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String Theory

FOR

DUMMIES®

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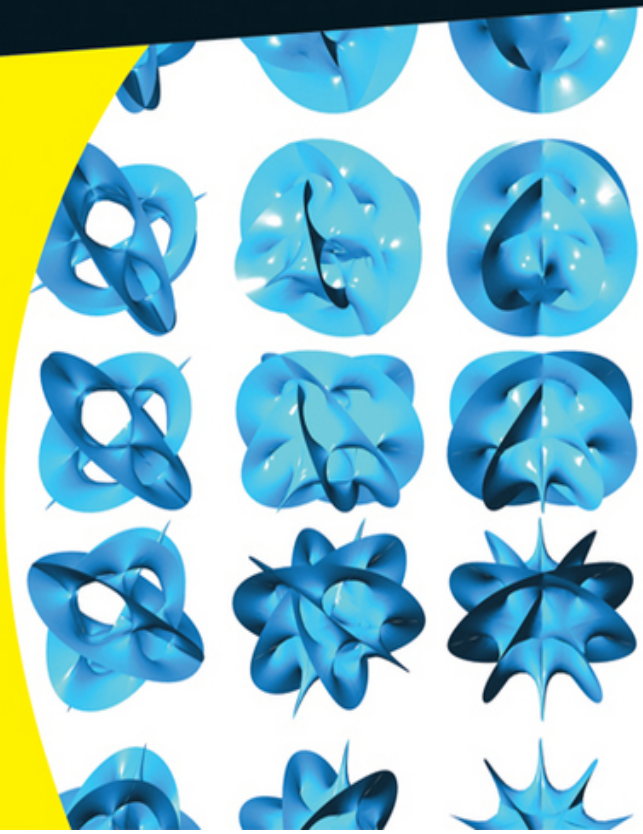
- String theory hypotheses and predictions
- The different viewpoints in the field
- How to relate this theory to the world around you



String Theory For Dummies®

Table of Contents

Part II: The Physics Upon Which String Theory Is Built

by Andrew Zimmerman Jones

with Daniel Robbins, PhD in Physics

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About the Author

Andrew Zimmerman Jones is the Physics Guide at About.com, a New York Times Company, where he writes and edits news and articles on all areas of physics. He spends his days working as an editor for an educational assessment company. He holds a bachelor's degree in physics from Wabash College, where he also studied mathematics and philosophy, and a master's degree in mathematical education from Purdue University.

In addition to work for About.com, Andrew has written a number of nonfiction essays and reviews, which have appeared in The Internet Review of Science Fiction, EpicSFF.com, Pink Floyd and Philosophy, Black Gate, and Heroes and Philosophy. His fiction credits include short stories in Abyss and Apex, KidVisions, The Four Bubbas of the Apocalypse, and International House of Bubbas.

He has been a member of Mensa since the eighth grade and has been intensely interested in both science and science fiction since even earlier. Along the way, he's also become an Eagle Scout, a Master Mason in the Freemasons, and won the Harold Q. Fuller Prize in Physics at Wabash College. His plan for world domination nears completion with the publication of this book.

Andrew lives in central Indiana with his beautiful wife, Amber, and son, Elijah. When he's not writing or editing, he is most often found reading, playing games, watching television, investigating bizarre scientific phenomena, or updating his personal Web page, which can be found at www.azjones.info. Andrew also regularly reports on any new string theory implications on his Web site at physics.about.com.

Dedication

This book is dedicated to my loving and lovely wife, Amber Eckert-Jones. While physicists still search for a law to unify all of the forces in the physical universe, I don’t need to, because all the forces in my universe come together in you.

Author’s Acknowledgments

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Introduction

Why are scientists so excited about string theory? Because string theory is the most likely candidate for a successful theory of quantum gravity — a theory that scientists hope will unite two major physical laws of the universe into one. Right now, these laws (quantum physics and general relativity) describe two totally different types of behavior in totally different ways, and in the realm where neither theory works completely, we really don’t know what’s going on!

Understanding the implications of string theory means understanding profound aspects of our reality at the most fundamental levels. Are there parallel universes? Is there only one law of nature or infinitely many? Why does our universe follow the laws it does? Is time travel possible? How many dimensions does our universe possess? Physicists are passionately seeking answers to these questions.

Indeed, string theory is a fascinating topic, a scientific revolution that promises to transform our understanding of the universe. As you’ll see, these sorts of revolutions have happened before, and this book helps you understand how physics has developed in the past, as well as how it may develop in the future.

This book contains some ideas that will probably, in the coming years, turn out to be completely false. It contains other ideas that may ultimately prove to be fundamental laws of our universe, perhaps forming the foundation for whole new forms of science and technology. No one knows what the future holds for string theory.

