The Universe in the Rearview Mirror: How Hidden Symmetries Shape Reality FREE

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misses the grandeur of Lorentz invariance, embedded in electrodynamics from its inception but hidden from full view until Albert Einstein recognized its implications and replaced Newton's concepts of space and time with spacetime. Zangwill's choice of Minkowski's imaginary component in four-vectors is strange; given the straightforward mathematics of special relativity, that choice adds unnecessary complexity and heightens the potential for confusion. Also, numerical methods are not addressed in this book.

I sometimes advise advanced undergraduates to begin building their own physics libraries with classic advanced textbooks, even before the books are assigned in class. Such texts can broaden perspectives on core subjects and would be readily accessible as the student advances in his or her studies and work. Where shall I put *Modern Electrodynamics* on such a reading list? It has a lot to offer, so I think it should be somewhere pretty high up, but after John David Jackson's *Classical Electrodynamics* (3rd edition, Wiley, 1998), David Morin's update of Edward Purcell's *Electricity and Magnetism* (3rd edition, Cambridge University Press, 2013; reviewed in PHYSICS TODAY, August 2013, page 48), and the timeless classic, Lev Landau and Evgeny Lifshitz's *Classical Theory of Fields* (Addison-Wesley Press, 1951).

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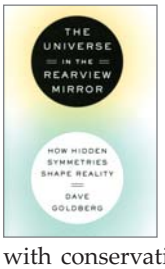
The Universe in the Rearview Mirror

How Hidden Symmetries Shape Reality

Dave Goldberg
Dutton, 2013. $27.95 (352 pp.).
ISBN 978-0-525-95366-1

In *The Universe in the Rearview Mirror: How Hidden Symmetries Shape Reality*, Dave Goldberg expounds on the important role of symmetries in the fundamental laws of physics. He starts with the discrete operations of charge conjugation, parity, and time inversion—and their combinations. Then, after introducing readers to mathematician Emmy Noether and her work connecting symmetries with conservation laws, Goldberg discusses continuous symmetries, homogeneity and isotropy, and Lorentz invariance. Later chapters deal with gravity, gauge symmetries, and symmetry breaking; the book's finale considers proposals beyond the standard model of particle physics, grand unification, supersymmetry, and the missing theory of quantum gravity.



Goldberg does a remarkably good job of conveying technical topics in nontechnical terms and with only a handful of equations (yes, $E = mc^2$ is among them). He works mostly with analogies and writes in an engagingly colloquial way. The bibliography and the guide to further reading provide helpful references for readers who want more details. The book also has a brief glossary.

Symmetries that "shape reality," as mentioned in the subtitle, cover a vast subject area, of course. Except for offering one brief analogy, Goldberg does not touch on the broad topic of emergent symmetry and order in condensed-matter, biological, and other systems. His focus on fundamentals has the benefit of keeping the book relatively lean and maintaining its momentum, but the description on the cover could have been more explicit.

Unfortunately, *The Universe in the Rearview Mirror* is somewhat confusingly organized, and readers who do not possess sufficient prior knowledge might become frustrated. In several instances, Goldberg refers to concepts that he has not previously discussed; he gives other explanations repeatedly. For example, he introduces "the elusive dark matter particle" in chapter 9 without so much as mentioning what dark matter is or what evidence we have for it. He uses the Planck length in chapter 6, but he doesn't explain what it is until chapter 10. The graphics that have been produced specifically to accompany the text are well done and helpful, but the book also contains a number of images that are only loosely connected to the text and come without caption or explanation.

Parts of the book are just too superficial to be of much use. For example, Goldberg mentions that cosmic inflation was proposed "to get around the horizon problem," but readers are not actually told how inflation solves the problem. The evidence he provides for inflation amounts to "we're reasonably certain that it is [correct]." He elaborates on the multiverse and later on the compactified dimensions of M-theory, but he does not connect the two topics. The *Wilkinson Microwave Anisotropy Probe* mission and the cosmic microwave background are mentioned twice before the actual explanation and the relevant image of the CMB temperature anisotropies appear. Those are just some places that might trip up readers who have little prior knowledge of the subject.

For the most part, Goldberg is to be credited for making his text timely by referring to recent research; in particular, he includes a good summary of the discovery of the Higgs particle and the relevance of that finding (see also page 10 and the article by Joseph Lykken and Maria Spiropulu, page 28, in this issue). He mentions Erik Verlinde's contribution to entropic gravity. That reference—the only one on the topic—appears in a section on the arrow of time, though for all I can tell, the only connection is that both have something to do with entropy. Goldberg presents Max Tegmark's proposed "level" structure of the multiverse. And in the last chapter on physics beyond the standard model we meet Garrett Lisi, the surfer without university affiliation who stunned everybody by proposing a unified theory of matter and gravity—it somehow goes unmentioned in the book that Lisi has a PhD in physics.

The Universe in the Rearview Mirror is valuable for its selection of topics and for inspiring a sense of awe for the relevance and power of symmetries in the laws of nature. But the execution leaves one wanting. Readers who do not have a background in modern physics will learn a great deal more from the didactic approach of Sean Carroll in his books *From Eternity to Here: The Quest for the Ultimate Theory of Time* (Dutton, 2010; reviewed in PHYSICS TODAY, April 2010, page 54) and *The Particle at the End of the Universe: How the Hunt for the Higgs Boson Leads Us to the Edge of a New World* (Dutton, 2012; reviewed in PHYSICS TODAY, July 2013, page 50). Together, those books cover a substantial part of the physics shaped by hidden symmetries.

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An Author's Guide to Scientific Journal Publishing

Philippa J. Benson and Susan C. Silver
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