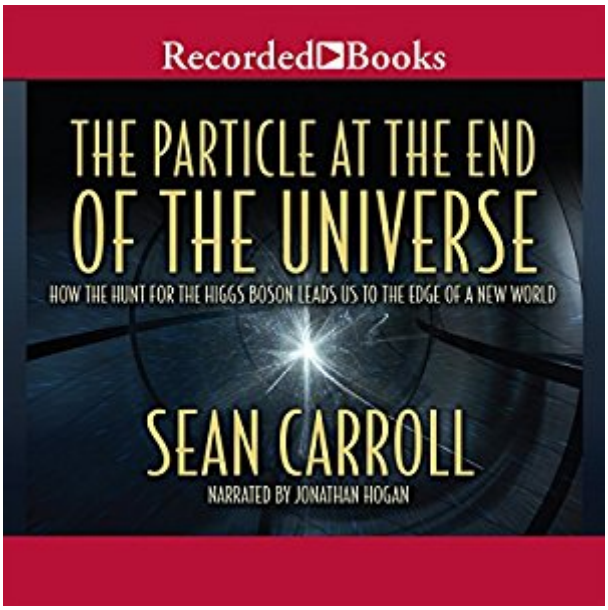
The Particle At The End Of The Universe: How The Hunt For The Higgs Boson Leads Us To The Edge Of A New World



Synopsis

Scientists have just announced an historic discovery on a par with the splitting of the atom: The Higgs boson, the key to understanding why mass exists has been found. In The Particle at the End of the Universe, Caltech physicist and acclaimed writer Sean Carroll takes readers behind the scenes of the Large Hadron Collider at CERN to meet the scientists and explain this landmark event.

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Customer Reviews

Many of us remember where we were during key world events; particle physicists would likely remember where they were on July 4, 2012. That was the day the Higgs boson was discovered at the Large Hadron Collider (LHC) in Geneva. By any measure it was one of the most momentous discoveries in physics, perhaps in all of science. But what exactly is the Higgs boson? Why is it important? And how was it discovered? In this engaging and informative book Caltech physicist Sean Carroll sheds light on all these aspects of the Higgs discovery.Carroll’s book can be roughly divided into three parts. In the first part, after giving us a brief overview of particle physics describing relativity, quantum mechanics, the Standard Model and the discovery of the twelve elementary particles that make up the universe, Carroll plunges into a description of the giant particle accelerators that have made possible our understanding of nature’s fundamental building blocks. Personally I found this part most enjoyable, since it’s a little more accessible than the theoretical part. Carroll tells us about the stupendous engineering challenges involved in the building of the LHC and takes us on a nice little tour of its interior. There’s all kinds of fascinating and amusing stuff

here; the lead tungstate crystals in the detectors that took ten years to grow, the earlier particle accelerator whose workings were affected by the moon’s tides, the baguette dropped by a bird that temporarily created electrical problems, the helium "explosion" caused by high voltage that crippled the machine for months, the physicist whose face was exposed to an intense beam of protons and who still escaped relatively unscathed. The sheer size and complexity of the ten-thousand pound detectors - ATLAS and CMS - beggar belief and the smooth functioning of these hunks of metal, plastic and electronics is a resounding tribute to human ingenuity and collaboration. Carroll is very good at describing the structure and function of the marvelous machines that made the Higgs possible and again confirms the fact that the best science involves both great intellectual ideas and world-class engineering. Many of the LHC’s components as well as the principal players are illustrated in color photographs in the center of the book.Carroll also gives us a lucid account of the statistical methods and data collection techniques used to confirm the discovery of particles. The sheer amount of data collected by the LHC is staggering; as Carroll puts it, enough to fill about a thousand terabyte hard-drives per second. He does a good job detailing the great difficulty of collecting the data from an incredibly complex dance of particle collisions and most importantly, of separating the signal from the noise. He tells us about the almost mythical "5-sigma" threshold, essentially a very stringent statistical test that allows you to claim a "discovery" of a new particle. In July 2012, data from both the ATLAS and CMS detectors was combined together to claim a 5-sigma threshold. Carroll who was in the audience when the discovery was announced captures well the excitement in Geneva and around the world as an intensely international collaboration of more than three thousand LHC-related scientists tuned in to hear the groundbreaking news. This was definitely the discovery of a lifetime, and Peter Higgs was in the audience to hear about it. Yet Carroll drives home the point that statistics is not everything, and illustrates this through the cautionary tale of the discovery of "faster-than-light" neutrinos which, although statistically significant, turned out to be incorrect.The second part of the book gives us the theoretical basis of the Higgs boson. To Carroll’s credit, he spends a fair amount of time dispelling the simplistic belief that the "Higgs boson gives everything mass" and does a pretty good job leading us through the subtleties of what’s called the "Higgs field" and exactly how it’s relevant to particles masses and interactions. He also addresses the common misunderstanding that most of the mass of an everyday object comes from the Higgs. It doesn’t; it comes from the strong interactions and therefore won’t suddenly disappear if the Higgs boson were to hypothetically vanish. Along the way Carroll explains important concepts like spontaneous symmetry breaking and Feynman diagrams which are integral to understanding the Higgs mechanism. The last part of the book also has interesting discussions on the potential

