physicists are satisfied with this explanation. Other explanations have been offered, and as Ellis says:

“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 inflation (the hypothetical particle corresponding to the scalar inflationary field). has been pinned down to a specific field that experiment confirms or particle physics requires to exist outside the visible domain.” (emphasis in the original).

Roger Penrose also has misgivings about inflationary theory, primarily due to what he thinks is a misplaced motivation for applying the theory to explain flatness and homogeneity:

“In the standard model these issues (the flatness, horizon and smoothness problems) are handled by the 'fine-tuning' of the initial Big Bang state, and this is regarded by inflationists as “ugly”. The claim is that the need for such fine tuning is removed in the inflationary picture and this is regarded as a more aesthetically pleasing

It should be understood that in this context, “aesthetically pleasing” corresponds to the absence of an intelligent designer to set the “fine-tuning”, that is to say the absence of a creative God, or, alternatively, the absence of an as yet unknown “theory of everything” that would set the fine-tuning by some universal physical law (my take).

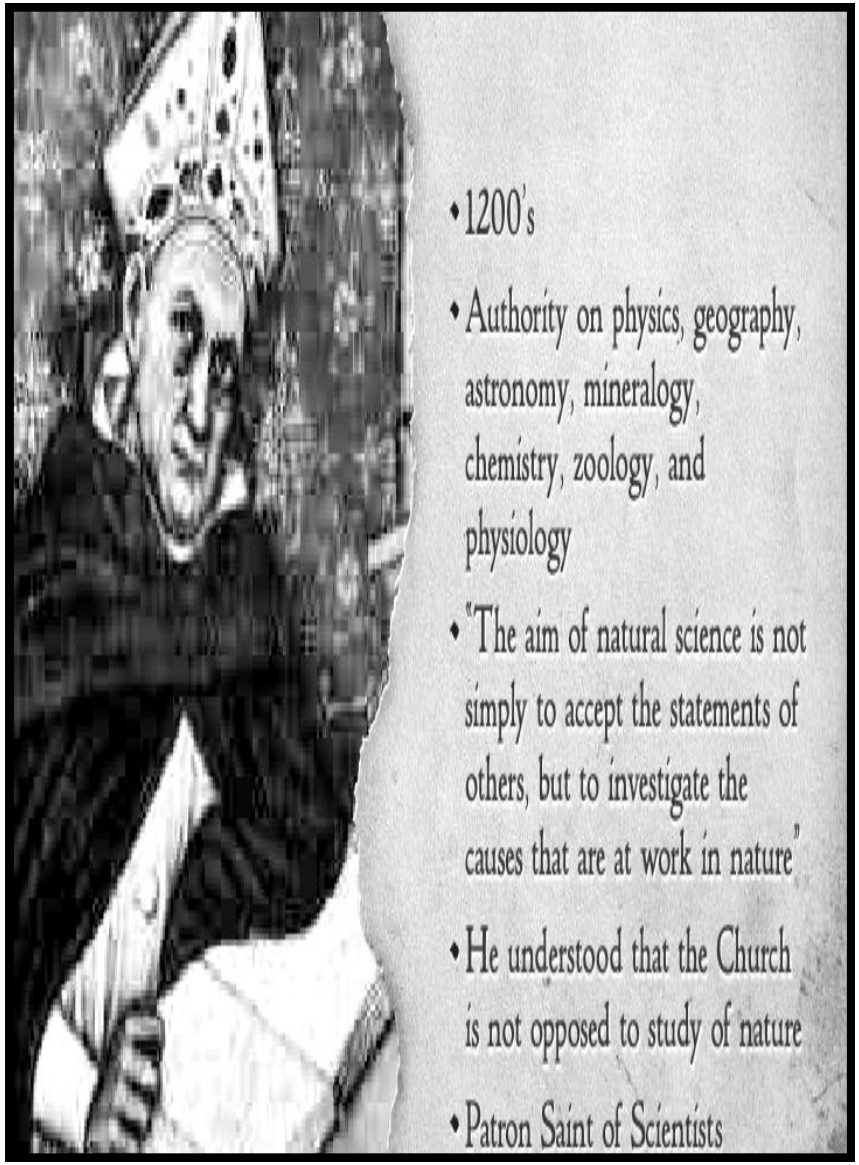
Recent B-mode measurements of the microwave background radiation are in agreement with inflation in that there is evidence of strong gravitational waves in the radiation. Added 28/12/14:See the comment below for links that contradict this interpretation.

