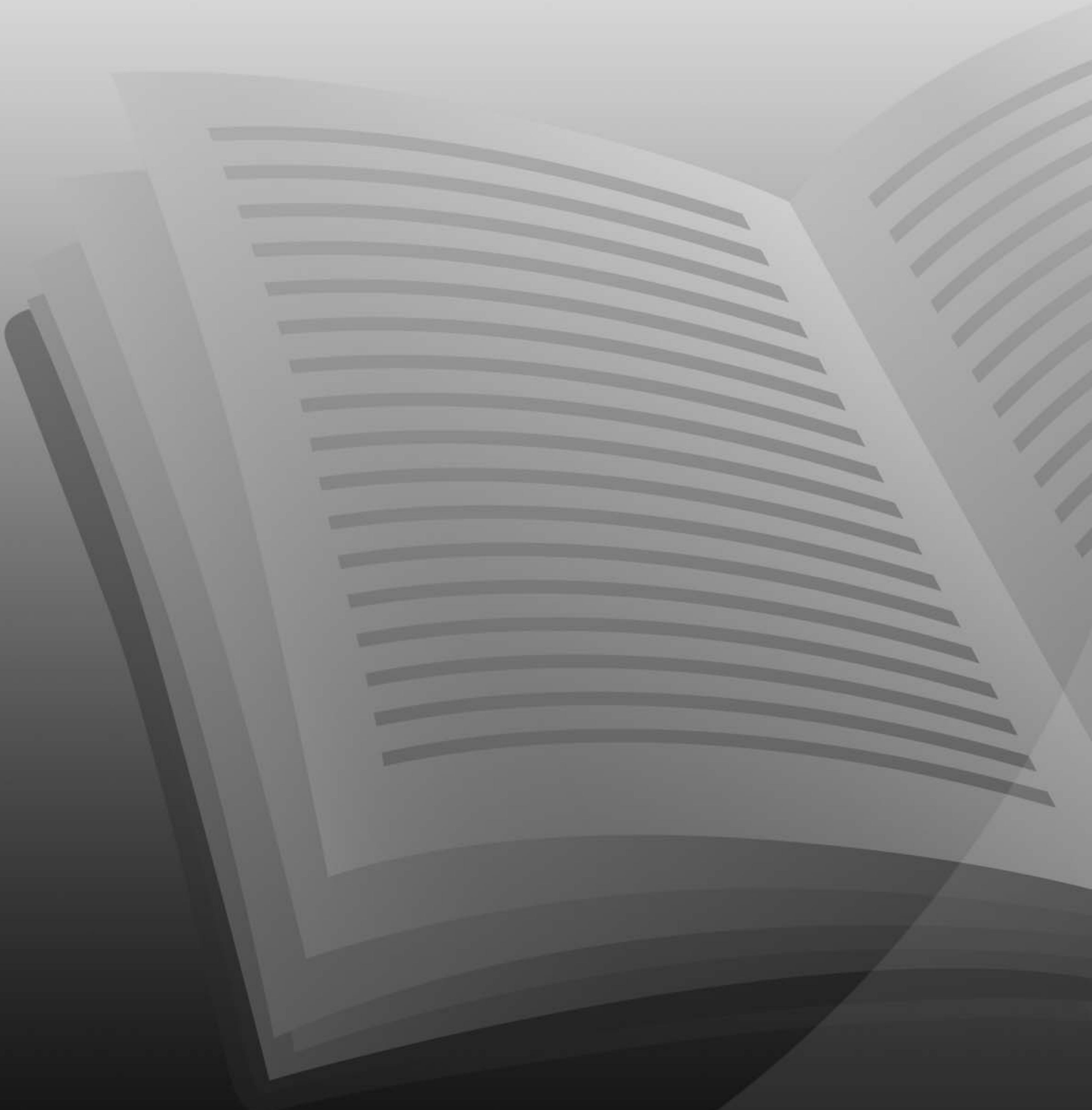
RANDOM HOUSE eBOOKS



The Dancing Wu Li Masters

Gary Zukav

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Also by Gary Zukav

THE SEAT OF THE SOUL

The Dancing Wu Li Masters

An Overview of the New Physics

Gary Zukav

RIDER

London Sydney Auckland Johannesburg

THE GREEK ALPHABET

Α	α	ALPHA	Ν	ν	NU
Β	β	BETA	Ξ	ξ	XI
Γ	γ	GAMMA	Ο	ο	OMICRON
Δ	δ	DELTA	Π	π	PI
Ε	ϵ	EPSILON	Ρ	ρ	RHO
Ζ	ζ	ZETA	Σ	σ	SIGMA
Η	η	ETA	Τ	τ	TAU
Θ	θ	THETA	Υ	υ	UPSILON
Ι	ι	IOTA	Φ	φ	PHI
Κ	κ	KAPPA	Χ	χ	CHI
Λ	λ	LAMBDA	Ψ	ψ	PSI
Μ	μ	MU	Ω	ω	OMEGA

FOOTNOTES FOR STABLE PARTICLE TABLE

1. This table was compiled with the assistance of the Particle Data Group, Lawrence Berkeley Laboratory, Berkeley, California. According to their convention, stable particles are particles that do not decay by strong interaction; but they do decay by electromagnetic and weak interactions. In fact, (as the table shows), the majority of stable particles are not ‘stable’ in the usual sense.
2. Incredible as it may seem, physicists measure particle lifetimes (and masses) to far greater degrees of accuracy than indicated here. (“Review of Particle Properties,” Physics Letter, 75B, 1, 1978.) (updated bi-annually).
3. Particles with this footnote are speculative to one degree or another. The graviton has been predicted solely on a theoretical basis while the tau neutrino, the F particle, and the charmed lambda have some experimental evidence to support their existence. However, none of them have been accepted, at this date, as confirmed particles by the Particle Data Group, Lawrence Berkeley Laboratory, the internationally accepted compiler of particle data. (The parameters shown for these particles have not been measured, but they generally are assumed to have the values shown). The blank spaces in the table represent a lack of data. [Information on the Tau and D particles, the newest particles as this table goes to print (1978), is still incomplete.]
4. The neutral kaon has two average lifetimes. If it decays in the shorter time it is called a K^0_S (“K zero short”). If it decays in the longer time it is called a K^0_L (“K

zero long”). All the other particles have only one average lifetime.

STABLE PARTICLE TABLE[1]

