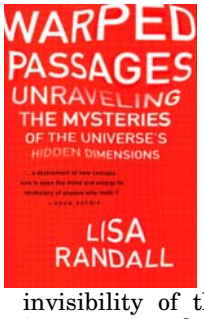
Exploring Unseen Worlds in Wondrous Ways

Warped Passages: Unraveling the Mysteries of the Universe's Hidden Dimensions

Lisa Randall
Ecco, New York, 2005. $27.95 (500 pp.). ISBN 0-06-053108-8

Reviewed by Paul H. Frampton

That extra dimensions may exist beyond the three familiar ones in everyday life is an idea at least 86 years old. In 1919 Theodor Kaluza of Poland suggested adding a fourth dimension to Albert Einstein's 1915 theory of general relativity. Independently, Sweden's Oskar Klein made a similar suggestion in 1926 but went further by proposing that the additional dimension is wrapped into a very small circle. His theory could explain the invisibility of the extra dimension, just as a garden hose appears one-dimensional from a distance large compared to the diameter of the hose.



The story is famous that Einstein, as the reviewer of Kaluza's paper, delayed its publication by two years. But since the paper's publication, the Kaluza–Klein (KK) scenario has at times come strongly into and out of fashion. Kaluza and Klein's motivation was the unification of electromagnetism with gravity. More recently, the ambitious aim in a KK scenario of more than one extra dimension has been to find a geometric interpretation of all internal quantum numbers, such as color and flavor. The idea is too beautiful to dismiss.

Lisa Randall, author of *Warped Passages: Unraveling the Mysteries of the Universe's Hidden Dimensions*, is a recent addition to the theoretical physics faculty at Harvard University. She came to the forefront of the physics community in 1999 by writing two papers with Raman Sundrum of Johns Hopkins University. The papers assume an additional space dimension and show two new possibilities for a KK scenario. The first explains why gravity may be weaker than the strong and electroweak forces, as exemplified by the fact that a small magnet can attract an iron nail against the gravitational pull of Earth. The proposed reason is that gravity propagates from a second brane (a second three-dimensional world) that is separated from our own brane by a tiny distance in a warped extra dimension, which means the extra dimension's unit of length varies rapidly along its direction. The second idea is that even with only one brane in such a warped extra dimension, the effective localized gravity on our brane can approximate four-dimensional general relativity with sufficient accuracy to agree with observation. The additional dimension may actually extend to infinity, quite unlike the situation Klein envisioned in 1926.

The papers attracted a large amount of attention, which proves that we physicists are in a KK era. Randall and Sundrum's papers have now surprisingly been cited about as much as those written by the architects of the standard model of particle phenomenology, which agrees with experiment and is certainly here to stay.

Randall makes very clear, however, that the idea of extra dimensions is, in contrast to the well-tested standard model, not only pure speculation but also a serious scientific possibility that just might show up at a future particle collider as scientists explore the high-energy frontier. For example, such a potential discovery is one goal behind the construction of the Large Hadron Collider, scheduled to begin operation at CERN in 2007, and the proposed International Linear Collider, which is currently under intense discussion. The search for extra dimensions is in addition to discovering the Higgs boson, which was the principal stated objective of the Superconducting Super Collider before its unfortunate cancellation (to say the least!) by myopic politicians in 1993.

Because we know of no better way to explore the high-energy frontier than through use of huge particle colliders costing billions of dollars to construct, high-energy physics is at the mercy of decisions by nonscientists. Explaining that fact to politicians is where Randall's book could be priceless. Trying to explain the Higgs boson to nonscientists was so difficult for physicists that in 1993 the UK science minister William Waldegrave asked "What is the Higgs boson, and why do we want to find it?" and issued a challenge that the answer fit on one side of a single sheet of paper. Clearly, for a nonscientist politician, extra dimensions are much easier to grasp than the Higgs boson.

The communication of frontier theoretical physics to the lay public has not been easy. Progress has been made by the likes of Brian Greene, for example, with his books *The Elegant Universe: Superstrings, Hidden Dimensions, and the Quest for the Ultimate Theory* (W. W. Norton, 1999) and *Fabric of the Cosmos: Space, Time, and the Texture of Reality* (Alfred Knopf, 2004). Randall's new book is of comparable quality, particularly in the ingenious choices of analogies. In communicating ideas to a nonspecialist, analogies are the best way to convey the essence of the science when technical details would be incomprehensible. Randall uses the garden-hose analogy mentioned above to explain why an extra dimension can go undetected, and she uses water sprinklers or shower heads to illustrate why gravity is weak. For a given water pressure, the spray is stronger when focused in one direction than when allowed to go in all directions; thus the forces confined to the brane are stronger than gravity, which "sprays" into the bulk. To discuss the warping of passages—the titular name for unseen dimensions—the analogy she uses is a duck pond with people feeding ducks only on one side. The congregation of ducks on the other side away from the people is successfully likened to the weakening of gravity on the brane where we live.

Historical slips do exist in the book. For example, in the discussion of the old quantum mechanics developed in Niels Bohr's groundbreaking work in 1913, Randall gives Bohr credit that

Paul H. Frampton, *Louis D. Rubin Jr Professor of Physics at the University of North Carolina, Chapel Hill, is on leave through December at the Perimeter Institute for Theoretical Physics in Waterloo, Ontario, Canada. He has about 350 publications under his name and is the author of* Dual Resonance Models *(W. A. Benjamin, 1974), the first book on string theory.*

belongs to Louis de Broglie, who first postulated electron waves in 1923. The author also gives credit incompletely for the origin of string theory, with no mention of the seminal contributions by, for example, Gabriele Veneziano, Yoichiro Nambu, or Holger Bech Nielsen.

