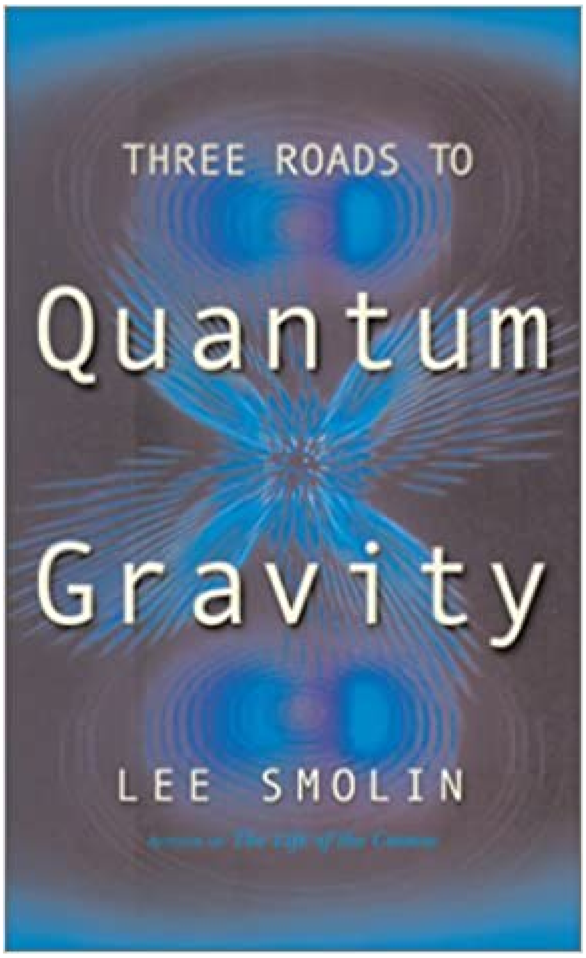
Three Roads To Quantum Gravity (Science Masters)



Synopsis

"It would be hard to imagine a better guide to this difficult subject."--Scientific AmericanIn Three Roads to Quantum Gravity, Lee Smolin provides an accessible overview of the attempts to build a final "theory of everything." He explains in simple terms what scientists are talking about when they say the world is made from exotic entities such as loops, strings, and black holes and tells the fascinating stories behind these discoveries: the rivalries, epiphanies, and intrigues he witnessed firsthand. "A mix of science, philosophy and science fiction, [this] is at once entertaining, thought-provoking, fabulously ambitious and fabulously speculative." -The New York Times"Provocative, original, and unsettling." -The New York Review of Books"An excellent writer, a creative thinker."-Nature

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Customer Reviews

It’s difficult, writes Lee Smolin in this lucid overview of modern physics, to talk meaningfully about the big questions of space and time, given the limitations of our technology and perceptions. It’s more difficult still given some of the contradictions and inconsistencies that obtain between quantum theory, which "was invented to explain why atoms are stable and do not instantly fall apart" but has little to say about space and time, and general relatively theory, which has everything to say about the big picture but tends to collapse when describing the behavior of atoms and their even smaller constituents. Whence the hero of Smolin’s tale, the as-yet-incomplete quantum theory of gravity, which seeks to unify relativity and quantum theory--and, in the bargain, to move toward a "grand theory of everything." Smolin ably explains concepts that underlie quantum gravity, such as background independence, the superposition principle, and the notion of causal structure, and he traces the development of allied theories that have shaped modern physics and led to this new view of the universe. Although he allows that "it has not been possible to test any of our new theories of quantum gravity experimentally," Smolin predicts that a solid framework will be established by 2015 at the outside. If he’s correct, the years in between promise to be an exciting time for students of the physical sciences, and Smolin’s book makes an engaging introduction to some of the big questions they’ll be asking. --Gregory McNamee

The most obvious questions--e.g., "What are time and space?"--are nearly impossible to answer. Smolin (The Life of the Cosmos), professor of physics at Pennsylvania State University, offers "a report from the front" of the current "revolution" in theories of space and time. Aimed at beginners, this careful treatment of the search for a single theory that brings together relativity and quantum theory will draw in potential explorers. Illus.

