

**Title:** *In Search of the True Universe ~ The Tools, Shaping and Cost of Cosmological Thought*

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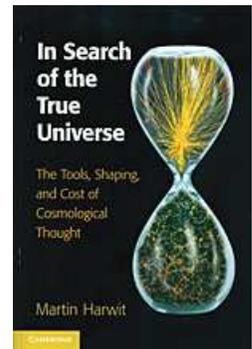
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**Reviewer:** Whitham D. Reeve



I purchased *In Search of the True Universe* because I had read and reviewed the author's 1984 book *Cosmic Discovery*; see [Reeve]. I liked the previous book because it clarified (for me) how discoveries are made. It also debunked the popular myths that advances in astrophysics were the result of great theoretical insight by brainy academics and that further advances would require larger and more expensive optical telescopes. Harwit showed in *Cosmic Discovery* that important discoveries were made by people generally not trained in astronomy and who used comparatively small telescopes at radio, infrared, x-ray and gamma-ray frequencies. He showed that theory and huge optical telescopes seldom (if ever) delivered important discoveries.

*In Search of the True Universe* is somewhat different – it attempts to answer the question, once a discovery is made how do we determine the way the phenomenon works and how do we know that we are right about it? The premise is that new discoveries – those of the true universe – will need new ways of doing science. The author says this will not be simple and it will not be cheap. As taxpayers, we already know it will not be cheap. And if we follow science at all, we also know that all contemporary astronomy data acquiring and processing involves international teams, not only for the expertise but also funding.

*In Search of the True Universe* consists of 16 chapters in three parts, **The Import of Theoretical Tools, A National Plan Shaping the Universe We Perceive** and **The Cost of Discerning the True Universe**. The first part flows smoothly through the chronology of discovery backed by theory and theory backed by discovery. Students of radio astronomy will see both familiar and unfamiliar names in the narrative. Chapter 11 in the second part stands out as different from the rest of the book. Here, the author explains or more accurately brags in great detail about his own contributions to certain space missions associated with radio astronomy. The chapter seemed out of place because of its unusual conversational detail.

The book's third part goes into great detail about the organization and functioning of the so-called *Astronomical Community*, the language this community uses and the problems with the jargon associated with each discipline and how it impedes communication and understanding. The last couple of chapters are less about discovery and more about the sociology associated with scientific processes and how it can help or hinder. I found these much less interesting than the chapters on how we got to where we are in terms of knowledge.

Given the sociology coverage in *In Search of the True Universe*, I was surprised the author barely touches on ethics in science. A recent study by National Science Foundation discussed in the June 2015 issue of **Physics Today** magazine found that about 2% of physicists across a range of disciplines admit to "fabrication, falsification, or plagiarism in proposing, performing, or reviewing research, or in reporting research results". This is seemingly a low number, but it depends on how "ethical ambiguity" and the so-called "gray areas" are

defined. It also depends on how willing scientists are to admit it. In other articles in **Physics Today**, there are reports of scientific papers being submitted to journals with fake email addresses and phony peer review reports. I think that if Harwit is going to discuss the sociological aspects of finding the “true universe” then he should discuss ethics in more detail. Scientists are fundamentally no different than people in other occupations so why would we expect their ethics to be different, and how does that affect the discoveries of the true universe?

A 17 page appendix includes a list of mathematical symbols used in the few equations in the book (this cannot be considered a technical book). Also included in the appendix are a very good glossary and the units of measure and their ranges that occur in nature. The latter shows the range of temperatures encountered in the cosmos, about 1 kelvin – slightly below the cosmic microwave background radiation temperature at 2.7 kelvin – to over  $10^{10}$  kelvin (1 followed by ten zeros) – the temperature thought to occur at the center of an exploding supernova. Another nice chart shows the range of masses and sizes of different bodies. Electrons have the smallest size and mass at  $< 10^{-10}$  cm and  $< 10^{-20}$  g and the universe itself has the largest at around  $10^{29}$  cm and  $10^{56}$  g (I have no idea why the obsolete centimeter-gram-second, CGS, system is used here, although it makes little difference when one considers the scales involved in the range). The book’s index is adequate.

Overall, *In Search of the True Universe* discusses in a very readable way the discoveries and explanations for cosmology as we have concocted it. Yes, concocted. The author uses a different word, the word “construct”, to indicate the way scientists have built our understandings the universe. He discusses fads in science and the cascade effect. A cascade occurs when a scientific idea is published that is embraced by the right people who then cite it in their own work, making the concept more credible and believable by even more people. The idea becomes popular and is accepted as truth. It does not necessarily mean the idea is right. The author mentions several notable examples where a scientist published an idea or concept in a journal that was not widely read. The concept languished until later, sometimes decades later, when someone else became the “first” to publish it in a more widely read journal and a cascade began.

In one of the final chapters the author asks “*Do our modern views about the Universe reflect inherent properties of the Cosmos, as is generally believed, or is our depiction of the Universe a social construct?*” Consider that we need go back only a few hundred years. Scientific thoughts at the time were taken as immutable truths. As time went on, many of those immutable truths were found to be, well, mutable. Corrections followed as investigators delved into and began to understand and link smaller (nuclear) and larger (cosmic) scales. Our knowledge of the full range of both scales is far from complete, so how can we say that what we think we know is correct?

Harwit is the first science writer I have seen who raises the question that the laws of physics might not be the same everywhere and for all time. I, too, have always been skeptical of this dogma. How could we possibly know? On the other hand, the laws of physics as we have constructed them seem to have served us well. The problem is, if physics are not the same everywhere, then the explanations of just about everything having to do with cosmology are wrong. Harwit also raises the question of physics for all time – the concept that the laws of physics were the same during all early epochs of the Big Bang as they are now and always will be. The author questions other tenets of physics, not with the tone of a heavily bearded crackpot, like those seen on innumerable pseudo-science and pseudo-discovery television programs, but by reasoned explanations of how we got to our present but incomplete understanding.

The author of *In Search of the True Universe* tells us once again that almost all major discoveries since WWII have been made using instruments and techniques originally designed and developed for military applications during WWII or the Cold War. In other words, if the technologies had not been funded for military purposes, they might not have existed for purely scientific purposes. Included in the list of fundamental discoveries aided by these systems are radio galaxies, x-ray stars and galaxies, infrared stars and galaxies, quasars, cosmic background microwave radiation, and gamma-ray bursts. That these discoveries were made with technology developed for military applications is no surprise to anyone who actually works for a living in a technical field but it is not obvious to others, especially some academics (for example, see [Munns]).

The funding of scientific projects, including the study of cosmology and the terrestrial and spacecraft instrumentation needed to make new discoveries or confirm theories, is covered extensively in *In Search of the True Universe*. As the author did in his previous book, he expounds on how he thinks this funding should be accomplished – how best to spend other people’s money. He recognizes the politics involved, which may derail good projects for less good projects, and “societal forces” – the clamoring for taxpayer’s money to fund things that have nothing to do with science or even sound thinking. He makes it clear that government and science politics are what determine funding. Harwit recounts how “*an endless stream of astrophysicists was dropping by ... (the Director of NASA’s Astrophysics Division) office to urgently advocate the priority of any one of (their) projects above all others*”. Here we have glimpses of what we should recognize by now as familiar – claims for society’s betterment being used to justify one’s job or improve one’s prestige.

Harwit often uses the words “urgent” and “pressing” to describe an astronomy project. I found this somewhat disconcerting. I hoped to but did not learn why we “urgently” need to discover or confirm some particular thing about the universe or that one discovery is more “pressing” than another. One should ask, is it important to make a cosmological discovery or confirm a theory next week, next year, next decade or next century, or ever? One of the biggest problems, as seen through the author’s eyes and is obvious to anyone who pays taxes and pays attention to where their taxes are spent, is the horrendous cost of new instrumentation needed to fulfill our need to understand the universe. No one country can any longer afford to carry the burden of space exploration, so there has been a shift over the last few decades to international efforts. Nevertheless, society can afford only so much, and the search for the “true universe” always will take a back seat to other funding, especially to money sinks perceived by politicians to help their reelection.

In conclusion, readers who enjoy pondering the big picture of how scientists think the universe works should also enjoy *In Search of the True Universe*. The book is current, well cited and easy to read. Used copies are available and affordable.

Readers of this review also may want to read a conversation that **Physics Today** magazine had with Harwit in October 2014: <http://scitation.aip.org/content/aip/magazine/physicstoday/news/10.1063/PT.5.3015>

[Munns] Munns, D., *A Single Sky: How an International Community Forged the Science of Radio Astronomy*, MIT Press, 2013 {see also review of this book in *Radio Astronomy*, January-February 2014)

[Reeve] Reeve, W., Book review of *Cosmic Discovery*, *Radio Astronomy*, November-December 2014