



HYPERSPACE

A Scientific Odyssey Through the 10th Dimension

MICHIO KAKU

'beautifully written, making difficult scientific ideas seem accessible'

The Independent

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Michio Kaku is the Henry Semat Professor of Theoretical Physics at the City College of New York. An internationally acclaimed physicist, he is the co-founder of string field theory. He graduated from Harvard and received his Ph.D. from Berkeley. He is the author of the critically acclaimed *Beyond Einstein* (with Jennifer Thompson), *Quantum Field Theory: A Modern Introduction*, *Introduction to Superstrings*, and his most recent bestseller *Visions*. He hosts a weekly hour-long radio science programme that is nationally syndicated.

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Through

Parallel Universes,

Time Warps, and

The Tenth Dimension

Michio Kaku

Illustrations by Robert O'Keefe

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This book is dedicated
to my parents

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Preface

Scientific revolutions, almost by definition, defy common sense.

If all our common-sense notions about the universe were correct, then science would have solved the secrets of the universe thousands of years ago. The purpose of science is to peel back the layer of the appearance of objects to reveal their underlying nature. In fact, if appearance and essence were the same thing, there would be no need for science.

Perhaps the most deeply entrenched common-sense notion about our world is that it is three dimensional. It goes without saying that length, width, and breadth suffice to describe all objects in our visible universe. Experiments with babies and animals have shown that we are born with an innate sense that our world is three dimensional. If we include time as another dimension, then four dimensions are sufficient to record all events in the universe. No matter where our instruments have probed, from deep within the atom to the farthest reaches of the galactic cluster, we have only found evidence of these four dimensions. To claim otherwise publicly, that other dimensions might exist or that our universe may coexist with others, is to invite certain scorn. Yet this deeply ingrained prejudice about our world, first speculated on by ancient Greek philosophers 2 millennia ago, is about to succumb to the progress of science.

This book is about a scientific revolution created by the *theory of hyperspace*,¹ which states that dimensions exist beyond the commonly accepted four of space and time. There is a growing acknowledgment among physicists worldwide, including several Nobel laureates, that the universe may actually exist in higher-dimensional space. If this theory is proved correct, it will create a profound conceptual and philosophical revolution in our understanding of the universe. Scientifically, the hyperspace theory goes by the names of Kaluza–Klein theory and supergravity. But

its most advanced formulation is called superstring theory, which even predicts the precise number of dimensions: ten. The usual three dimensions of space (length, width, and breadth) and one of time are now extended by six more spatial dimensions.

We caution that the theory of hyperspace has not yet been experimentally confirmed and would, in fact, be exceedingly difficult to prove in the laboratory. However, the theory has already swept across the major physics research laboratories of the world and has irrevocably altered the scientific landscape of modern physics, generating a staggering number of research papers in the scientific literature (over 5,000 by one count). However, almost nothing has been written for the lay audience to explain the fascinating properties of higher-dimensional space. Therefore, the general public is only dimly aware, if at all, of this revolution. In fact, the glib references to other dimensions and parallel universes in the popular culture are often misleading. This is regrettable because the theory's importance lies in its power to unify all known physical phenomena in an astonishingly simple framework. This book makes available, for the first time, a scientifically authoritative but accessible account of the current fascinating research on hyperspace.

To explain why the hyperspace theory has generated so much excitement within the world of theoretical physics, I have developed four fundamental themes that run through this book like a thread. These four themes divide the book into four parts.

In Part I, I develop the early history of hyperspace, emphasizing the theme that the laws of nature become simpler and more elegant when expressed in higher dimensions.

To understand how adding higher dimensions can simplify physical problems, consider the following example: To the ancient Egyptians, the weather was a complete mystery. What caused the seasons? Why did it get warmer as they traveled south? Why did the winds generally blow in one direction? The weather was impossible to explain from the limited vantage point of the ancient Egyptians, to whom the earth appeared flat, like a two-dimensional plane. But now imagine sending the Egyptians in a rocket into outer space, where they can see the earth as simple and whole in its orbit around the sun. Suddenly, the answers to these questions become obvious.

From outer space, it is clear that the earth's axis is tilted about 23 degrees from the vertical (the 'vertical' being the perpendicular to the plane of the earth's orbit around the sun). Because of this tilt, the northern hemisphere receives much less sunlight during one part of its orbit than during another part. Hence we have winter and summer. And since

the equator receives more sunlight than the northern or southern polar regions, it becomes warmer as we approach the equator. Similarly, since the earth spins counterclockwise to someone sitting on the north pole, the cold, polar air swerves as it moves south toward the equator. The motion of hot and cold masses of air, set in motion by the earth's spin, thus helps to explain why the winds generally blow in one direction, depending on where you are on the earth.

In summary, the rather obscure laws of the weather are easy to understand once we view the earth from space. Thus the solution to the problem is to go *up* into space, into the *third dimension*. Facts that were impossible to understand in a flat world suddenly become obvious when viewing a three-dimensional earth.

Similarly, the laws of gravity and light seem totally dissimilar. They obey different physical assumptions and different mathematics. Attempts to splice these two forces have always failed. However, if we add one more dimension, a *fifth* dimension, to the previous four dimensions of space and time, then the equations governing light and gravity appear to merge together like two pieces of a jigsaw puzzle. Light, in fact, can be explained as vibrations in the fifth dimension. In this way, we see that the laws of light and gravity become simpler in five dimensions.

Consequently, many physicists are now convinced that a conventional four-dimensional theory is "too small" to describe adequately the forces that describe our universe. In a four-dimensional theory, physicists have to squeeze together the forces of nature in a clumsy, unnatural fashion. Furthermore, this hybrid theory is incorrect. When expressed in dimensions beyond four, however, we have "enough room" to explain the fundamental forces in an elegant, self-contained fashion.

In Part II, we further elaborate on this simple idea, emphasizing that the hyperspace theory may be able to unify all known laws of nature into one theory. Thus the hyperspace theory may be the crowning achievement of 2 millennia of scientific investigation: the unification of all known physical forces. It may give us the Holy Grail of physics, the "theory of everything" that eluded Einstein for so many decades.

For the past half-century, scientists have been puzzled as to why the basic forces that hold together the cosmos—gravity, electromagnetism, and the strong and weak nuclear forces—differ so greatly. Attempts by the greatest minds of the twentieth century to provide a unifying picture of all the known forces have failed. However, the hyperspace theory allows the possibility of explaining the four forces of nature as well as the seemingly random collection of subatomic particles in a truly elegant