	Particle name	Symbol	Mass	Spin	Charge	Anti particle	Typical mode of decay	Average lifetime[2]
	Photon	γ	0	1	Neutral	Same particle	Stable	Infinite
	Graviton[3]	—	0	2	Neutral	Same particle	Stable	Infinite
Leptons	Electron neutrino	ν_e	0	½	Neutral	ν_e	Stable	Infinite
	Electron	e^-	1	½	Negative	e^+ (positron)	Stable	Infinite
	Muon neutrino	ν_μ	0	½	Neutral	$\bar{\nu}_\mu$	Stable	Infinite
	Muon	μ^-	207	½	Negative	μ^+	$\mu^- \rightarrow e^- + \nu_e + \nu_\mu$	2.2 millionths of a second (2.2 × 10^{-6})
	Tau neutrino[3]	ν_τ	—	½	Neutral	$\bar{\nu}_\tau$	—	—
	Tau	τ^-	3536	½	Negative	τ^+	$\tau^- \rightarrow e^- + \nu_e + \nu_\tau$	—
Mesons	Pion	π^+	273	0	Positive	π^- } same as the	$\pi^+ \rightarrow \mu^+ + \nu_\mu$	26 billionths of a second (26 × 10^{-9})
		π^-	273	0	Negative	π^+ } particles	$\pi^- \rightarrow \mu^- + \nu_\mu$	26 billionths of a second (26 × 10^{-9})
		π^0	264	0	Neutral	Same particle	$\pi^0 \rightarrow \gamma + \gamma$	80 quintillionths of a second (80 × 10^{-18})
	Kaon	K^+	996	0	Positive	K^-	$K^+ \rightarrow \mu^+ + \nu_\mu$	12 billionths of a second (12 × 10^{-9})
							$K^0_{short} \rightarrow \pi^+ + \pi^-$	90 trillionths of a second (90 × 10^{-12})
		K^0	974	0	Neutral	$\bar{K}^0$	$K^0_{long} \rightarrow \pi^+ + \pi^- + \pi^{0}$[4]	52 billionths of a second (52 × 10^{-9})
	Eta	η	1074	0	Neutral	Same particle	$\eta \rightarrow \gamma + \gamma$	0.8 quintillionth of a second (0.8 × 10^{-18})
	D	D^+	3656	0	Positive	D^-	$D^+ \rightarrow K^- + \pi^+ + \pi^+$	—
		D^0	3646	0	Neutral	$\bar{D}^0$	$D \rightarrow K^- + \pi^+$	—
	F[3]	F^+	—	0	Positive	F^-	—	—
Baryons	Proton	p	1836	½	Positive	$\bar{p}$	Stable	Infinite
	Neutron	n	1837	½	Neutral	$\bar{n}$	$n \rightarrow p + e^- + \bar{\nu}_e$	918 seconds
	Lambda	Λ	2183	½	Neutral	$\bar{\Lambda}$	$\Lambda \rightarrow p + \pi^-$	0.3 billionths of a second (0.3 × 10^{-9})
	Sigma	Σ^+	2328	½	Positive	$\bar{\Sigma}^-$	$\Sigma^+ \rightarrow p + \pi^0$	80 trillionths of a second (80 × 10^{-12})
		Σ	2334	½	Neutral	$\bar{\Sigma}$	$\Sigma \rightarrow \Lambda + \gamma$	58 sextillionths of a second (58 × 10^{-21})
		Σ^-	2343	½	Negative	$\bar{\Sigma}^+$	$\Sigma^- \rightarrow n + \pi^-$	0.2 billionth of a second (0.2 × 10^{-9})
	Xi	Ξ^0	2573	½	Neutral	$\bar{\Xi}^0$	$\Xi^0 \rightarrow \Lambda + \pi$	0.3 billionth of a second (0.3 × 10^{-9})
		Ξ^-	2586	½	Negative	$\bar{\Xi}^+$	$\Xi^- \rightarrow \Lambda + \pi^-$	0.2 billionth of a second (0.2 × 10^{-9})
	Omega	Ω^-	3272	3/2	Negative	$\bar{\Omega}^+$	$\Omega^- \rightarrow \Xi^0 + \pi^-$	0.1 billionth of a second (0.1 × 10^{-9})
	Lambda[3]	Λ_c^+	—	—	Positive	$\bar{\Lambda}_c^-$	—	—

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The Dance

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1887 (Michelson-Morley experiment)
GEORGE FRANCIS FITZGERALD
1892 (FitzGerald contractions)
HENDRIK ANTOON LORENTZ
1893 (Lorentz transformations)
ELECTRON
1897 (discovered)
MAX PLANCK
1900 (quantum hypothesis)
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1905 (photon theory)
1905 (special theory of relativity)
HERMANN MINKOWSKI
1908 (space-time)
NUCLEUS
1911 (discovered)
NIELS BOHR
1913 (specific-orbits model of the atom)
ALBERT EINSTEIN
1915 (general theory of relativity)
LOUIS DE BROGLIE
1924 (matter waves)
NIELS BOHR, H. A. KRAMERS, JOHN SLATER
1924 (first concept of probability waves)
WOLFGANG PAULI
1925 (exclusion principle)

