Title: ***Deconstructing Cosmology***
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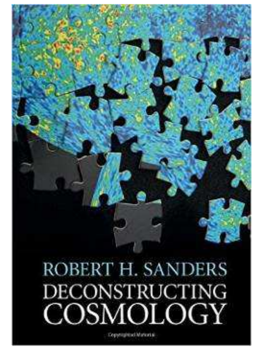

Cosmology is the study of the origin, evolution, and future of the universe. People have used myths and religion to answer the age-old question "where and when did it all begin and where and when is it all going?" Some people still depend on those sources. The rest of us see cosmology as a credible science increasingly based on measurements – this type of cosmology often is differentiated by calling it *physical cosmology*.

Deconstructing Cosmology was written to disassemble, describe and compare the main components of what we think we understand about the universe. The book's title sounds like a revisionist mantra but that is not what it is about. The author attempts to describe cosmology by presenting modern scientific thoughts both for and against the current consensus of how the universe works. Yes, I said consensus – because nobody really understands how the universe works but many people think they know and they have more or less agreed to a basic plan.

A basic assumption of cosmology is that the physical laws determined locally (on Earth and in our solar system) and at present apply everywhere else at all times, even at the beginning if there was such a thing. However, some measurements have indicated that the universe and objects within it do not behave as expected when those laws are applied to extremely large scales. Martin Harwit is the first author I know to suggest that our modern physics may not be the same at all scales and all times [Harwit].

Although the book is overpriced for its page count and sometimes convoluted (as is cosmology itself), it is very interesting and informative and I enjoyed reading it – twice. It is not a book written for the layman and some familiarity with general relativity – Einstein's gravitational theory – is necessary. Unfortunately, the author never specifies his intended audience or a reader's required level of knowledge. For my money, I am glad I read ***Relativity: The Special and the General Theory, 100th Anniversary edition*** [Einstein1] and also ***The Cosmic Microwave Background: How It Changed Our Understanding of the Universe*** [Evans] before reading the current book. I also am glad I attended the *Science at Low Frequencies II* conference in New Mexico in late 2015 to learn more about anisotropies (variations) found in the measurements of the cosmic microwave background radiation, or CMBR. These provided to me much of the background necessary to follow the discussion in ***Deconstructing Cosmology***.

Deconstructing Cosmology has a number of illustrations, but they often do not appear to show what is intended and the accompanying captions and text explanations are not always clear or adequate (an example is shown below). The author sometimes seems to assume that the reader already knows the material, so he does not try to explain it clearly; after all, "everyone knows" what that illustration is about don't they? A good chart can explain a lot of things but in this book some charts do a poor job. Many chart scales are based on ratios so do not have units of measure, which for me quickly promoted loss of perspective because the reference quantity was not always clear.

Deconstructing Cosmology consists of ten chapters and notes for each chapter. The index is adequate. The book starts with creation mythology in chapter 1 and jumps into the three predictions of modern cosmology in chapter 2 (discussed below). The problem of inflation in the early universe is addressed in chapter 3 followed by what the author calls "precision cosmology" in chapter 4 and the "concordance model" in chapter 5. The concordance model takes into account the boundaries of our knowledge and assumptions and places self-imposed limits or constraints on how the universe works. In colloquial terms, this means that any other concept is viewed as just plain baloney by scientists who subscribe to the concordance model.

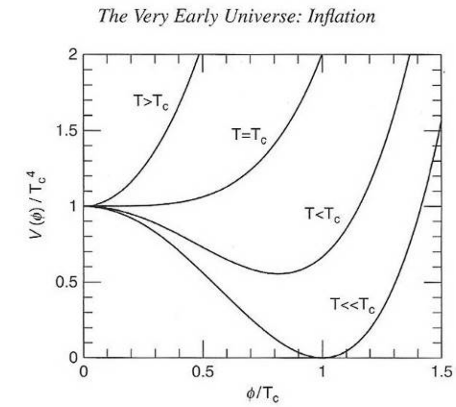

Figure 3.1. The effective potential in the original inflationary scenario for different values of the temperature of the background medium. The horizontal axis is the value of the scalar field in units of the critical temperature – the energy at which the vacuum begins to dominate the energy density of the Universe. The vertical axis is the energy density in the potential of the scalar field in units of the critical energy to the fourth power. The different curves show the effective potential at various values of the energy of the thermal background in units of T_c, a critical temperature corresponding to the energy of unification, supposedly 10^{15} GeV. At high energies ($T > T_c$) the potential is very symmetric with one vacuum state. At low energies the potential has a lower symmetry with two vacuum states: a false vacuum at $\phi = 0$ and a true vacuum at $\phi = T_c$. The Universe is hung for some time in the false vacuum, and this drives the exponential expansion – the inflation.