About This Book

In this book, I aim to give a clear understanding of the ever-evolving scientific subfield known as string theory. The media is abuzz with talk about this “theory of everything,” and when you’re done with this book you should know what they’re talking about (probably better than they do, most of the time).

In writing this book, I’ve attempted to serve several masters. First and foremost among them has been scientific accuracy, followed closely by entertainment value. Along the way, I’ve also done my best to use language that you can understand no matter your scientific background, and I’ve certainly tried to keep any mathematics to a minimum.

In writing this book, I set out to achieve the following goals:

- Provide the information needed to understand string theory (including established physics concepts that predate string theory).
- Establish the successes of string theory so far.
- Lay out the avenues of study that are attempting to gain more evidence for string theory.
- Explore the bizarre (and speculative) implications of string theory.
- Present the critical viewpoints in opposition to string theory, as well as some alternatives that may bear fruit if it proves to be false.
- Have some fun along the way.

Avoid mathematics at all costs. (You're welcome!)

I hope you, good reader, find that I've been successful at meeting these goals.

And while time may flow in only one direction (Or does it? I explore this in Chapter 16), your reading of this book may not. String theory is a complex scientific topic that has a lot of interconnected concepts, so jumping between concepts is not quite as easy as it may be in some other *For Dummies* reference books. I've tried to help you out by including quick reminders and providing cross-references to other chapters where necessary. So feel free to wander the pages to your heart's content, knowing that if you get lost you can work your way back to the information you need.

Conventions Used in This Book

The following conventions are used throughout the text to make things consistent and easy to understand:

I use `monofont` for Web sites. ***Note:*** When this book was printed, some Web addresses may have needed to break across two lines of text. If that happened, rest assured that I haven't put in any extra characters (such as hyphens) to indicate the break. So, when using one of these Web addresses, just type in exactly what you see in this book, as though the line break doesn't exist.

I've done my best not to fill the book with technical jargon, which is hard to do in a book on one of the

most complex and mathematically driven scientific topics of all time. When I use a technical term, it's in *italics* and closely followed by an easy-to-understand definition.

Bold is used to highlight key words and phrases in bulleted lists.

Finally, one major convention used in this book is in the title: I use the term "string theory." In Chapter 10, you discover that string theory is actually called *superstring theory.* As you see in Chapter 11, in 1995 physicists realized that the various "string theories" (five existed at the time) included objects other than strings, called *branes*. So, strictly speaking, calling it by the name "string theory" is a bit of a misnomer, but people (including string theorists themselves) do it all the time, so I'm treading on safe ground. Many physicists also use the name *M-theory* to describe string theory after 1995 (although they rarely agree on what the "M" stands for), but, again, I will mostly refer to it just as "string theory" unless the distinction between different types matters.

What You're Not to Read

All the chapters provide you with important information, but some sections offer greater detail or tidbits of information that you can skip for now and come back to later without feeling guilty:

Sidebars: Sidebars are shaded boxes that give detailed examples or explore a tangent in more detail. Ignoring these won't compromise your understanding of the rest of the material.

Anything with a Technical Stuff normal: This normal indicates information that's interesting but that you can live without. Read these tidbits later if you're pressed for time.

Foolish Assumptions

About the only assumption that I've made in writing this book is that you're reading it because you want to know something about string theory. I've tried to not even assume that you *enjoy* reading physics books. (I do, but I try not to project my own strangeness on others.)

I have assumed that you have a passing acquaintance with basic physics concepts — maybe you took a physics class in high school or have watched some of the scientific programs about gravity, light waves, black holes, or other physics-related topics on cable channels or your local PBS station. You don't need a degree in physics to follow the explanations in this book, although without a degree in physics you might be amazed that anyone can make sense of any theory this disconnected from our everyday experience. (Even with physics degree, it can boggle the mind.)

As is customary in string theory books for the general public, the mathematics has been avoided. You need a graduate degree in mathematics or physics to follow the mathematical equations at the heart of string theory, and while I have a graduate degree in mathematics, I've assumed that you don't. Don't worry — while a complete understanding of string theory is rooted firmly in the advanced mathematical concepts of quantum field

theory, I've used a combination of text and figures to explain the fascinating ideas behind string theory.

How This Book Is Organized

String Theory For Dummies is written so you can easily get to the information you need, read it, and understand it. It's designed to follow the historical development of the theory as much as possible, though many of the concepts in string theory are interconnected. Although I've attempted to make each chapter understandable on its own, I've included cross-references where concepts repeat to get you back to a more thorough discussion of them.

Part I: Introducing String Theory

This first part of the book introduces the key concepts of string theory in a very general way. You read about why scientists are so excited about finding a theory of quantum gravity. Also, you get your first glimpse into the successes and failures of string theory.

Part II: The Physics Upon Which String Theory Is Built