WERNER HEISENBERG
1925 (matrix mechanics)
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1926 (Schrödinger wave equation)
1926 (equates matrix mechanics with wave mechanics)
1926 (visits Bohr in Copenhagen to attack the idea of quantum jumps—and gets the flu)
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1926 (probability interpretation of wave function)
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1927 (complementarity)
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1927 (uncertainty principle)
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1928 (anti-matter)
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1932 (discovered)
POSITRON
1932 (discovered)
JOHN VON NEUMANN
1932 (quantum logic)
ALBERT EINSTEIN, BORIS PODOLSKY, NATHAN ROSEN
1935 (EPR paper)
HIDEKI YUKAWA
1935 (predicts meson)
MESON
1947 (discovered)
RICHARD FEYNMAN
1949 (Feynman diagrams)
SIXTEEN NEW PARTICLES
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1959 (rotation explanation)
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1962 (discovered)
QUARKS
1964 (hypothesized)
J. S. BELL
1964 (Bell's theorem)
DAVID BOHM
1970 (implicate order)
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1972 (Freedman-Clauser experiment)
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1975 (superluminal information transfer theory)
ALAIN ASPECT
1978 (Aspect experiment—in progress)

FOREWORD

WHEN GARY ZUKAV announced his plans for this book, creating the outline with A1 Huang and me watching at a dinner table at Esalen, 1976, I did not realize the magnitude of the job he took on with such joy. Watching the book grow has been instructive and rewarding, because Zukav has insisted on going through the whole evolution of the quantum relativistic physics of today, treating it as it is, an unfolding story. As a result this book is not only readable, but it also puts the reader in touch with all the various ways that physicists have worked out for talking about what is so hard to talk about. In short, Gary Zukav has written a very good book for laymen.

Zukav’s attitude to physics is rather close to mine, so I must be a layman too, and it is more stimulating to talk physics with him than with most professionals. He knows that physics is—among other things—an attempt to harmonize with a much greater entity than ourselves, requiring us to seek, formulate and eradicate first one and then another of our most cherished prejudices and oldest habits of thought, in a never-ending quest for the unattainable.

Zukav has graciously offered me this place to add my own emphases to his narrative. Since it has been three years since we met, I must sift my memory for a while.

Migrating whales come to mind first. I remember us standing on the Esalen cliffs and watching them cavort as they headed south. Next comes to mind beautiful Monarch butterflies, dotting the fields from the first day, and covering one magic tree as thick as leaves in a grand finale.

Between the whales and the butterflies it was difficult for us to feel self-important and very easy for us to play.

The very difficulty of communicating with the physicists at Esalen helped me to realize how differently most physicists think about quantum mechanics than I do. Not that my way is new, it is one of two ways already pointed out in John Von Neumann's 1932 book. *The Mathematical Foundation of Quantum Mechanics*:

1. Quantum mechanics deals with propositions defined by processes of preparation and observation involving subject and object and obeying a new logic; not with objective properties of the object alone.
2. Quantum mechanics deals with objective properties of the object alone, obeying the old logic, but they jump in a random way when an observation is made.

Most working physicists seem to see one of these ways (the second) and not the other. Perhaps personality can determine the direction of science. I think there are "thing" minds and "people" minds. Good parents, psychologists and writers have to be "people" people, while mechanics, engineers and physicists tend to be "thing" people. Physics has become too scary for such physicists because it is already so thingless. New evolutions, as profound as those of Einstein and Heisenberg, are waiting for a new generation of more daring and integrated thinkers.

While most physicists take for granted the quantum tools of their daily work, there is a vanguard already testing roads to the next physics, and a rearguard still conscientiously holding the road back to the old. Bell's theorem is mainly important to the latter, and its prominence in the book does not mean it uncovers problems in present-day quantum physics. Rather Bell's theorem drives toward a view that most physicists already assume: that quantum mechanics is something new and different.

