Review of The Inflationary Universe by Alan Guth 358 p (1997)

Michael Starks

ABSTRACT

This is one of the best popular cosmology books ever written and Guth is now (2016) a top physics Professor at MIT. He tells the extremely complex story of inflation and related areas of particle physics in such an absorbing style that it reads like a detective novel-in fact, it is a detective novel-how he and others found out how the universe started! The interweaving of his personal story and that of many colleagues along with their photos and many wonderfully clear diagrams allows just the right amount of relaxation from the intensity of the physics. In places the style reminds one of Watson´s famous book ``The Double Helix``. He tells how his work on magnetic monopoles and spontaneous symmetry breaking led to the discovery of the inflationary theory of the very early universe (ca. 10 to minus 35 seconds!).

Along the way you will learn many gems that should stay with you a long time such as: the observed universe(e.g., everything the Hubble telescope etc. can see out to ca. 15 billion light years when the universe began) is likely just a vanishingly tiny part of the entire inhomogeneous universe which is about 10 to the 23rd times larger; the big bang probably took place simultaneously and homogeneously in our observed universe; there probably have been and will continue to be an infinite number of big bangs in an infinite number of universes for an infinite time; when a bang happens, everything(space, time, all the elements) from the previous universe are destroyed; the stretching of space can happen at speeds much greater than the speed of light; our entire observed universe lies in a single bubble out of an endless number so there may be trillions of trillions just in our own entire(pocket) universe(and there may be an endless number of such); none of these infinite number of universes interact-i.e., we can never find out anything about the others; each universe started with its own big bang and will eventually collapse to create a new big bang; all this implies that the whole universe is fractal in nature and thus infinitely regresses to ever more universes(which can lead one to thinking of it as a giant hologram); disagreements between the endless(hundreds at least) variations of inflation are sometimes due to lack of awareness that different definitions of time are being used; some theories suggest that there was a first big bang but we can never find out what happened before it; nevertheless it appears increasingly plausible that there was no beginning but rather an eternal cycle of the destruction and creation, each being the beginning of spacetime for that universe; to start a universe you need about 25g of matter in a 10 to minus 26cm diameter sphere with a false vacuum and a singularity(white hole).

He deliberately spends little time on the endless variants of inflation such as chaotic, expanded and supernatural inflation or on dark matter´, supersymmetry and string theory, though they were well known at the time as you can find by reading other books such as Michio Kaku´s `Hyperspace` (see my review) and countless others. Of course much has happened since this book appeared but it still serves as an excellent background volume so cheap now it's free for the cost of mailing.

Those interested in all my writings in their most recent versions may consult my e-book Philosophy, Human Nature and the Collapse of Civilization - Articles and Reviews 2006-2016 662p (2016).

This is one of the best popular cosmology books ever written and Guth is now (2016) a top physics Professor at MIT. He tells the extremely complex story of inflation and related areas of particle physics in such an absorbing style that it reads like a detective novel--in fact, it is a detective novel--how he and others found out how the universe started!

The interweaving of his personal story and that of many colleagues along with their photos and many wonderfully clear diagrams allows just the right amount of relaxation from the intensity of the physics. In places the style reminds one of Watson´s famous book ``The Double Helix``. He tells how his work on magnetic monopoles and spontaneous symmetry breaking led to the discovery of the inflationary theory of the very early universe (ca 10 to minus 35 seconds!).

Along the way you will learn many gems that should stay with you a long time such as: the observed universe (e.g., everything the Hubble telescope etc. can see out to ca. 15 billion light years when the universe began) is likely just a vanishingly tiny part of the entire inhomogeneous universe which is about 10 to the 23rd times larger; the big bang probably took place simultaneously and homogeneously in our observed universe; there probably have been and will continue to be an infinite number of big bangs in an infinite number of universes for an infinite time; when a bang happens, everything(space, time, all the elements) from the previous universe are destroyed; the stretching of space can happen at speeds much greater than the speed of light; our entire observed universe lies in a single bubble out of an endless number so there may be trillions of trillions just in our own entire(pocket) universe(and there may be an endless number of such); none of these infinite number of universes interact—i.e., we can never find out anything about the others; each universe started with its own big bang and will eventually collapse to create a new big bang; all this implies that the whole universe is fractal in nature and thus infinitely regresses to ever more universes(which can lead one to thinkg of it as a giant hologram); disagreements between the endless (hundreds at least) variations of inflation are sometimes due to lack of awareness that different definitions of time are being used; some theories suggest that there was a first big bang but we can never find out what happened before it; nevertheless it appears increasingly plausible that there was no beginning but rather an eternal cycle of the destruction and creation, each being the beginning of spacetime for that universe; to start a universe you need about 25g of matter in a 10 to minus 26cm diameter sphere with a false vacuum and a singularity (white hole).

