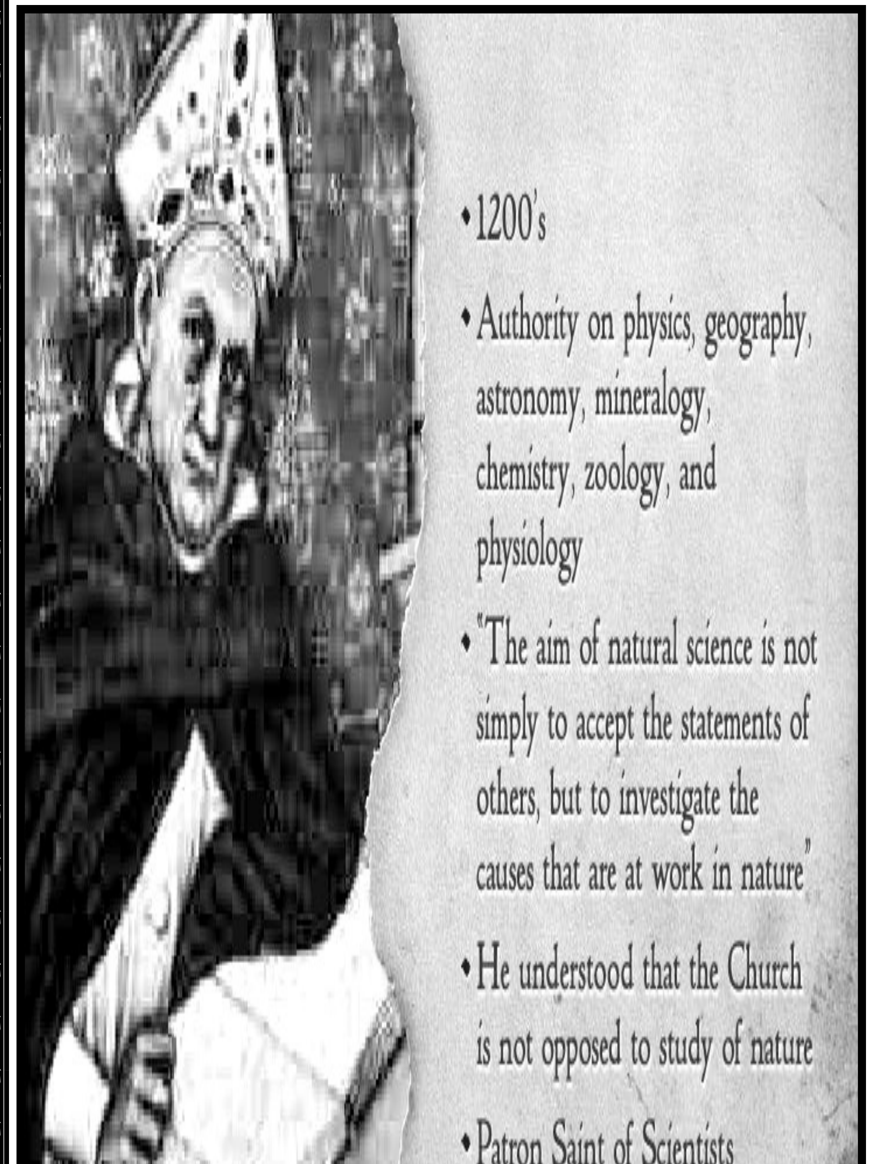
Catholic Physics - Reflections of a Catholic Scientist - Part 34

Philosophic Issues in Cosmology 8: Foundational Propositions and Conclusions



Philosophic Issues in Cosmology 8: Foundational Propositions and Conclusions

“One question in science is not ' is this hypothetical model true' but "is this model better than the alternatives'...If we believe dogmatically in a particular view, then no amount of contradictory data will convince us otherwise...” John Skilling, “Foundations and Algorithms” in Bayesian Methods in Cosmology

This is the eighth post summarizing Issues in the Philosophy of Cosmology by George F.R. Ellis. A complete list of the issues and theses he presents is given in the Appendix below*. Before addressing the philosophic issues themselves, some preliminary remarks are in order. First, because of space limitations, the summary has been selective; a number of technical issues have not been discussed; if a reader is interested in these, I'd recommend the original article, via the web link given above.

Second, contrary to some comments on these posts, neither Ellis nor I are making any arguments for theism or anti-atheism in the post proper; philosophic alternatives are presented, and if a reader draws theological conclusion from these alternatives, that's up to him/her.*

Third, no values for evidential probability (in the post on Anthropic Coincidences) have been presented; indeed, Ellis argues (and I agree) that inferring an evidential probability for one datum (our universe) is not a valid procedure.