Here it helps to distinguish between a *complete* theory, predicting everything, what Newtonians look for (it does not seem that Newton was a strict Newtonian, since he wanted God to reset the world clock now and then) and a *maximal* theory, predicting as much as possible, what quantum physicists look for. In spite of their controversy, Einstein and Bohr both agreed, in their different ways, that quantum mechanics is incomplete, and even that it is not yet maximal. What they really debated was whether or not an incomplete theory can be maximal. Throughout their famous controversy Einstein argued, “Alas, our theory is too poor for experience”, and Bohr replied, “No, no! Experience is too rich for our theory”; just as some existential philosophers despair at the indeterminacy of life and the existence of choices, and others feel *élan vital*.

One of the features of quantum mechanics that leads to such controversy is its concern with the nonexistent, the potential. There is some of this in all language, or words could only be used once, but quantum mechanics is more involved with probabilities than classical mechanics. Some people feel this discredits quantum theory, makes it less than maximal theory. So it is important to mention in defense of quantum theory that in spite of indeterminacy, quantum mechanics can be entirely expressed in yes-or-no terms about individual experiments, just like classical mechanics, and that probabilities can be derived as a law of large numbers and need not be postulated. I prefer to state the difference between classical and quantum theories not as presented in textbooks, but thus: Once sufficient data is given, classical mechanics gives yes-or-no answers for all further questions while quantum mechanics simply leaves *unanswered* some questions in the theory, to be answered by experience. I wish here also to note the regrettable tendency, in myself also, to feel that quantum mechanics must thereby deny physical existence to those answers that are found in experience only, not in the theory, such as the momentum of a localized electron. So involved are we in our symbol systems.

After a week of talking, the conference was still working on the elements of quantum logic, and never did get far into the new quantum time concepts we wanted to try out, but it made it easier to move on to the next set of problems, which occupy me today. Quantum mechanics is characterized by its unanswered questions. Some logicians, Martin Davis for one, have suggested these may be related to the undecidable propositions dominating logic since Gödel. I used to know better. Nowadays I think they may be right, the common element being reflexivity and the impossibility for finite systems of total self-knowledge. The proper study of mankind is endless, it seems. I hope these ideas work out and Gary Zukav writes a book about them. He does it well.

DAVID FINKELSTEIN
New York
July 1978

INTRODUCTION

MY FIRST EXPOSURE to quantum physics occurred a few years ago when a friend invited me to an afternoon conference at the Lawrence Berkeley Laboratory in Berkeley, California. At that time, I had no connections with the scientific community, so I went to see what physicists were like. To my great surprise, I discovered that (1), I understood everything that they said, and (2), their discussion sounded very much like a theological discussion. I scarcely could believe what I had discovered. Physics was not the sterile, boring discipline that I had assumed it to be. It was a rich, profound venture which had become inseparable from philosophy. Incredibly, no one but physicists seemed to be aware of this remarkable development. As my interest in and knowledge of physics grew, I resolved to share this discovery with others. This book is a gift of my discovery. It is one of a series.

Generally speaking, people can be grouped into two categories of intellectual preference. The first group prefers explorations which require a precision of logical processes. These are the people who become interested in the natural sciences and mathematics. They do not become scientists because of their education, they choose a scientific education because it gratifies their scientific mental set. The second group prefers explorations which involve the intellect in a less logically rigorous manner. These are the people who become interested in the liberal arts. They do not have a liberal arts mentality because of their education, they choose a liberal arts education because it gratifies their liberal arts mental set.

Since both groups are intelligent, it is not difficult for members of one group to understand what members of the other group are studying. However, I have discovered a notable *communication* problem between the two groups. Many times my physicist friends have attempted to explain a concept to me and, in their exasperation, have tried one explanation after another, each one of which sounded (to me) abstract, difficult to grasp, and generally abstruse. When I could comprehend, at last, what they were trying to communicate, inevitably I was surprised to discover that the idea itself was actually quite simple. Conversely, I often have tried to explain a concept in terms which seemed (to me) laudably lucid, but which, to my exasperation, seemed hopelessly vague, ambiguous, and lacking in precision to my physicist friends. I hope that this book will be a useful *translation* which will help those people who do not have a scientific mental set (like me) to understand the extraordinary process which is occurring in theoretical physics. Like any translation, it is not as good as the original work and, of course, it is subject to the shortcomings of the translator. For better or worse, my first qualification as a translator is that, like you, I am not a physicist.