Taking inflation to be true because it is the "best" explanation for several cosmological features is an example of "abductive" reasoning, reasoning to the best explanation. Such reasoning has been faulted by several philosophers of science (Nancy Cartwright, Bas van Fraassen) with some cause. Historically phlogiston was the best explanation for heat before Count Rumford's cannon-boring experiments; ether was the best explanation for electromagnetic wave vibration before the Michelson-Morley experiments.

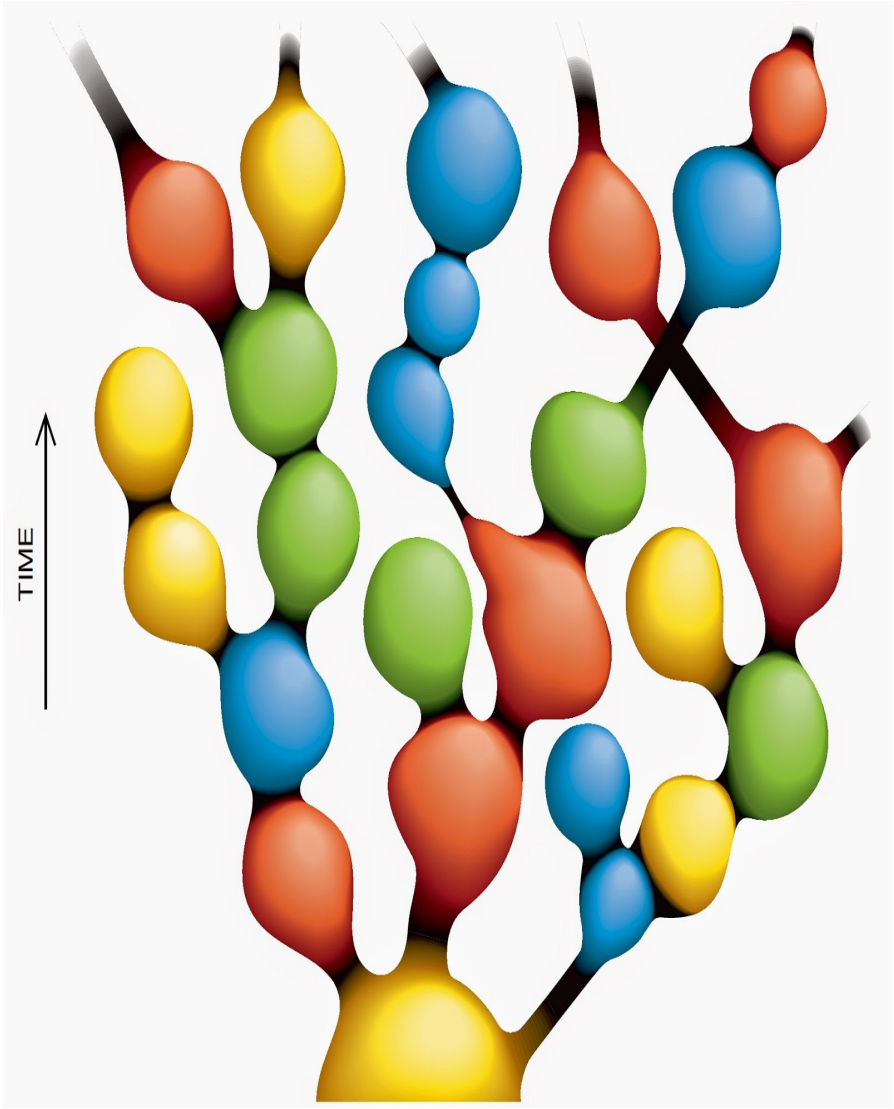
From a series of articles written by: Bob Kurland - a Catholic Scientist

Catholic Physics - Reflections of a Catholic Scientist - Part 33

Philosophic Issues in Cosmology 7: Is there a Multiverse?