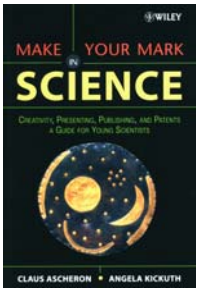
Randall is quite willing to share her views. For instance, she is "agnostic" about string theory, a compelling theory that motivates the book's speculation. She personally does not believe extra dimensions are large—that is, directly detectable at colliders—but she does admit to believing in some form of extra dimensions. Quite frankly, I agree with all of the above views. In the book, Randall describes a humorous episode in 2001 when well-meaning conference organizers, who misunderstood her work, invited her to speak on "large" extra dimensions, which would exclude her own papers!

All in all, *Warped Passages* is a major accomplishment. The intended readership includes adult nonscientists and high-school students who want to learn about scientific research. One can hope it will help convince politicians to support the expensive research and encourage the public at large to embrace science.

Make Your Mark in Science: Creativity, Presenting, Publishing, and Patents—A Guide for Young Scientists

Claus Ascheron and Angela Kickuth
Wiley, Hoboken, NJ, 2005.
$29.95 paper (235 pp.).
ISBN 0-471-65733-6

Make Your Mark in Science: Creativity, Presenting, Publishing, and Patents—A Guide for Young Scientists, by physicists Claus Ascheron and Angela Kickuth, is intended as a guide for young scientists who face the challenges of doing creative scientific work and producing it in concrete form. Although most of its examples are, of course, drawn from physics, the book is just as relevant to other scientific fields.



Chapters 3, 5, and 6, on scientific presentation and publishing, are quite useful. Chapter 3, on talks and posters, contains much of the advice that mentors should give to young scientists but sometimes don't, as evidenced by the poor talks and posters one can see at any meeting. Also covered in the chapter are suggestions on how to plan different types of talks for different audiences; how much detail to include (less than you think); how to make good visual aids, speak clearly, and point to the screen effectively; and how to respond to questions at the end of the talk. A section within the chapter discusses how to produce a visually appealing and informative poster. Any inexperienced scientist—and many experienced ones!—could benefit by carefully studying and applying the principles outlined in the section. Chapter 5, on writing a good paper, includes a complete set of guidelines for organizing the paper, writing clearly, and preparing good figures, tables, and reference lists. Chapter 6 covers electronic publishing, including its benefits, problems, and future. The pages of all three chapters could easily become dogeared if placed in an office occupied by graduate students and postdocs.

The seventh and final chapter concerns the patent process and succinctly describes what may or may not be patented and how the process works in Europe and the US. The main advice running throughout the chapter is "hire a good patent attorney," which is no doubt wise.

Chapter 4, on the culture and ethics of scientific publishing, is somewhat unusual for such a book. Its contents are rarely discussed in research groups, perhaps because mentors assume the implications of publishing and ethical dilemmas and behavior are more obvious to young scientists than is truly the case. The first part of the chapter is a brief description of the different purposes of various kinds of scientific publications—general science journals like *Nature*, specialist journals, multiauthored books, monographs, preprints, conference proceedings, and so forth—coupled with discussions on why and when to publish. The second part, on ethics, includes an explication of the American Physical Society's "Guidelines for Professional Conduct" and a summary of several cases of scientific fraud, most notably that of Jan Hendrik Schön. Although the coverage is brief, including the culture and ethics of publishing is valuable because those are issues that young scientists are unlikely to ask their elders about.

Chapter 2, on scientific creativity, is unfortunately the least successful. One hopes that most students will receive guidance from their mentors on how to write a good paper, give a good talk, or produce a good patent application. However, how to become a creative scientist is much more of a mystery, even to those who have accomplished the feat. The authors discuss various "prerequisites for creative work," including diligence, curiosity, and an understanding of the foundations of the field. To foster creativity, they suggest that one work at a time of day and in a place that promotes concentration, with good lighting and fresh air; eat a healthy diet; and exercise. Readers cannot take exception to their advice, but most young scientists will already have heard it from their mothers. Discussions on the kinds of intelligence typically displayed by younger and older scientists, and statistics about regional differences in scientific output, complete the chapter but do nothing to guide readers.

Make Your Mark in Science largely succeeds at its intent, which is to give good advice on basic skills necessary for a successful scientific career. It is marred by mostly irrelevant illustrations, some of which are meant to be more humorous than they actually are, and by sloppy editing. For example, the lead journal of the American Physical Society is not titled *Physics Review Letters*. Yet such slips do not detract significantly from the book's usefulness. A good mentor might consider putting a copy in a room where graduate students and postdocs socialize or work. For students who have a negligent mentor, the book will be even more valuable.

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A World Without Time: The Forgotten Legacy of Gödel and Einstein

Palle Yourgrau
Basic Books, New York, 2005.
$24.00 (210 pp.).
ISBN 0-465-09293-4

During the World Year of Physics 2005, hundreds of authors couldn't resist using the golden recipe "Albert Einstein and *X*" to publish yet another book on their pet subject of *X*. Unfortunately, Palle Yourgrau, a philosopher at Brandeis University in Waltham, Massachusetts, and an acknowledged expert on Kurt Gödel, is no exception with his *A World Without Time: The Forgotten Legacy of Gödel and Einstein*.