implications of the Higgs for understanding dark matter, dark energy and the Big Bang. And an amusing chapter lays to rest the slightly paranoid "end-of-world" scenarios postulated before the LHC went online. This same chapter also takes a thoughtful look at the public promotion of science and addresses the role of blogs and other media which communicate science, often correctly but sometimes prematurely. Carroll makes us appreciate the fact that scientists have to tread a fine line in being accurate while still not giving the media an opportunity to sensationalize their findings.Finally in the third part, Carroll sheds light on the human aspect of science. Part of this is in the earlier chapters where he details the political jockeying and the clash of personalities that was involved in the cancellation of the high-stakes Superconducting Supercollider (SSC) project during the 90s. The fact is that these days even the most fundamental curiosity-driven research can involve billion-dollar equipment like the LHC. Carroll wonders whether governments around the world will now support these increasingly expensive endeavors, especially during times of recession, but also underscores the importance of this research for human creativity and unexpected practical spinoffs (like the World Wide Web). The human aspect of science is also revealed in a separate chapter that among other things asks who would get the Nobel Prize for the discovery. There is no doubt that somebody should get it (and almost universal consensus that Higgs should be included), but the history that Carroll describes makes it clear that at least six people came up with various parts of the idea within a narrow time frame. And the experimentalists seem to deserve it as much as the theoreticians. One thing is certain; any Nobel Prize for the Higgs is going to be at least somewhat controversial.In general I greatly enjoyed reading "The Particle at the End of the Universe". It’s engaging and an easy read and would complement similar other volumes like Ian Sample’s "Massive" (which focuses more on the human side) and Frank Close’s "The Infinity Puzzle" (which is heavier on the science). Carroll is a pleasant, informative, patient and humorous guide on our tour of the LHC and the Higgs. He is also measured and tends to temper the enthusiasm of discovery with realism; for instance he makes it clear that the discovery of the Higgs still leaves many questions unanswered, and it has no impact on other outstanding scientific problems like discovering cancer drugs or understanding the economy. What Carroll does manage to communicate is the deep satisfaction of discovery, the thrill of the chase and the astonishing achievements that human imagination and skill can make possible.

Sean Carroll is clearly one of the giants in his ability to make comprehensible the incomprehensible world of particle physics. In terms of cataloguing and explaining the fields, forces and matter (and their relationships) that make up reality, this is the ultimate work that I’ve read so far (at least for

those of us not in the particle physics profession). And importantly, we need to remember that this is an area of science in the process of very rapid evolution. That brings us to one of the major themes of the book. Carroll does an excellent job presenting the history and the ongoing research at the Large Hadron Collider (LHC) including the critical search for the illusive Higg's Boson. A word of caution: don't skip the appendices.I'd have to rate this an "important read" for anyone obsessed with understanding what existence is all about. Not surprisingly it doesn't have the answer, but it does help explain the process and the path science is on to reach that goal.

Sean Carroll is a great writer, with his own brand of penmanship. He elegantly introduces particle physics without the mathematical jargon that can be confusing to some scientifically illiterate readers, which is a good thing if his goal is to explicate this topic to the masses. It does contain some repetitive info though, especially if you have already browsed through a bunch theoretical physics books. However, Sean Carroll's book does have an advantage, since the discovery of the particle, that seems to be the Higgs boson, was just around the corner. If you are interested in particle physics, amazed by the standard model's newly discovered member, and eager to fill your curiosity bucket with as much information as possible, than this book is a must read for you.

This book is a good read. If you want a basic understanding of the evolution of particle physics and the scientists involved it definitely is worth the time. It will give you some idea of what the Higgs Boson is and why it is so important in particle physics. If you are new to particle physics, I do not think the author's introduction to the classes of particles is clear or very well laid out. The tables, graphs, and explanations need to be better organized. If you do not have some basic understanding of quantum mechanics or relativity, many pages of the book will be difficult to comprehend. The appendix on spin needs to be rewritten for the average lay reader. If the book gets you interested in this complex subject and leads to further study, the author has done his job.

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