Quantum mechanics and general relativity are great, but they are known to be hardly merged into one theory. But if there is a unified theory that describes nature, they should be. Physicists believe in such a unified theory. So there have been a lot of efforts to unify them, and physicists call the unified theory quantum gravity. According to the book, "Three Roads to Quantum Gravity" by Lee Smolin, there are three main approaches to quantum gravity. These are string theory, loop quantum gravity, and theories invented by some original thinkers like Penrose and Connes.If you are interested in such a topic, you may hear about string theory. I am also a little familiar with string theory by reading articles and books like Brian Green’s "Elegant Universe". But unlike with other books about the ultimate physical theory, this book focuses its attention to loop quantum gravity. I also heard the theory and searched wiki, but I could hardly understand it. In the book, although Smolin deals with both of string theory and loop quantum gravity, the focus is laid on loop quantum gravity. One of the reasons would be that loop quantum gravity is his specialty. The book was unlike any other article or book in that the book guided me to loop quantum gravity so easily, interestingly and concretely.In Prologue, he says,"I have tried to aim this book at the intelligent layperson, interested in knowing what is going on at the frontiers of physics. I have not assumed any previous knowledge of relativity or quantum theory."But in my opinion, one would feel comfortable with the book if he has already taken a year-long course of physics and read some books related to this topic like Brian Green’s "Elegant Universe", "The Fabric of the Cosmos", and Susskind’s "The Black