Fourth, the general focus of the article, and my emphasis in these posts, is on what can science say about cosmology and what philosophic assumptions underlie such scientific conclusions.

SCIENTIFIC CRITERIA

Ellis gives as an important criteria for a scientific theory that it be empirically testable. My position may be even stronger than that of

Ellis: if a theory cannot be confirmed by quantitative measurements then it is not in my view (and that of Fr. Stanley Jaki), science, but something else—mathematical metaphysics?

What can be confirmed by measurement is limited by the time, distance and physics horizons mentioned in the first post.

Using electromagnetic radiation we cannot see further back in time than when radiation decoupled from matter, about 380,000 years after the origin.

We cannot see further in space than given by the distance horizon, the distance at which space will be expanding at faster than the speed of light.

We cannot duplicate the tremendous energies present in the initial, quantum stages of the beginning of the universe (these energies are orders of magnitude greater than even the huge energies that will be available in the SLAC Hadron supper collider), so we cannot test projected theories of particle creation.

What can be measured are inferred consequences of various theories: what the cosmic background radiation (CBR) shows about homogeneity, isotropy, fluctuations, the cosmological constant (lambda, representing expansion pressure), etc. Recent examples are the report of Gurzadyan and Penrose of rings in the CBR representing cataclysmic events pre-Big Bang and B-mode measurements of the CBR from which are inferred gravitational waves in the early universe and thus inflation. One may disagree with the aspects of the theory, but the tie-in with measured data is commendable.

THESES FOR PHILOSOPHIC ISSUES

Ellis gives a series of theses for his position on philosophic issues and these are presented as an appendix, to give a complete summary. The theses in Issue F, “The explicit philosophic basis”, will be presented in detail. As a preliminary and review, here are theses pertinent to the science of cosmology (NOTE: the theses are taken directly from the article even though no quotation marks are present):

THESIS A1: The universe itself cannot be subjected to physical experimentation. We cannot re-run the universe with the same or altered conditions to see what would happen if they were different , so we cannot carry out scientific experiments on the universe itself.

THESIS A2: The universe cannot be observationally compared with other universes. We cannot compare the universe with any similar object, nor can we test our hypotheses about it by observations determining statistical properties of a known class of physically existing universes.

THESIS B3: Establishing a Robertson-Walker geometry for the universe relies on plausible philosophic assumptions. The deduction of spatial homogeneity follows not directly from astronomical data but because we add to the observations a philosophical principle that is plausible but untestable.

(In Thesis B3, Ellis refers to the notion that the universe is isotropic and homogeneous (on a large scale). From our vantage point, we can see that the CBR (cosmic background radiation) yields this result; but to show that the inference is valid for the universe as a whole, we would need to make the same observation from at least two other (far removed) vantage points. However, if the Copernican Principle is invoked that we do not occupy a special place in the universe (this is the philosophic principle Ellis refers to in Thesis B3), then what see is equivalent to what would be seen from other positions, and the homogeneity and isotropy is demonstrated.)

Issue H: The possible existence of multiverses

Thesis H1: The Multiverse proposal is unprovable by observation or experiment
Thesis H2: Probability-based arguments cannot demonstrate the existence of multiverses
Thesis H3: Multiverses are a philosophical rather than scientific proposal
Thesis H4: The underlying physics paradigm of cosmology could be extended to include biological insights

Issue I: The natures of existence

Thesis I1: We do not understand the dominant dynamical matter components of the universe at early or late times
Thesis I2: The often claimed physical existence of infinities is questionable
Thesis I3: A deep issue underlying the nature of cosmology is the nature of the laws of physics.

Thesis of Uncertainty: Ultimate uncertainty is one of the key aspects of cosmology.

THESIS B6: Observational horizons limit our ability to observationally determine the very large scale geometry of the universe. We can only see back to the time of decoupling of matter and radiation and so have no direct information about earlier times; and unless we live in a 'small universe', most of the matter in the universe is hidden behind the visual horizon. Conjectures as to its geometry on larger scales cannot be observationally tested. The situation is completely different in the small universe case: then we can see everything there is in the universe, including our own galaxy at earlier times! (emphasis and exclamation point added)

THESIS C1: The Physics Horizon limits our knowledge of physics relevant to the very early universe. We cannot experimentally test much of the physics that is important in the very early universe because we cannot attain the required energies in accelerators on Earth. We have to extrapolate from known physics to the unknown and then test the implications; to do this, we assume some specific features of known lower energy physics are the true key to how things are at higher energies. We cannot experimentally test if we have got it right.

