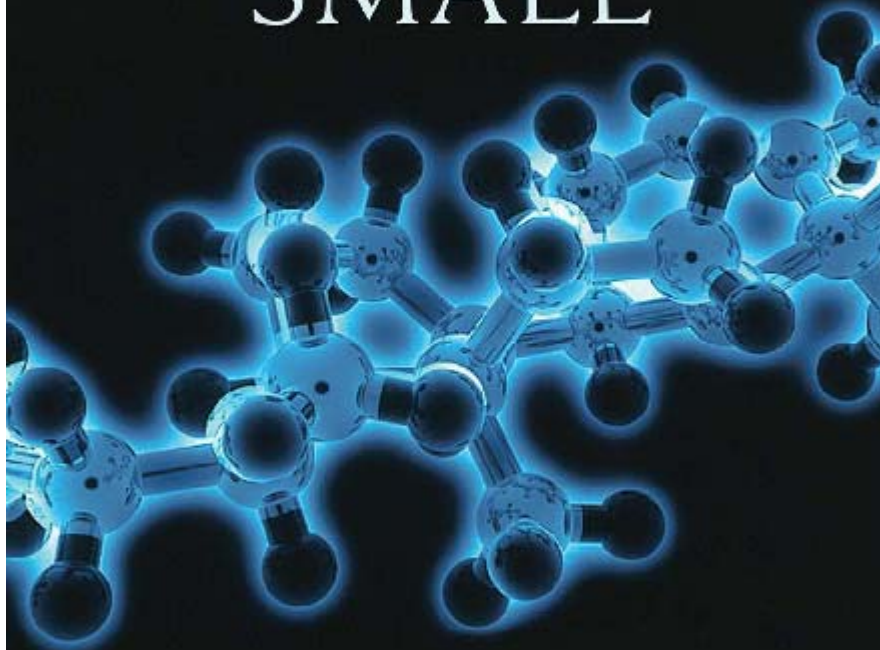


ABSOLUTELY SMALL



How Quantum Theory Explains Our Everyday World

MICHAEL D. FAYER

“There are a few books that I always keep near at hand, and constantly come back to. *The Feynman Lectures in Physics* and Dirac's classic textbook on *Quantum Mechanics* are among them. Michael Fayer's wonderful new book, *Absolutely Small*, is about to join them. Whether you are a scientist or just curious about how the world works, this is the book for you.”

Leonard Susskind, Professor of Physics, Stanford University, Author of *The Black Hole War: My Battle With Stephen Hawking to Make the World Safe for Quantum Mechanics*. Professor Susskind is widely regarded as one of the fathers of string theory.

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Preface

IF YOU ARE READING THIS, you probably fall into one of two broad categories of people. You may be one of my colleagues who is steeped in the mysteries of quantum theory and wants to see how someone writes a serious book on quantum theory with no math. Or, you may be one of the vast majority of people who look at the world around them without a clear view of why many things in everyday life are the way they are. These many things are not insignificant aspects of our environment that might be overlooked. Rather, they are important features of the world that are never explicated because they are seemingly beyond comprehension. What gives materials color, why does copper wire conduct electricity but glass doesn't, what is a trans fat anyway, and why is carbon dioxide a greenhouse gas while oxygen and nitrogen aren't? This lack of a picture of how things work arises from a seemingly insurmountable barrier to understanding. Usually that barrier is mathematics. To answer the questions posed above—and many more—requires an understanding of quantum theory, but it actually doesn't require mathematics.

This book will develop your quantum mechanics intuition, which will fundamentally change the way you view the world. You

have an intuition for mechanics, but the mechanics you know is what we refer to as classical mechanics. When someone hits a long drive baseball, you know it goes up for a while, then the path turns over and the ball falls back to Earth. You know if the ball is hit harder, it takes off faster and will go farther before it hits the ground. Why does the ball behave this way? Because gravity is pulling it back to Earth. When you see the moon, you know it is orbiting the Earth. Why? Because gravity attracts the moon to the Earth. You don't sit down and start solving Newton's equations to calculate what is going on. You know from everyday experience that apples fall down not up and that if your car is going faster it will take longer to stop. However, you don't know from everyday experience why cherries are red and blueberries are blue. Color is intrinsically dependent on the quantum mechanical description of molecules. Everyday experience does not prepare you to understand the nature of things around you that depend on quantum phenomena. As mentioned here and detailed in the book, understanding features of everyday life, such as color or electricity, requires a quantum theory view of nature

Why no math? Imagine if this book contained discussions of a topic that started in English, jumped into Latin, then turned back to English. Then imagine that this jumping happened every time the details of an explanation were introduced. The language jumping is what occurs in books on quantum theory, except that instead of jumping from English to Latin, it jumps from English to math. In a hard core quantum mechanics book (for example, my own text, *Elements of Quantum Mechanics* [Oxford University Press, 2001]), you will find things like, "the interactions are described by the following set of coupled differential equations." After the equations, the text reads, "the solutions are," and more equations appear. In contrast, the presentation in this book is descriptive. Diagrams replace the many equations, with the exception of some small algebraic equations—and these simple equations are explained in detail.

Even without the usual overflow of math, the fundamental philosophical and conceptual basis for and applications of quantum theory are thoroughly developed. Therefore, anyone can come away with an understanding of quantum theory and a deeper understanding of the world around us. If you know a good deal of math, this book is still appropriate. You will acquire the conceptual understanding necessary to move on to a mathematical presentation of quantum theory. If you are willing to do some mental gymnastics, but no math, this book will provide you with the fundamentals of quantum theory, with applications to atomic and molecular matter.