To compensate for my lack of education in physics (and for my liberal arts mentality) I asked, and received, the assistance of an extraordinary group of physicists. (They are listed in the acknowledgments). Five of them, in particular, read the entire manuscript. As each chapter was completed, I sent a copy of it to each physicist and asked him to correct any conceptual or factual errors which he found. (Several other physicists read selected chapters).

My original intention was to use these comments to correct the text. However, I soon discovered that my physicist friends had given more attention to the manuscript than I had dared to hope. Not only were their comments thoughtful and penetrating, but, taken together, they formed a significant volume of information by themselves. The more I studied them, the more strongly I felt that I should share these comments with you. Therefore, in addition to correcting the manuscript with them, I also included in the footnotes those comments which do not duplicate the corrected text. In particular, I footnoted those comments which would have slowed the flow of the text or made it technical, and those comments which disagreed with the text and also disagreed with the comments of the other physicists. By publishing dissenting opinions in the footnotes, I have been able to include numerous ideas which would have lengthened and complicated the book if they had been presented in the text. From the beginning of *The Dancing Wu Li Masters* to the end, no term is used which is not explained immediately before or after its first use. This rule is not followed in the footnotes. This gives the footnotes an unmitigated freedom of expression. However, it also means that the footnotes contain terms that are not explained before, during, or after their use. The text respects your status as newcomer to a vast and exciting realm. The footnotes do not.

However, if you read the footnotes as you read the book, you will have the rare opportunity to see what five of the finest physicists in the world have to say about it as they, in effect, read it along with you. Their footnotes punctuate, illustrate, annotate, and jab at everything in the text. Better than it can be described, these footnotes reveal the aggressive precision with which men of science seek to remove the flaws from the work of a fellow scientist, even if he is an untrained colleague, like me, and the work is nontechnical, like this book.

The “new physics”, as it is used in this book, means quantum mechanics, which began with Max Planck’s theory of quanta in 1900, and relativity, which began with Albert Einstein’s special theory of relativity in 1905. The old physics is the physics of Isaac Newton, which he discovered about three hundred years ago. “Classical physics” means any physics that attempts to explain reality in such a manner that for every element of physical reality there is a corresponding element in the theory. Therefore, “classical physics” includes the physics of Isaac Newton and relativity, both of which are structured in this one-to-one manner. It does not, however, include quantum mechanics, which, as we shall see, is one of the things that makes quantum mechanics unique.

Be gentle with yourself as you read. This book contains many rich and multifaceted stories, all of which are heady (pun?) stuff. You cannot learn them all at once any more than you can learn the stories told in *War and Peace, Crime and Punishment,* and *Les Miserables* all at once. I suggest that you read this book for your pleasure, and not to learn what is in it. There is a complete index at the back of the book and a good table of contents in the front. Between the two of them, you can return to any subject that catches your interest. Moreover, by enjoying yourself, you probably will remember more than if you had set about to learn it all.

One last note; this is not a book about physics and eastern philosophies. Although the poetic framework of *Wu Li* is conducive to such comparisons, this book is about quantum physics and relativity. In the future I hope to write another book specifically about physics and Buddhism. In view of the eastern flavor of *Wu Li,* however, I have included in this book those similarities between eastern philosophies and physics that seemed to me so obvious and significant that I felt that I would be doing you a disservice if I did not mention them in passing.

Happy reading.

GARY ZUKAV
San Francisco
July 1978

Most of the fundamental ideas of science are essentially simple, and may, as a rule, be expressed in a language comprehensible to everyone.