THESIS C2: The unknown nature of the inflation means inflationary universe proposals are incomplete. The promise of inflationary theory in terms of relating cosmology to particle physics has not been realized. This will only be the case when the nature of the inflaton (the particle representing the scalar force causing inflation)has been pinned down to a specific field that experiment confirms or particle physics requires to exist.
THESIS D2: Testable physics cannot explain the initial state and hence specific nature of the universe. (emphasis added)
Ellis expands on Thesis D2 as follows:

"A choice between different contingent possibilities has somehow occurred; the fundamental issue is what underlies this choice. Why does the universe have one specific form rather than another, when other forms consistent with physical laws seem perfectly possible? The reason underlying the choice between different contingent possibilities for the universe (why one occurred rather than another) cannot be explained scientifically. It is an issue to be examined through philosophy or metaphysics." (emphasis added).

This last proposition is, I believe, the most important of those Ellis sets forth.

THESIS E1: Physical laws may depend on the nature of the universe. Ellis is saying here that the fundamental constants (e.g. the fine-structure constant, the gravitational constant may vary in time and space). It is a philosophical assumption that they remain constant. (Note: one recent finding, which is controversial, suggests that there is an asymmetric variation through space [and time] in the fine-structure constant.)

PHILOSOPHIC CRITERIA FOR SCIENTIFIC THEORIES

THESIS F1: Philosophic choices necessarily underlie cosmological theory.Unavoidable metaphysical issues inevitably arise, in both observational and physical cosmology. Philosophical choices are needed in order to shape the theory.

THESIS F2: Criteria of satisfactoriness for theories cannot be scientifically chosen or validated. Criteria of satisfactoriness are necessary for choosing good cosmological theories; these criteria have to be chosen on the basis of philosophical considerations. They should include criteria for satisfactory structure of the theory, intrinsic explanatory power, and observational and experimental support. These criteria are listed below:

1. Satisfactory structure: a) internal consistency, b) simplicity (Ockham's razor), and c) aesthetic appeal ('beauty' or 'elegance')

Issue D: Explaining the universe — the question of origins

Thesis D1: An initial singularity may or may not have occurred
Thesis D2: Testable physics cannot explain the initial state and hence specific nature of the universe
Thesis D3: The initial state of the universe may have been special or general

Issue E: The Universe as the background for existence

Thesis E1: Physical laws may depend on the nature of the universe
Thesis E2: We cannot take the nature of the laws of physics for granted
Thesis E3: Physical novelty emerges in the expanding universe

Issue F: The explicit philosophical basis

Thesis F1: Philosophical choices necessarily underly cosmological theory
Thesis F2: Criteria for choice between theories cannot be scientifically chosen or validated
Thesis F3: Conflicts will inevitably arise in applying criteria for satisfactory theories
Thesis F4: The physical reason for believing in inflation is its explanatory power re structure growth.
Thesis F5: Cosmological theory can have a wide or narrow scope of enquiry
Thesis F6: Reality is not fully reflected in either observations or theoretical models

Issue G: The Anthropic question: fine tuning for life

Thesis G1: Life is possible because both the laws of physics and initial conditions have a very special nature
Thesis G2: Metaphysical uncertainty remains about ultimate causation in cosmology

APPENDIX

SUMMARY TABLE OF ISSUES AND THESES

Issue A: The uniqueness of the universe

Thesis A1: The universe itself cannot be subjected to physical experimentation
Thesis A2: The universe cannot be observationally compared with other universes
Thesis A3: The concept of 'Laws of Physics' that apply to only one object is questionable
Thesis A4: The concept of probability is problematic in the context of existence of only one object

Issue B: The large scale of the Universe in space and time

Thesis B1: Astronomical observations are confined to the past null cone, and fade with distance
Thesis B2: 'Geological' type observations can probe the region near our past world line in the very distant past
Thesis B3: Establishing a Robertson-Walker geometry relies on plausible philosophical assumptions
Thesis B4: Interpreting cosmological observations depends on astrophysical understanding
Thesis B5: A key test for cosmology is that the age of the universe must be greater than the ages of stars
Thesis B6: Horizons limit our ability to observationally determine the very large scale geometry of the universe
Thesis B7: We have made great progress towards observational Completeness

Issue C: The unbound energies in the early universe

Thesis C1: The Physics Horizon limits our knowledge of physics relevant to the very early universe
Thesis C2: The unknown nature of the inflation means inflationary universe proposals are incomplete

2. Intrinsic explanatory power: a) logical tightness, b) scope of the theory—the ability to unify otherwise separate phenomena, and c) probability of the theory or model with respect to some well-defined measure.