Ideally, theories should make predictions that are testable by repeatable measurements and observations. Chapter 2 tells us there are three basic predictions associated with modern consensus cosmology. Consensus cosmology is physical cosmology agreed upon by everyone who, well, agrees with it. The redshift-distance relation described by the Hubble *constant* was the first predictive success of physical cosmology. This relationship says the farther away an object is the faster it is receding. Measurements combined with many fragile assumptions show the universe is not just expanding, the expansion is accelerating. However, it needs to be noted that any one (or all) of the assumptions could be wrong. A problem with the Hubble constant is that it is, in fact, not constant and various measurement methods provide significantly different values for it [SN02Feb2017]. More time, money and measurements may tell what is going on here.

The accidental discovery of the CMBR in 1964 was the event that kicked off the serious study of modern physical cosmology (Einstein's 1917 paper *Cosmological Considerations in the General Theory of Relativity* [Einstein2] is considered the start of modern theoretical cosmology). Theoretical considerations by Ralph Alpher and Robert Herman but most often attributed to George Gamow, see [Alpher], made prior to the CMBR discovery indicated the existence of a background radiation that signified a time in the early universe when nucleons, the constituents of matter, combined for the first time ever and electromagnetic radiation was able to escape the confines of an extremely hot and dense early universe. Detection of the CMBR turned out to be the second predictive success of physical cosmology. Present measurements and interpretations indicate the timestamp for production of the CMBR was 375 000 years after what we think was time zero of the Hot Big Bang.

The CMBR originally was thought to be isotropic – the same in all directions and on all scales – but relatively recent measurements indicate this is not so. Very detailed and expensive measurements indicate the CMBR is perfect blackbody radiation but it has both large- and small-scale fluctuations (anisotropies) that depend on scale. The existence and measurement of these fluctuations was the third successful prediction of modern cosmology. It turns out the standard model for consensus cosmology hinges on the CMBR, which was a singular event in the evolution of the universe. Thus, the entire scientific view essentially is based on one snapshot, a risky proposition at best. The author of ***Deconstructing Cosmology*** points out, and rightly so, that it seems much more effort is put toward supporting rather than challenging the modern construct of when and how the CMBR was produced.

Chapters 6 and 7 are devoted to *dark energy* and *dark matter*, respectively. The density of the universe appears to be very close to the critical density for a flat universe – a universe that asymptotically expands forever. The question arises, if it is so close to the critical density, why is it not *exactly* the critical density? The problem is, not enough actual matter (baryons) has been found to justify what is observed in galaxies and galaxy clusters. What to do? Easy – make up some stuff and call it *dark energy* and *dark matter*, the *dark* part means it is thought to be there but is undetectable through normal means.

Dark energy is a concept of a near-uniform field that is thought to dominate the energy budget of the current universe and to drive its accelerated expansion. It is said to account for about 68% of the total energy in the universe as observed today. Dark energy is used to solve two problems. One is the amount of energy needed to explain the critical density referred to above. The other is how the small fluctuations seen in the CMBR became the observed cosmic structures – galaxies and galaxy clusters. But these lead to a bigger problem: Dark energy is only an operational description and has not been measured or supported by theoretical considerations. Simon White at the Max Planck Institute for Astrophysics questions whether or not dark energy is a useful subject for astronomical research, that is, spending money on it [White}. His arguments are largely based on cultural grounds but his paper is one of very few that even mentions the need for money management instead of doing something scientific regardless of cost.

Deconstructing Cosmology tells us that other stuff, dark matter, is intended to explain the acoustic oscillations indicated by anisotropies in the CMBR. Dark matter, if it exists, is not standard matter. That is, it is not made up of protons and neutrons as is the case for baryonic matter. Dark matter is very high on the list of things to discover because it is thought to make up most of the mass in the universe, by far. Careers and reputations, to say nothing of the huge investments in instrumentation, depend on its detection. Because its discovery is highly competitive we now have a sociological problem in that scientist's personal feelings and prejudices enter the picture more than normal. This also means further advances in cosmology will be made by today's students who are greatly influenced by those scientists and will carry with them the same prejudices.