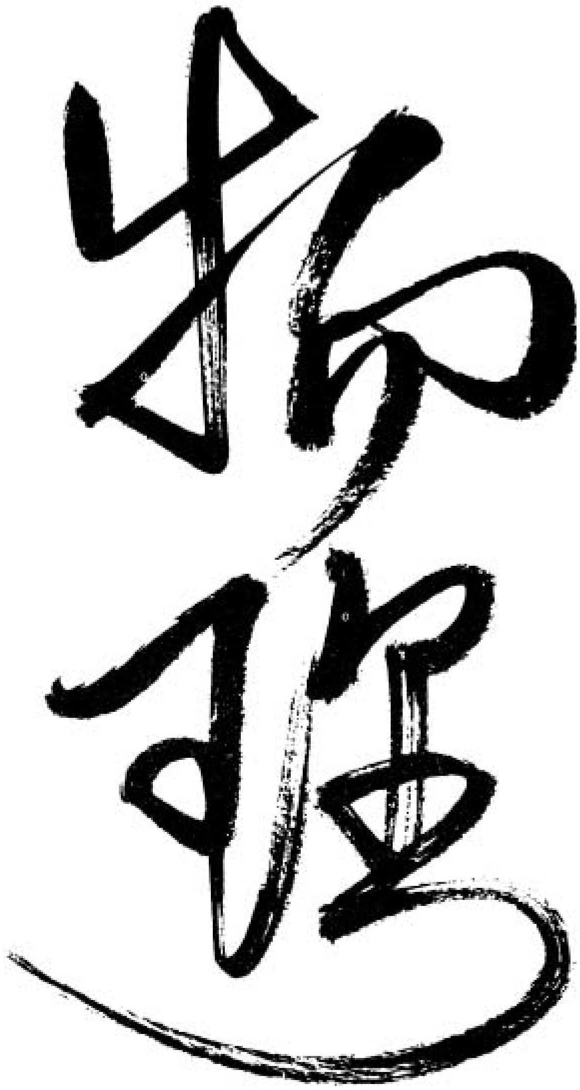
—*ALBERT EINSTEIN*[1]

Even for the physicist the description in plain language will be a criterion of the degree of understanding that has been reached.

—*WERNER HEISENBERG*[2]

If you cannot—in the long run—tell everyone what you have been doing, your doing has been worthless.

—*ERWIN SCHRÖDINGER*[3]



Part One

Wu Li?

CHAPTER **1**

BIG WEEK AT BIG SUR

THE UNIVERSAL REACTION to the word “physics” is a wall that stands between what physicists do and what most people think they do. There is usually a big difference between the two.

Physicists themselves are partly to blame for this sad situation. Their shop talk sounds like advanced Greek, unless you are Greek or a physicist. When they are not talking to other physicists, physicists speak English. Ask them what they do, however, and they sound like the natives of Corfu again.

On the other hand, part of the blame is ours. Generally speaking, we have given up trying to understand what physicists (and biologists, etc.) really do. In this we do ourselves a disservice. These people are engaged in extremely interesting adventures that are not that difficult to understand. True, *how* they do what they do sometimes entails a technical explanation which, if you are not an expert, can produce an involuntary deep sleep. *What* physicists do, however, is actually quite simple. They wonder what the universe is really made of, how it works, what we are doing in it, and where it is going, if it is going anyplace at all. In short, they do the same things that we do on starry nights when we look up at the vastness of the universe and feel overwhelmed by it and a part of it at the same time. That is what physicists really do.

Unfortunately, when most people think of “physics”, they think of chalkboards covered with undecipherable symbols of an unknown mathematics. The fact is that physics is not mathematics. Physics, in essence, is simple wonder at the way things are and a divine (some call it compulsive) interest in how that is so. Mathematics is the *tool* of physics. Stripped of mathematics, physics becomes pure enchantment.

I had spoken often to Jack Sarfatti, who is the physicist director of the Physics/Consciousness Research Group, about the possibility of writing a book, unencumbered with technicalities and mathematics, to explain the exciting insights that motivate current physics. So when he invited me to a conference on physics that he and Michael Murphy were arranging at the Esalen Institute, I accepted with a purpose.

