

The Holy Grail of modern physics is the theory of "quantum gravity." It is a search for a view of the Universe that unites two seemingly opposed pillars of modern science: Einstein's theory of general relativity, which deals with large scale phenomena like planets, solar systems and galaxies, and quantum theory, which deals with the world of the very small—molecules, atoms and electrons. In the last few years physicists have made steps toward their goal of a completely new theory of space, time and the universe, a "theory of everything." In *Three Roads to Quantum Gravity*, Lee Smolin, who has spent his career at the forefront of these new discoveries, presents for the first time the main ideas behind the new developments that have brought a quantum theory of gravity in sight.

Written with exceptional style and clarity, *Three Roads to Quantum Gravity* confronts the deepest questions of the nature of the universe and provides a preview of some of the remarkable scientific developments we can look forward to in the twenty-first century.



Praise for *THREE ROADS TO QUANTUM GRAVITY*

"[Smolin] argues lucidly and effectively.... This is a deeply philosophical work that asks us to rethink the epistemological roots of the mental pictures we make about nature."
—*NEW YORK TIMES BOOK REVIEW*

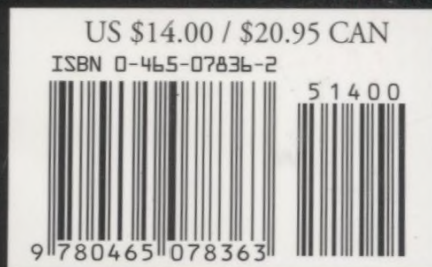
"Absolutely compelling... Lee Smolin is one of a small handful of physicists around the world who have been able to make genuine progress on an extraordinarily difficult problem that has stumped some of the world's finest minds for 80 years. [R]equired reading for anyone interested in the problem of quantum gravity and the future of theoretical physics." —*THE AMERICAN SCIENTIST*



LEE SMOLIN is a leading contributor to the search for a quantum theory of gravity. He is currently a researcher at Perimeter Institute for Theoretical Physics and Professor of Physics at Waterloo University. He is also the author of *Life of the Cosmos*.



A Member of the Perseus Books Group
www.basicbooks.com



CONTENTS

Acknowledgments	vii
Prologue: The quest for quantum gravity	1
Part I Points of departure	15
1 There is nothing outside the universe	17
2 In the future we shall know more	26
3 Many observers, not many worlds	33
4 The universe is made of processes, not things	49
Part II What we have learned	67
5 Black holes and hidden regions	69
6 Acceleration and heat	77
7 Black holes are hot	88
8 Area and information	95
9 How to count space	106
10 Knots, links and kinks	125
11 The sound of space is a string	146

vi THREE ROADS TO QUANTUM GRAVITY

Part III The present frontiers	167
12 <i>The holographic principle</i>	169
13 <i>How to weave a string</i>	179
14 <i>What chooses the laws of nature?</i>	194
Epilogue: A possible future	207
Postscript	212
Glossary	226
Suggestions for further reading	235
Index	241