So far, the detection of dark matter has failed, but everyone seems to be on the "verge of discovery" or their experimental results show "a very exciting thing". Of course, one does not obtain more funding by saying "well, we are far from discovering anything" or "none of our extremely expensive measurements indicate anything worth reporting". Many of these experiments involve trying to detect Weakly Interacting Massive Particles, or WIMPs, which are thought to be evidence that dark matter does exist. WIMPs supposedly were detected recently by the DAMA/LIBRA experiment, but the XENON100 experiment and other experiments have debunked this discovery [SN25Oct2015], [SN10Jan2017]. The acronym DAMA/LIBRA is derived from Dark Matter Large Sodium Iodide Bulk for Rare Processes, but I could not determine what XENON stands for. It would be an interesting study to determine just how much time is spent naming these experiments; scientists have to have their acronyms.

There are many competing and sometimes mutually exclusive ideas about the universe and we certainly do not understand everything we think we know about it. As humans we are stuck between if, where and when the universe started and if, where and when it will end. We do not know if the second law of thermodynamics even applies at cosmological scales (the second law says that the disorder or randomness of an isolated system can only increase over time). When we examine and measure distant objects in the physical universe, we are looking at electromagnetic radiation produced at some point far back it time. Based on these measurements and many, many assumptions, the thought is that we can predict the future of the universe: Will it eventually go into gravitational collapse and fall into itself, continue expanding forever (a flat universe) or end in a “Big Rip”, in which the universe’s expansion speeds up more and more as time goes on, eventually destroying itself?

Whether or not the universe had a beginning and whether or not it will end is the basis for spending billions of dollars on space missions and associated scientific study. Why would we want to do this, especially when neither the beginning nor end has any apparent effect whatsoever on our here and now or even the future of mankind? ***Deconstructing Cosmology*** does not provide an answer, probably because there are as many answers as there are people getting paid to think about it. But in spite of all that, many people will admit that it is fun gazing up at the universe on a dark starry night and thinking about how it all happened and where it is going. One can do that without spending a dime, after one gets to a place without light pollution.

Chapters 8 and 9 focus on an alternative to dark matter called Modified Newtonian Dynamics. MOND does a good job of explaining galaxies and galaxy clusters, something dark matter does not. However, MOND requires a modification to Einstein’s general relativity and the gravity defined by it. In the minds of many scientists, that is a no, no. Not mentioned anywhere in the book are other concepts that do not need dark matter or modifications to gravity, one of which has been put forth by SARA member Bruce Rout [Rout1] and [Rout2]. There undoubtedly are others but none are “camp” in the science consensus community. In fact, the biggest flaw in the whole of physical cosmology is that critics of the camp are simply dismissed or not taken seriously.

If it cannot be measured directly, then it does not exist and we really cannot say we know anything about it. This is the basis for chapter 10, *Plato’s Cave Revisited*, which goes like this: People who have lived in a cave and never left it have an understanding of the universe based entirely on their measurements made inside the cave. If those cave dwellers move outside, their understanding of the universe inevitably changes completely. When those dwellers migrate to another region and eventually travel in space their understanding changes again, and again, and again....

The universe we think we understand is about 13.8 billion years old. We have been studying small parts of it – electromagnetic radiation from celestial objects – with great scientific detail for less than 100 years, or about 0.000 000 7% of the universe’s existence as we understand it. We have never been outside our own solar system, except for the two Voyager spacecraft that recently (2012 ±) reached the interface between the solar system and interstellar space. Everything we know is based on measurements taken in our cave so to speak. Sure, we can look back in time by examining the electromagnetic radiation from distant celestial objects, but actually being there almost always changes the way we understand something.

Cosmology clearly is an evolving field with many, many new discoveries and claims of discovery ahead. Also ahead are reports that will debunk many of those. The subject is even more interesting because scientists often marry their hypotheses and claims and become angry when someone tells them the marriage was a mistake or maybe there is an interloper. This often makes for exciting reading in the science press and online science forums. Think of the TV show "*Cheaters*".

If you are interested in learning about cosmology and can find a copy cheaper than the publisher's list price, ***Deconstructing Cosmology*** should be on your reading list but not at the top. It would be wise to first study the three predictions discussed above – the redshift-distance relation (Hubble constant and its measurement), the cosmic microwave background radiation, and fluctuations, or anisotropies, in the CMBR. A working knowledge of general relativity will not hurt.

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