AMERICAN Scientist

BOOK REVIEW

Exploring Matter and the Cosmos

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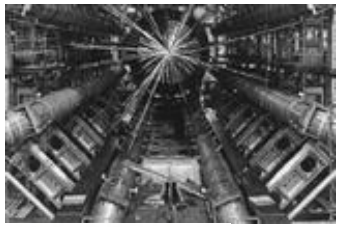
KNOCKING ON HEAVEN'S DOOR: How Physics and Scientific Thinking Illuminate the Universe and the Modern World. Lisa Randall. xxii + 442 pp. Ecco, 2011. $29.99.

Lisa Randall is a well-known figure both in contemporary physics and in its popularization. Her bold theories about the possible physical significance of conjectured extra dimensions have caught the popular imagination no less than the attention of her colleagues. Her bestselling first book, *Warped Passages* (2005), is an engaging account of her personal path to the theory of warped geometry in extra dimensions that she and Raman Sundrum proposed in 1999; this is interspersed with an account of modern physics notable for its level of detail and commitment to making complex material accessible to the general reader.

Randall's new book, *Knocking on Heaven's Door: How Physics and Scientific Thinking Illuminate the Universe and the Modern World*, takes us 10 years past her initial conjectures and in some ways may be even more ambitious. As the subtitle indicates, she wishes to take up larger questions about the nature of scientific thinking, including its relation to religion and its reliance on probability. At the same time, she wishes to bring her audience up to date regarding the status of her theory within the larger ambit of particle physics and cosmology as the Large Hadron Collider (LHC) begins its work, a monumental collaboration involving the whole world. (Americans are the largest single nationality involved in its operation, although the United States is not an official member state of CERN, its operating consortium.)



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The resulting book is valuable and engaging; like its predecessor, it is a tour de force of popularization. The good part about its wider ambition emerges in Randall's clarification of the exact purport and scope of scientific work. But as she interweaves this with descriptions of theories and experiments, past and present, the reader may feel some tension between her somewhat divergent goals, which work together but also divide the reader's attention and hence lead to organizational challenges.

Randall acknowledges in the preface that *Knocking on Heaven's Door* is "in some respects . . . two books in one," a statement that portends problems for the unity and cohesive force of the whole. Making a comparison with movie prequels, she says that her new book offers "the origin story to my previous book, *Warped Passages*, combined with an update of where we are now and what we are anticipating." Sequels and prequels notoriously tend to fall off in quality from the

primary story, often becoming derivative collections of outtakes, retakes or scattered postscripts. These problems haunt Randall′s book, too.

Fortunately, *Knocking on Heaven′s Door* has compensating strengths that redeem it. Among these, the most notable is Randall′s description of the book′s implicit protagonist, the LHC itself. The sections about this amazing project are the high point of the book, for the LHC is her unsung hero. She is eloquent in describing its many remarkable features, the narration gaining vividness from her own sense of awe. In part, this stems from the sheer magnitude of the project, for the LHC is the largest, most expensive, altogether most superlative foray into ″big science″ ever undertaken. Its 27-kilometer-diameter ring connects France and Switzerland; its superconducting magnets generate fields more than 100,000 times stronger than the Earth′s, using a cold deeper than that of outer space. I wish the illustrations (which seem too small, given the page space available) could have better conveyed the visual impact she describes with such animation.

These magnitudes are outward emblems of even larger ambitions. The LHC will use its powers to collide protons at energy scales sufficient to probe new realms of subnuclear reality. This behemoth is ″a most delicate monster,″ to borrow a phrase from Shakespeare. Randall goes into admirable depth to explain just how the LHC will detect the fleeting events it generates. Although she is a theorist by profession, Randall also has something of the practical vision and passion of an experimentalist; her close descriptions of some of the key experimental devices are both lucid and compelling, as if she has been taken out of herself by sheer wonder.

Randall is an interested party in all this, because her own theories are very much at stake in the impending work of the LHC; she keeps reminding us that her speculative work remains unconfirmed, however promising it may be. But the days are long past when only physicists who had made amply confirmed discoveries were accorded a public forum for their views. I confess that this notable shift makes me uneasy. Ever since the advent of string theory and its provocative possibilities, the public rhetoric of physics popularizations has moved to speculative ground that used to be reserved for science fiction: Arguably beautiful or at least intriguing theories that might even be true are put forth even though they remain unconfirmed. In this context, Randall seems interestingly eclectic, using ideas from M-theory and string theory to build models that capitalize on those theories′ powerful ideas without rigid adherence to their (still unclear) basic tenets.

Augmenting her account of the scientific promise of the LHC, Randall also observes the political and economic scene surrounding this huge undertaking. She reminds us that in 1993, the U.S. Congress scuttled the Superconducting Supercollider (SSC) that was planned to have achieved almost three times the maximum energy of the LHC. This was ostensibly for budgetary reasons, but Randall observes that the SSC′s projected $10 billion price tag was dwarfed by the $150 billion Americans paid in the 1990s to resolve the savings-and-loan crisis. President Clinton said at the time that ″abandoning the SSC . . . would signal that the United States is compromising its position of leadership in basic science—a position unquestioned for generations.″ And it did so to save what would have been a measly per capita sum: According to Randall, the comparably priced LHC cost each European only $15.

Such perspectives are crucial to wise decisions in the political and scientific spheres, for which Randall rightly stresses the importance of understanding issues of scale. Those issues are the centerpiece of her larger reflections on the nature of science. She argues persuasively that scientific questions need to be placed in the context of their appropriate scale: Happenings important on the subatomic scale are generally negligible for phenomena at other, very different scales. Accordingly, she emphasizes (as she did in *Warped Passages*) the way in which physics uses ″effective theories″ to distill what is truly relevant at the scale in question. She also defends the importance of reason as a tool of science, in contrast to doctrinal or religious prejudice and recurrent human tendencies to disprize rationality in favor of common (and often irrational) intuition; here she makes cogent and important points that deserve hearing by a wide audience.

Interspersed throughout are summary accounts of a great variety of physical theories and experiments, which Randall obviously felt were needed to help her readers follow her arguments, whether about science in general or about its current state. Some of these explanations go over ground she covered in *Warped Passages* at greater length, and, at times, the newer versions suffer by comparison with the earlier ones. In *Knocking on Heaven's Door,* Randall's exposition of many complex theories seems pressed by the ambitious, multifaceted agenda she has set for herself.

Altogether, Randall deserves praise for helping readers deal with such difficult material, which she tries to present in some detail without dumbing it down. When she is describing her own work, her illustrations are vivid and compelling. But in the chapter on the Higgs mechanism, she struggles to make its analogical argument really convincing. This is quite understandable, given the formidable difficulty of this concept, which falls far outside our common experience. How to explain the subtle mechanism by which an all-pervasive, but nevertheless elusive, field is supposed to render some elementary particles heavier than others? Still, Randall is such a gifted expositor, I had hoped for more; here, uncharacteristically, she seems to be resigned to not making her point as vividly as would have been suitable, given the importance of the search for the Higgs particle at the LHC. Perhaps a bolder and freer use of narrative and diagrams, which she employs to good effect in other sections, would have helped the reader.

In this book, the need for slow, careful explanations finds itself in competition with the author's desire to offer sweeping perspectives and to address the large problems she perceives in public misunderstanding of the scope and character of scientific research. It's hard to knock on heaven's door while attending to the perplexities of one's readers, back on Earth. Nevertheless, Randall's generous cornucopia of ideas, her engaging style, and above all her deep excitement about physics make this a book that deserves a wide readership.

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