Hole War".The most important claim of loop quantum gravity is that space-time (the whole history of our universe) is nothing but evolvement of a network of loops. In the theory, there is no space and time independent of matter. And there are limits on the smallest possible sizes of space and time. In the smallest world, they are not continuous, but discrete, that is, there are atoms for space-time. On page 138, the author says, "The spin networks do not live in space; their structure generates space."According to the book, it is proper that quantum gravity starts with the works of Unruh and Bekenstein on the black hole in 1970s. Bekenstein's work is that the amount of information (here, what information precisely means seems to be an issue) inside a black hole is proportional to the area of the event horizon of the black hole. So if the information inside the black hole increases by some amount, then the area of the event horizon increases by constant times of that amount. This seems to suggest the followings.1. Information (as we see 0 and 1 in the computer science books) is a discrete quantity, so, according to Bekenstein, the area increases by a discrete amount. If information and area can be regarded being equivalent, then this may imply that the geometric quantity, area, is discrete.2. The maximal possible information inside a black hole with a fixed horizon area is limited. More generally, the information inside a space of finite volume is finite. This means that space is discrete in a very small scale. To see this, consider a chunk of space. If space is continuous (not discrete), then the chunk can contain an infinite amount of information because to point out the position of an electron in the chunk, we need an infinite length of decimals. Therefore, if there is an upper bound on information, there must be a smallest size of space and so space is discrete.But the idea of discreteness (quantization) of space and time itself may have been claimed since 1920s. It is because quantum physics established during that period taught people that in very small scales, many fundamental physical quantities including momentum and energy are quantized, and so physicists may very well have thought that space and time also must be quantized.As I understand the book, string theory and loop quantum gravity have the same origin. In 1950s, there were huge studies on superconductors. People found that, very strangely, the magnetic field lines in a superconductor are quantized. The quantized fields looked like a finite number of strings connecting two poles. But this was really mathematically true. So the Duality Principle was advocated, that is, strings and fields are two ways of looking at the same thing. Among those people, physicists who favoured quantum mechanics developed string theory and physicists who favoured general relativity developed loop quantum gravity. It seems that not until the late 1980s, loop quantum gravity does not have its position as one of the reliable quantum theories of gravity. Among great thinkers of loop quantum gravity in the late 1980s, there are Smolin, Ashtekar, and Rovelli. The book is written in 2001. During 1990s, Thiemann's work seems to be distinguished.In the book, the author compares loop quantum gravity with string theory. String theory is better in that it seems to succeed in explaining all the four interactions, especially incorporating gravity. Loop quantum gravity does not yet seem to give the whole picture of how we can explain the existing physical world from a network of loops.For example, as loop quantum gravity claims, if space-time is just a network of loops, then we should be able to explain how to construct the network so that its collective chunk is smooth and has the three dimensional Euclidean geometry. To do that, physicists tried to get ideas from material physics. There are many crystal structures by that metals form Euclidean shapes. We may be able to mimic the crystal structure if we are to explain the case of the networks of loops. But in the case, we also have to explain why nature chose the structure of the networks among other possibilities.Loop quantum gravity is better in that it is background independent as general relativity is, that is, matter does not move on the fixed, unchanging stage of space-time, but matter and space-time are all changing together. In string theory, strings move on a fixed, unchanging stage of continuous space-time. But according to the book, the ultimate quantum gravity must be background independent, so string theory is at most an approximation of the ultimate quantum gravity.There are many other interesting stories about string theory and loop quantum gravity. For example, the book says that there goes a programme of research under work to unify them. Their point of view is that loop quantum gravity describes the smallest scale of the world and string theory describes the world of the next smallest scale, so string theory can be explained from loop quantum gravity.Reading the book, at a few places, I felt the difficulty in understanding what the book was saying.1. At the beginning of Chapter 3, it poses an important problem. "The root of the apparent paradox is that my own experience is of one thing or the other, but the description of me that would be given in quantum theory by another observer has me most often in a superposition which is none of the things I actually experience. There are a few possible resolutions of this mystery." (page 39)But I was totally not able to understand the following possible resolutions in the book. For me, Chapter 3 has its meaning only in raising the paradox.2. At the end of Chapter 5, it says that if we can observe light from near the horizon of a black hole, we may get a clue about the structure of space and time at the Planck scale. Following that, it says, "Unfortunately, it has so far proved impractical to make a black hole, so no one has been able to do this experiment." But I cannot understand why we need to make a black hole in a laboratory. As far as I know, there are plenty of candidates of black holes in the sky. It would be done if we observe the candidates.3. In Chapter 6, it introduces the work of Bill Unruh in the 1970s;"Accelerating observers (in vacuum) see themselves as embedded in a gas of hot photons at a temperature proportional to their acceleration."Temperature is related to the random motion of particles in the vacuum. The book explains where the randomness comes from. To do that, introducing the EPR experiment, it gives an example of two photons that are created together. When two photons are created together, they are found to have to following property."... when they are measured... their properties are correlated in such a way that a complete description of either one of them involves the other." (page84)This is the basic argument for the next discussions of the book. I could not understand the sentence. Suppose I have two things A and B. The sentence seems to imply that if I want to completely know A, I must know B. But this is absurd. Even in quantum mechanics, if I want to know just one property of A at a time, then I can definitely know it. The cases that are inhibited in quantum mechanics are when we try to know some two properties of an object simultaneously.I listed these for the readers who are not so skillful in English or Physics. They may feel ashamed when it happens that they cannot understand some parts of the book. I think that they don’t need to feel that way. Such parts are either mistakes of the author or not important now to the readers, so they can be skipped without worry.I was extremely thrilled while reading the book. I read the book twice. The second reading was far beneficial and exciting than the first reading. I’d like to appreciate the author for the nice experience.

As a layperson (and closet science geek), I really appreciated the author’s straightforward and mostly non-mathematical approach to a difficult and incomplete new theory about quantum gravity. It covers three approaches which include super strings and M theory and black hole thermodynamics, both of which I hadn’t really looked into before. It was great fun and I really enjoyed reading this book!I found this work to be brilliant and very thought-provoking and would highly recommend it to anyone who may not be a physicist, but has some basic knowledge of science and would like to learn more about a fascinating subject!

Excellent account of recent development in quantum gravity, accessible to the informed non-physicist.

Nice job, Lee.