The Esalen Institute (it is named for an Indian tribe) is in Northern California. The northern California coast is an awesome combination of power and beauty, but nowhere so much as along the Pacific Coast Highway between the towns of Big Sur and San Luis Obispo. The Esalen facilities are located about a half hour south of Big Sur between the highway and the coastal mountains on the one side and rugged cliffs overlooking the Pacific Ocean on the other. A dancing stream divides the northern third of the grounds from the remainder. On that side is a big house (called the Big House) where guests stay and groups meet, along with a small home where Dick Price (cofounder of Esalen with Murphy) stays with his family. On the other side of the stream is a lodge where meals are served and meetings are held, accommodations for guests and staff, and hot sulfur baths.

Dinner at Esalen is a multi-dimensional experience. The elements are candlelight, organic food, and a contagious naturalness that is the essence of the Esalen experience. Sarfatti and I joined two men who already were eating. One was David Finkelstein, a physicist from Yeshiva University (in New York) who was attending the conference on physics. The other was A1 Chung-liang Huang, a T'ai Chi Master who was leading a workshop at Esalen. We could not have chosen better companions.

The conversation soon turned to physics.

"When I studied physics in Taiwan," said Huang, "we called it Wu Li (pronounced 'Woo Lee'). It means 'Patterns of Organic Energy'".

Everyone at the table was taken at once by this image. Mental lights flashed on, one by one, as the idea penetrated. "Wu Li" was more than poetic. It was the best definition of physics that the conference would produce. It caught that certain something, that living quality that we were seeking to express in a book, that thing without which physics becomes sterile.

"Let's write a book about Wu Li!" I heard myself exclaim. Immediately, ideas and energy began to flow, and in one stroke all of the prior planning that I had done went out the window. From that pooling of energy came the image of the Dancing Wu Li Masters. My remaining days at Esalen and those that followed were devoted to finding out what Wu Li Masters are, and why they dance. All of us sensed with excitement and certitude that we had discovered the channel through which the very things that we wanted to say about physics would flow.

The Chinese language does not use an alphabet like western languages. Each word in Chinese is depicted by a character which is a line drawing. (Sometimes two or more ideograms are combined to form different meanings). This is why it is difficult to translate Chinese into English. Good translations require a translator who is both a poet and a linguist.

For example, "Wu" can mean either "matter" or "energy". "Li" is a richly poetic word. It means "universal order" or “universal law”. It also means “organic patterns”. The grain in a panel of wood is Li. The organic pattern on the surface of a leaf is also Li, and so is the texture of a rose petal. In short, Wu Li, the Chinese word for physics, means “patterns of organic energy” (“matter/energy” [Wu] + “universal order/organic patterns” [Li]). This is remarkable since it reflects a world view which the founders of western science (Galileo and Newton) simply did not comprehend, but toward which virtually every physical theory of import in the twentieth century is pointing! The question is not, “Do they know something that we don’t?” The question is, “How do they know it?”

English words can be pronounced almost any way without changing their meanings. I was five years a college graduate before I learned to pronounce “consummate” as an adjective (con-SUM-mate). (It means “carried to the utmost extent or degree; perfect”). I live in anguish when I think of the times that I have spoken of *con*summate linguists, *con*summate scholars, etc. Someone always seemed to be holding back a smile, almost. I learned later that these were the people who read dictionaries. Nonetheless, my bad pronunciation never prevented me from being understood. That is because inflections do not change the denotation of an English word. “No” spoken with a rising inflection (“No?”), with a downward inflection (“No!”), and with no inflection (“No . . .”) all mean (according to the dictionary) “a denial, a refusal, negative”.

This is not so in Chinese. Most Chinese syllables can be pronounced several different ways. Each different pronunciation is a different word which is written differently and which has a meaning of its own. Therefore, the same syllable, pronounced with different inflections, which unaccustomed western listeners scarcely can distinguish, constitutes distinctly separate words, each with its own ideogram and meaning, to a Chinese listener. In