Philosophic Issues in Cosmology 7: Is there a Multiverse?



Exploding Universes in a Multiverse Section from
Andrei Linde, Stanford University

**All about Inflation.

One development of quantum cosmology that does have measurable consequences is the notion of inflation introduced by Guth (1981), here explained by Ellis:

"Particle physics processes dominated the very early eras, when exotic processes took place such as the condensation of a quark-gluon plasma to produce baryons. Quantum field theory effects were significant then, and this leads to an important possibility: scalar fields producing repulsive gravitational effects could have dominated the dynamics of the universe at those times. This leads to the theory of the inflationary universe, proposed by Alan Guth ...an extremely short period of accelerating expansion will precede the hot big bang era . This produces a very cold and smooth vacuum-dominated state, and ends in 'reheating': conversion of the scalar field to radiation, initiating the hot big bang epoch. This inflationary process is claimed to explain the puzzles mentioned above: why the universe is so special (with spatially homogeneous and isotropic geometry and a very uniform distribution of matter), and also why the space sections are so close to being flat at present (we still do not know the sign of the spatial curvature), which requires very fine tuning of initial conditions at very early times. (emphasis added) Inflationary expansion explains these features because particle horizons in inflationary FL models will be much larger than in the standard models with ordinary matter, allowing causal connection of matter on scales larger than the visual horizon, and inflation also will sweep topological defects outside the visible domain."

Inflation also explains the rarity (absence) of magnetic monopoles (predicted by the standard model of particle physics), the presence of stars/galaxies (from quantum fluctuations expanded by inflation) and several features of the observed CBR (Cosmic Background Radiation). The projected time scale for the inflationary period is from about 10^-36s after the origin to about 10^-32s, during which period the volume increased by a factor of at least 10^78. As pointed out above, the source of the inflationary increase is an assumed force, a scalar field or isotropic negative pressure, counteracting the force of gravity. Although the notion of inflation explains many puzzling features about our universe, not all

“Probability arguments cannot be used to prove the existence of a multiverse, for they are only applicable if a multiverse (that is to say, a population of multiverses) exists. Furthermore probability arguments can never prove anything for certain, as it is not possible to violate any probability predictions, and this is a fortiori so when there is only one case to consider, so that no statistical observations are possible. (emphasis in the original). All one can say on the basis of probability arguments is that some specific state is very improbable. But this does not prove it is impossible; indeed if is stated to have a low probability, that is precisely a statement that it is possible... probability arguments … (are) equivalent to the claim that the universe is generic rather than special, but whether this is so or not is precisely the issue under debate.”

The issue of whether a multiverse can contain an infinite number of universes (thus justifying the claim that “whatever can happen will happen”) is addressed by Ellis as part of the question whether an infinite number can be considered as real (rather than as a mathematical construct) in his analysis of the philosophic/metaphysical questions involved in cosmology, and will be discussed in the last post of this summary.

In conclusion, Ellis argues that Multiverses are a philosophical rather than scientific proposal.

“The idea of a multiverse provides a possible route for the explanation of fine-tuning. But it is not uniquely defined, is not scientifically testable ... and in the end simply postpones the ultimate metaphysical questions.”

These philosophic issues will be discussed in the final post of this series. (See Part 34)

*Quotations, unless otherwise specified, are from Issues in the Philosophy of Cosmology , George F.R. Ellis.

