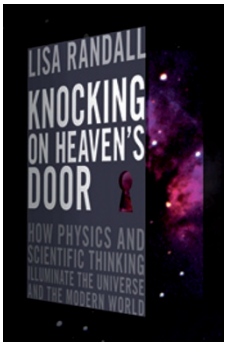
The big test



Knocking on Heaven's Door: How Physics and Scientific Thinking Illuminate the Universe and the Modern World

By Lisa Randall

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The 10 September 2008 was a day to remember for those involved in building the Large Hadron Collider (LHC) at CERN, Europe's particle physics laboratory near Geneva, Switzerland. As theoretical physicist Lisa Randall relates in *Knocking on Heaven's Door*, the day that the vast machine was switched on marked the culmination of 25 years of painstaking travails by particle physicists worldwide.

Emotions ran high in the CERN control room, Randall observed, as the researchers became transfixed by two spots of light on a computer screen. The dots represented opposing twin proton beams, which were revved up for the first time to loop around the 27-km-long collider ring, set 100 metres below the Swiss–French countryside. Millions of members of the public also tuned in to watch the groundbreaking feat. Since then, the LHC has — despite a hiatus due to a technical hiccup — worked well, producing large amounts of data that keep particle physicists on the edges of their seats.

Although she says she is not prone to superlatives, Randall has no trouble wheeling them out when describing the LHC. Packets of billions of protons orbit the LHC ring 11,000 times a second, held in place by 1,232 giant magnets, each 15-metres long, weighing 30 tons and costing €700,000. The superconducting coils within them contain 1,200 tons of niobium–titanium wire, which is narrower than a human hair, but would be long enough if unravelled to encircle the orbit of Mars. Cooled to just 1.9 K, the coils are colder than outer space (the cosmic microwave background has a temperature of 2.7 K).

With attention to detail and in elegant and easy prose, Randall explains how the LHC accelerates packets of protons to huge energies. The machine has already reached 7 TeV; after closing temporarily for a reconfiguration in 2012 it will achieve 14 TeV, hopefully high enough to reveal signs of new physics. Within the experiment's sights are the Higgs boson, a predicted particle associated with the property of mass, and an explanation of why different particles have the masses they do. Randall ably describes the basics of particle physics, the Standard Model and the more speculative tenets of supersymmetry and string theory that the experiment may also eventually test.

Pegging her explanations to the concept of relative scale, she ventures from quarks to cosmic dimensions, with the final chapters rounding up discoveries in cosmology. She explains how scientists construct models by building up a 'Russian doll' sequence of approximations for the behaviour of systems on various scales. The trick, she says, is to be sure that your approximations on small scales hold no surprises at larger ones. Her clear descriptions of the scientific method will be illuminating for many non-scientists.

Randall is palpably excited at the prospect of finally testing physics models with the LHC. She also seems a little jealous that the Europeans have won the race to build such an instrument, after the plug was pulled on the US's Superconducting Super Collider. Blaming that on the failure of the American particle physics community to persuade politicians of the broader significance of their work, she aims to set records straight in this book by trumpeting the significance of fundamental research.

Clearly defensive about the public perception of scientists, Randall goes beyond physics to tackle contentious topics like religion, risk and creativity. She is logical, rational and inclusive in her assessments, but the results of her digressions can be unsurprising. Although an atheist, she respects people of faith, but argues for the importance of evidence in belief; she recognizes that risk is difficult to ascertain in complex cases such as climate change or economics, yet is relaxed about the quantum mechanical threat of rogue black holes that could possibly be produced by the LHC. She sees creativity as the result of hard work and an open mind.

Randall touches on concepts shared between art and science: the sublime, symmetry and the search for beauty and elegance. She wrote an opera libretto in 2009 about multiple dimensions, so it would have been interesting to hear more about her thoughts on the growth of science–art collaborations, which are now part of the programme at CERN. For example, a new artist-in-residence scheme was recently announced and a sculpture by British artist Anthony Gormley was unveiled in the main building. The landscape designer Charles Jencks is also constructing a series of grassy landforms within the collider ring that will highlight the universal ideas of particle physics and cosmology.

Randall has little to say though on the future of particle physics once the experiment runs its course. It is too soon to know if CERN's forthcoming discoveries will ignite the public's imagination sufficiently that they stump up funds for an even bigger machine. Perhaps the arts projects will help make the science seem more relevant to our lives, and books like Randall's are doing their bit. But how should the particle physics community manage future research on such a grand scale?

Researchers could group their resources and follow the ultra-collaborative European model, embedded in a hierarchical management structure that, Randall notes with admiration, has so far seen out funding and political upheavals such as German unification and the current financial crisis. The US and Europe could combine forces and include others to make it a global effort. But worldwide networks can have their own challenges, as the complex negotiations over the fusion project ITER illustrate.

Or are our giant-scale particle-smashing days nearing their end? The LHC, like the Hubble Space Telescope and NASA's other great observatories, is a relic of the 1980s when cold-war attitudes fostered expensive machine building. As NASA did in the 1990s with its smaller, faster, cheaper ethos, should we now invest money in narrower experiments such as the particle astrophysics projects that target dark-matter searches or detect cosmic rays? Or should we relax and spend more time investigating new theories and analysing the data we have?

Irrespective, *Knocking on Heaven's Door* is an open and erudite answer to why we are pursuing fundamental physics research. It will enlighten the public and hopefully reach some of those difficult-to-impress politicians. As the recession eases, perhaps LHC's scientific legacy will be the tonic society needs. ❐

REVIEWED BY JOANNE BAKER

Joanne Baker is Acting Chief Commissioning Editor of Nature and a former cosmologist.