3. Extrinsic explanatory power, or relatedness:
a) connectedness to the rest of science, b) extendability providing a basis for further development;

4. Observational and experimental support, in terms of
a) testability: the ability to make quantitative as well as qualitative predictions that can be tested; and
b) confirmation: the extent to which the theory is supported by such tests as have been made." (emphasis added)

The last criterion in my view (and that of many other scientists and philosophers of science) is critical. If a theory cannot in principle be confirmed quantitatively it is not science, but belongs to other disciplines.

THESIS F3: Conflicts will inevitably arise in applying criteria for satisfactory cosmological theories. Philosophical criteria for satisfactory cosmological theories will in general come into conflict with each other, so that one will have to choose between them to some degree; this choice will shape the resulting theory.

Ellis elaborates on this last thesis:

"The thrust of much recent development has been away from observational tests towards strongly theoretical based proposals, indeed sometimes almost discounting observational tests. (emphasis added) At present this is being corrected by a healthy move to detailed observational analysis of the proposed theories, marking a maturity of the subject."

THESIS F4: The physical reason for believing in inflation is its explanatory power as regards structure growth in the universe. ... This theory has been vindicated spectacularly through observations of the CBR and matter power spectra. It is this explanatory power that makes it so acceptable to physicists, even though the underlying physics is neither well-defined nor tested, and its major large-scale observational predictions are untestable. (emphasis added).

Expanding on Thesis F4, Ellis adds:

“Inflation provides a causal model that brings a wider range of phenomena into what can be explained by cosmology (Criterion 2b), rather than just assuming the initial data had a specific restricted form. Explaining flatness (omega0 approximately 1, as predicted by inflation) and homogeneity reinforces the case, even though these are philosophical rather than physical problems (they [the initial restricted conditions] do not contradict any physical law; things could just have been that way). However claims on the basis of this model as to what happens very far outside the visual horizon (as in the chaotic inflationary theory) results from prioritizing theory over the possibility of observational and experimental testing. It will never be possible to prove these claims are correct.” (emphasis added)

Ellis asks, “how much should we try to explain” with cosmology? What should the scope of cosmology include?

THESIS F5:Cosmological theory can have a wide or narrow scope of enquiry. The scope we envisage for our cosmological theory shapes the questions we seek to answer. The cosmological philosophical base becomes more or less dominant in shaping our theory according to the degree that we pursue a theory with more or less ambitious explanatory aims in terms of all of physics, geometry and underlying fundamental causation.

Elaborating on this point, Ellis says:

With respect to the significance of cosmology, Ellis concludes:

THESIS OF UNCERTAINTY: Ultimate uncertainty is a key aspect of cosmology.Scientific exploration can tell us much about the universe, but not about its ultimate nature, or even much about some if its major geometrical and physical characteristics. Some of this uncertainty may be resolved, but much will remain. Cosmological theory should acknowledge this uncertainty.

Some final thoughts of my own:

First, Ellis's review of the philosophical issues underlying cosmology is a most useful antidote to more grandiose presentations that ignore considerations of epistemology and metaphysics. Although in this article he touches only lightly on the place of man in the cosmos, he has also written a short book, “Before the Beginning-Cosmology Explained”, that addresses this question and theological considerations more fully. The book also gives a much simpler (ground up from basic physics) summary of the science in cosmology than that in the article.

Second, much of the reasoning used to justify various cosmological models and theories is abductive , that is, to say that theory/model is "true" because it is the best (most elegant) explanation for the phenomena. That type of reasoning has been criticized by philosophers of science, e.g. Bas van Fraassen, William Stoeger, Nancy Cartwright. There are historical examples to show that the best explanation (at the time) is not necessarily true--e.g. phlogiston, disproved by Count Rumford's cannon-boring experiments, the ether, disproved by the Michelson-Morley experiments. Unfortunately (or maybe fortunately), as Ellis emphasizes, we can't experiment on the cosmos.

the stance one takes should be related to the totality of man's existence in the universe.

“Firstly, even in order to understand just the material world, it can be claimed that one needs to consider forms of existence other than the material only — for example a Platonic world of mathematics and a mental world, both of which can be claimed to exist and be causally effective in terms of affecting the material world. Our understanding of local causation will be incomplete unless we take them into account.