Regardless of all this we still want to know how and why it all started even if this question seems to make no sense and he notes that Tryon speculated long ago that quantum fluctuations could give rise to our universe instantly any time from the very beginning (e.g., 10 to minus 35 seconds) to this instant, complete with our particle accelerators and Guth with his ``memories`` of inventing inflation! The probability is incredibly small, but as there may be an infinite amount of time and space even the improbable becomes certain! Of course those familiar with my writing will recognize the we are dealing with a group of ill defined (unclear conditions of satisfaction) language games here and as we clarify them the mysteries will disappear. The physicist Vilenkin extended Tryon´s idea in a mathematically well defined way, giving a quantum description of general relativity that shows that the universe (spacetime) can arise from nothing. It seems this is based on the fact that one of the possible geometries of the universe is an empty one with no points in which quantum tunnels to a nonempty state which then

inflates. Inflation requires only a false vacuum and some mechanism to produce baryons and is independent of and GUTs. Even Einstein´s infamous cosmic constant has reappeared as the energy density in the vacuum--which is a very complex state in which particles and antiparticles are appearing (from the vacuum!), annihilating one another, and disappearing at an enormous rate. When you get to the most advanced (basic) theory, it is utter chaos, with only thin threads of observation from accelerators and astronomical instruments linking it the universe.

Hawking came up with perhaps the most outrageous theories of the beginning--a set of equations in which (at 10 to minus 43 sec) the concepts of space and time dissolve into quantum ambiguity. The universe just is and can inflate from there: i.e., the famous Hartle- Hawking quantum wave function where spacetime has no initial boundary with quantum fluctuations(randomness) determining the probability of every possible outcome(all possible universes). This implies that the universe must be, because nothingness is impossible, but then why are there laws of physics?

Strings are an alternative to quantum fluctuations but they are even harder to connect to reality. It is their mathematical elegance (so elegant that we have to develop more complex math before it can evolve further!) and power (24 dimensional geometry!)that makes them irresistible. One gets the impression that String Theory could explain any possible universe and indeed, that is one of the major problems--the equations have millions of solutions and which one is for our universe!? (if you want to know about this see my review of Kaku's ' Hyperspace').

Guth gets into a very interesting discussion of what ´nothing´ and ´beginning´ mean but he has no idea about Wittgenstein and language games. In fact the last chapter (Epilogue) is the most speculative and for many probably the most interesting part of the book and is (like much of modern physics for most people) almost indistinguishable from science fiction--incredible special effects, but it lacks a plot, character development, a beginning and an end!

Nobody knew in 1997 that the universe was expanding at an increasing rate but due to the endless variations on the theory and the high degree of arbitrariness and virtually limitless nature of possible assumptions, I doubt it will consitute a problem for very long. Likewise with the various theories about how space itself is expanding, not just the matter in it.

Cosmology and particle physics are intimately connected and since we have probably reached the limit in cost for accelerators (the world´s entire GDP would not be near enough to build one that could get remotely near the 10 to the 19th BEV required to examine events at the Planck length) the next few years may see the end of input to cosmology from the bottom end. The top end--mostly outer space instruments- are less costly and will likely yield new info for a few decades yet -but the coming collapse of civilization will likely put an end to them as well by mid century. So it seems we may have another 50 years to evolve our GUTs (Grand Unified Theories) and our cosmology and `know the mind of God`(Hawking).

He does not spend alot of time in philosophical digressions but I think most would agree that our psychology (e.g., the cognitive templates or inference engines) severely limits the kinds of theories we can produce. Perhaps one day computers will generate many (an infinite number?) of advanced theories but we probably will not be able to understand most of them. One needs a certain level of brain power to understand something and ours was evolved about

a million years ago to get food, find mates and manipulate other monkeys. Just as a truck needs a certain horsepower to haul a load up a hill, a brain must have a certain calculating ability to understand an idea or an algorithm and it seems probable to me that our computers will soon produce many beyond our reach.

It occurs to me that if the universe is a giant computer (as many have theorized—e,g. Wolfram most recently in ``A New Kind of Science``) then we hope that it uses some kind of algorithm that we can understand -and prove with our math. But if so, maybe only our computers will be able to understand it or communicate with it! Also since the 'incompleteness' theorems of Godel and Chaitin show that there are an infinite number of well formed algorithms that we cannot, even in principle ever prove or disprove (and no computer can do it either), it occurs to me that it is possible that the algorithms of the universal computer may be among those, and in that case even our most advanced computers may never prove all the algorithms of the universal computer—i.e., the universe) and so it will forever remain as physics is now, with some laws that cannot be connected to the others and some the truth of which will be always undecidable. Perhaps Chaitin´s omega number (giving the limits of math) may someday tell us something about the ability of computers (our most advanced future one vs the universe) to prove each others algorithms. Perhaps it is consistent with one of the endless versions of inflation that each universe has a different algorithm or that the algorithms change with time (and they have already used such ideas as gravity changing with time). However the notions of incompleteness, limits to computation, undecidability are complex language games which I have commented on extensively in my other reviews and articles so I will not repeat it here.

He deliberately spends little time on the endless variants of inflation such as chaotic, expanded and supernatural inflation or on dark matter´, supersymmetry and string theory, though they were well known at the time as you can find by reading other books such as Michio Kaku´s `Hyperspace` published in 1994 (see my review). Of course much has happened since this book appeared but it still serves as an excellent background volume so cheap now it's almost free.