Smolin’s presentation of the three theories was so thought provoking for me that I realized that I wanted to learn more. I had majored in Physics 35 years ago so I had QM and SR under my belt but nothing more modern. One thing that I particualry liked about Smolin’s presentation of the three theories currently being worked on - superstring theory, quantum loop theory and blackhole thermodynamics - was the balanced way he kept saying how all three undoubtedly would contribute to the ongoing progress rather than trying to say one has to be right to the exclusion of the other two - it’s simply too early to tell. I’ve spent 2 years (with a tutor) studying QFT in order, hopefully, to be able to at least approach the mathematics behind these theories. I’ve just ordered a "First Course in String Theory" and realized that I had never written a review of Smolen’s book to so-to-speak thank him so I now fill that gap.

"Three Roads to Quantum Gravity’ is an excellent book for those looking to learn more about a potential alternative to string theories. The author does an excellent job of explaining an incredibly complex theory in a book that is only a few hundred pages.

Lee Smolin has again created an excellent non-mathematical book that has his distinctive style and clearly that explains his view point on how we get to a theory of everything. Lee presents a partial history of the different approaches used by the Physics community to solve solve the problems of creating a theory of everything. His approach is heavly vested in the Quantun Gravity history and development. This is only natural in that his life has been spent primarly in this area of development. However, he does a very adaquite job of explaining the history and issues with string theory. Lee does a excellent job in this book to present a possible direction for the science community to persue. I only hope that our science community will take Lee’s approaces seriously.

I approached this book with great enthusiasm, hoping for a pedestrian treatment of loop quantum gravity (LQG). To be fair, most of this book is pretty good. Smolin writes pretty well, especially about relational quantum mechanics and how it relates to quantum gravity and cosmology. In addition, Smolin clearly points out why many relativists have issue with string/m-theory’s lack of background independence.I was, however, mildly disappointed in his discussion of the physical meaning of spin networks and loops and in his exposition of a possible synthesis of M-theory and LQG. Perhaps I overlooked it, but this book doesn’t directly point out how you go from spin networks and spin foams to spacetime. But, you can figure it out... if you know enough general relativity and quantum field theory.The appendix of this book is excellent! It provides many useful references to the literature.All things considered though, this book is worth a read, especially to learn about the connection between spacetime, gravity, and quantum mechanics.I originally rated this three stars. I recently reread the book and now want to give it four stars.

Three Roads To Quantum Gravity (Science Masters) Covariant Loop Quantum Gravity: An Elementary Introduction to Quantum Gravity and Spinfoam Theory (Cambridge Monographs on Mathematical Physics) Three Roads to Quantum Gravity Advanced Molecular Quantum Mechanics: An Introduction to Relativistic Quantum Mechanics and the Quantum Theory of Radiation (Studies in Chemical Physics) Defining Gravity (Defining Gravity Series Book 1) Reality Is Not What It Seems: The Journey to Quantum Gravity A First Course in Loop Quantum Gravity Back Roads Ireland (Eyewitness Travel Back Roads) Back Roads Germany (Eyewitness Travel Back Roads) The Silk Roads, 2nd: includes routes through Syria, Turkey, Iran, Turkmenistan, Uzbekistan, Kyrgyzstan, Pakistan and China (Silk Roads: A Route & Planning Guide) Back Roads Australia (Eyewitness Travel Back Roads) Back Roads France (Eyewitness Travel Back Roads) Back Roads Spain (Eyewitness Travel Back Roads) The Roads of Oklahoma (The Roads of Series) ADC The Map People South Hampton Roads, Virginia: Street Atlas (South Hampton Roads, Virginia Street Map Book) Quantum Ontology: A Guide to the Metaphysics of Quantum Mechanics Quantum Nanoelectronics: An introduction to electronic nanotechnology and quantum computing Introduction to Topological Quantum Matter & Quantum Computation Quantum Mechanics: Re-engineering Your Life With Quantum Mechanics & Affirmations Quantum Runes: How to Create Your Perfect Reality Using Quantum Physics and Teutonic Rune Magic (Creating Magick with The Universal Laws of Attraction Book 1)