Secondly, in examining these issues one needs to take into account data about the natures of our existence that come from our daily lives and the broad historical experience of humanity (our experiences of ethics and aesthetics, for example), as well as those discoveries attained by the scientific method. Many writings claim there is no purpose in the universe: it is all just a conglomerate of particles proceeding at a fundamental level in a purposeless and meaningless algorithmic way. But I would reply, the very fact that those writers engage in such discourse undermines their own contention; they ignore the evidence provided by their own actions. There is certainly meaning in the universe to this degree: the fact they take the trouble to write such contentions is proof that they consider it meaningful to argue about such issues; and this quality of existence has emerged out of the nature of the physical universe.... Indeed the human mind is causally effective in the real physical world precisely through many activities motivated by meanings perceived by the human mind. Any attempt to relate physics and cosmology to ultimate issues must take such real world experience seriously, otherwise it will simply be ignoring a large body of undeniable data. This data does not resolve the ultimate issues, but does indicate dimensions of existence that indeed do occur.”

“...The study of expansion of the universe and structure formation from nucleosynthesis to the present day is essential and well-informed. The philosophical stance adapted is minimal and highly plausible. The understanding of physical processes at earlier times, back to quantum gravity, is less well -founded. The philosophical stance is more significant and more debatable. Developments in the quantum gravity era are highly speculative, the philosophical position adapted is dominant because experimental and observational limits on the theory are lacking.” (emphasis added)....the basic underlying cosmological questions are:

1. Why do the laws of physics have the form they do? Issues arise such as what makes particular laws work? for example, what governs the behaviour of a proton, the pull of gravity?...

2. Why do boundary conditions have the form they do?

3. Why do laws of physics at all exist? This relates to unsolved issues concerning the nature of the laws of physics: are they descriptive or prescriptive? ...Is the nature of matter really mathematically based in some sense, or does it just happen that its behaviour can be described in a mathematical way?

4. Why does anything exist? This profound existential question is a mystery whatever approach we take.

5. Why does the universe allow the existence of intelligent life? This of somewhat different character than the others and largely rests on them but is important enough to generate considerable debate in its own right. (Note: this question is that related to the Anthropic Principle--#6 in this series.)

The status of all these questions is philosophical rather than scientific, for they cannot be resolved purely scientifically. How many of them—if any—should we consider in our construction of and assessments of cosmological theories?”

The next important question Ellis considers is how well does science, particularly cosmology, represent reality.

> "It follows...that there are limits to what the scientific method can achieve in explanatory terms. We need to respect these limits and acknowledge clearly when arguments and conclusions are based on some philosophical stance rather than on purely testable scientific argument. If we acknowledge this and make that stance explicit , then the bases for different viewpoints are clear and alternatives can be argued rationally."

THESIS F6: Reality is not fully reflected in either observations or theoretical models. Problems arise from confusion of epistemology (the theory of knowledge) with ontology (the nature of existence) existence is not always manifest clearly in the available evidence. The theories and models of reality we use as our basis for understanding are necessarily partial and incomplete reflections of the true nature of reality, helpful in many ways but also inevitably misleading in others. They should not be confused with reality itself!"

"It may be suggested that arguments ignoring the need for experimental/observational verification of theories ultimately arise because t**hese theories are being confused with reality, or at least are being taken as completely reliable total representation of reality.** (emphasis added)   This occurs in:

"... confusing computer simulations of reality with reality itself, when they can in fact represent only a highly simplified and stylized version of what actually is."

"...confusing the laws of physics themselves with their abstract mathematical representation (if indeed they [the laws] are ontologically real)

... confusing a construction of the human mind ("Laws of Physics") with the reliable behaviour of ponderable matter...

...confusing theoretically based outcomes of models with proven observational results (e.g. claiming the universe necessarily has flat special sections (omega0 =1) and so this can be taken for granted, when the value of omega0 can and should be observationally determined precisely because this then tests that prediction.)"

Another important question Ellis addresses is whether infinities are physically realizable or mathematical constructs. He agrees with the renowned 20th century mathematician David Hilbert that infinity is not a real quantity:

"Our principal result is that the infinite is nowhere to be found in reality. It neither exists in nature nor provides a legitimate basis for rational thought . . . The role that remains for the infinite to play is solely that of an idea .. . which transcends all experience and which completes the concrete as a totality . . ." (quote is from Hilbert).

Since one can never count an infinite number of objects, the claim that the universe is infinite or that there are an infinite number of universes in a multiverse can never be tested or confirmed.

THESIS I2: The often claimed physical existence of infinities is questionable. The claimed existence of physically realized infinities in cosmology or multiverses raises problematic issues. One can suggest they are unphysical; in any case such claims are certainly unverifiable.

Ellis concludes that there is much uncertainty in what one can infer from cosmology, and those inferences one draws are based on the philosophical basis one uses. More importantly,