“It’s hard to build models of inflation that don't lead to a multiverse. It’s not impossible, so I think there’s still certainly research that needs to be done. But most models of inflation do lead to a multiverse, and evidence for inflation will be pushing us in the direction of taking [the idea of a] multiverse seriously.” Alan Guth

"Well, there is the hypothesis ... that all possible universes exist, and we find ourselves, not surprisingly, in one that contains life. But that is a cop-out, which dispenses with the attempt to explain anything. And without the hypothesis of multiple universes, the observation that if life hadn't come into existence we wouldn't be here has no significance. One doesn't show that something doesn't require explanation by pointing out that it is a condition of one's existence. If I ask for an explanation of the fact that the air pressure in the transcontinental jet is close to that at sea level, it is no answer to point out that if it weren't, I'd be dead.” Thomas Nagel, Mind and Cosmos.

This is the seventh in a series of posts summarizing Issues in the Philosophy of Cosmology by George F.R. Ellis*. Also, we'll discuss "inflation" below**, the extremely rapid expansion of the very early universe, since the existence of "bubble universes", a multiverse is predicated on inflation, and since this was not discussed extensively in previous posts.

The notion of an ensemble of many possible universes (small u), not causally connected, “a multiverse”, has been used to counter the unlikeliness of all the anthropic coincidences. To quote Ellis*:

“If there is a large enough ensemble of numerous universes with varying properties, it may be claimed that it becomes virtually certain that some of them will just happen to get things right, so that life can exist; and this can help explain the fine-tuned nature of many parameters whose value values are

otherwise unconstrained by physics... However there are a number of problems with this concept. Besides, this proposal is observationally and experimentally untestable, thus its scientific status is debatable." (emphasis added).

One problem (other than the untestable aspect) is that the probabilistic character of the multiverse is never specified by authors who invoke it:

"These three elements (the possibility space [the population description], the measure [the quantities that describe the particular universe], and the distribution function [for the measure]) ,must all be clearly defined in order to give a proper specification of a multiverse.... This is almost never done."

What is also not usually specified are the possible types of universes contained in a multiverse. Which of the types below should be included?

"Weak Variation: only the values of the constants of physics are allowed to vary?...

Moderate Variation: different symmetry groups, or numbers of dimensions…

Strong Variation: different numbers and kinds of forces, universes without quantum theory or in which relativity is untrue (e.g. there is an aether), some in which string theory is a good theory for quantum gravity and others where it is not, some with quite different bases for the laws of physics (e.g. no variational principles).

Extreme Variation: universes where physics is not well described by mathematics, with different logic; universes ruled by local deities; allowing magic... Without even mathematics or logic?

Which is claimed to be the properties of the multiverse, and why? We can express our dilemma here through the paradoxical question: Are the laws of logic necessary in all possible universes?"

Although the existence of multiverses cannot be justified by measurements, do they offer good explanations for the anthropic coincidences? Ellis answers:

"It has been suggested that they (multiverses) explain the parameters of physics and of cosmology and in particular the very problematic values of the cosmological constant (lambda, the constant for negative pressure) The argument goes as follows: assume a multiverse exists; observers can only exist in one of the highly improbable biophilic outliers where the value of the cosmological constant is very small. ...If the multiverse has many varied locations with differing properties that may indeed help us understand the Anthropic issue: some regions will allow life to exist, others will not. This does provide a useful modicum of explanatory power. However it is far from conclusive. (emphasis added)

Firstly, it is unclear why the multiverse should have the restricted kinds of variations of the cosmological constant assumed in (these) analyses...If we assume 'all that can happen, happens' the variations will not be of that restricted kind; those analyses will not apply."

"Secondly, ultimate issues remain. Why does the unique larger whole (the multiverse)have the properties it does? (emphasis added) Why this multiverse rather than any other one?"

I will add to Ellis's comment that even though one universe in a multiverse has an appropriate value for a particular constant (say, lambda), it will not necessarily be the case that other parameters will be appropriate. There still has to be a conjunction of values for all the laws and constants, which requires either a Theory of Everything to give that (something to wonder about in itself) , or more amazing coincidences.

Ellis further argues that probability-based arguments cannot demonstrate the existence of a multiverse: