books

An advocate for the anthropic principle

The Cosmic Landscape: String Theory and the Illusion of Intelligent Design

Leonard Susskind
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Reviewed by Paul Langacker

The Great Debate in 1920 at the Smithsonian Museum of Natural History between Harlow Shapley and Heber Curtis concerned the size of the Milky Way and whether it constituted the entire universe or was just one of innumerable island universes, or separate galaxies. The issue was settled in 1924 when Edwin Hubble observed Cepheid variables in the Andromeda galaxy, which allowed him to show that Andromeda was an enormously distant, separate galaxy. And like Shapley's determination that the solar system is not at the center of our galaxy, and the earlier Copernican revolution, Hubble's findings helped to demote the significance of humans. Hubble summarized it quite well: "The history of astronomy is a history of receding horizons."

Recently, a new but related great debate has been quietly raging within the communities of string theorists and cosmologists. One side holds the traditional view that the laws of physics and the values of the physical constants are the same throughout the universe—a universe presumably determined as the unique solution of some ultimate physical theory. Another side, a growing minority in both communities, suspects the existence of an enormous landscape of some 10^{500} possible vacua of an underlying superstring theory. Each vacuum leads to its own laws of physics, and no known principle distinguishes one as preferred over the others. Furthermore, most of those who hold that minority view speculate that the universe consists of an infinite multiverse, or megaverse, of regions, each expanding or contracting according to its own laws of physics. New regions are constantly formed by quantum tunneling so that all of the vacua of the landscape are sampled.

Leonard Susskind's *The Cosmic Landscape: String Theory and the Illusion of Intelligent Design* surveys the new debate clearly and amusingly for the general reader. Susskind, one of the inventors of string theory and a leading advocate of the landscape and multiverse ideas, does an excellent job developing the necessary background in quantum mechanics, relativity, particle physics, supersymmetry, string theory, black holes, cosmology, and inflation.

Underlying the debate between the landscape idea and the more traditional view is the observation that our universe and its physical principles appear to be remarkably fine-tuned to allow the development of life: the anthropic principle. For example, small variations in the relative masses of the electron and proton or in the value of the fine-structure constant would preclude the necessarily rich structure of atoms and molecules. Similarly, the observed vacuum energy, or cosmological constant, is some 120 orders of magnitude smaller than what is typically expected from string theory. Steven Weinberg has argued that a positive value much larger than observed would have led to such rapid expansion of the universe that galaxies and stars could never have formed; a large, negative value, on the other hand, would have led to a catastrophically rapid collapse. Many other examples exist in Big Bang nucleosynthesis, long-lived stars, and the supernova explosions needed to eject elements into the universe. Susskind describes at great length "The Mother of All Physics Problems"—the cosmological constant—and the other lucky accidents that make our existence possible. He argues strongly that the only plausible nonsupernatural explanation is "a Landscape of possibilities populated by a megaverse of actualities."

Except for possibly appealing to the idea of an intelligent designer, the traditional view of unique laws and constants offers little explanation for why we are fortunate that nature has just the right conditions for life. The multiverse–landscape paradigm, on the other hand, provides a plausible framework for the anthropic principle: Life only evolved in the tiny fraction of regions of the multiverse that had suitable conditions. This view is analogous to the paradigm shift that resolved the old question of why we are so lucky that Earth has hospitable conditions: If billions of stars in the galaxy have planets, then some are bound to be just right.

Many scientists are strongly opposed to the multiverse–landscape paradigm. Some objections are technical. For example, are there really 10^{500} vacua, or does the multiverse really exist? Others are that the ideas are not testable and not really science, or that they might seduce researchers into giving up the traditional goal of finding a unique and elegant explanation for the observed laws of nature. Susskind makes no attempt to give an impartial overview—after all, he is advocating his own ideas. However, he does offer a reasonable survey of the objections and his own responses to them.

The Cosmic Landscape is a fascinating introduction to the new great debate, which will most likely be argued with passion in the years to come and may once again greatly alter our perception of the universe and humanity's place in it.

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It's About Time: Understanding Einstein's Relativity

N. David Mermin
Princeton U. Press, Princeton, NJ, 2005. $29.95 (192 pp.). ISBN 0-691-12201-6

I first came across relativity theory in an example featured in an instruction book for an early electronic calculator. I was 11 years old and was amazed to read that an astronaut could travel for 50 years