FOUR REFLECTIONS

PREFACE

Physics is in crisis. On the one hand, dedicated research has led to two great theories, which explain most of the physics of the known Universe. The theory of relativity describes the physics on large scales, quantum mechanics on small scales. On the other hand, the two theories are completely different. Why would our Universe be described by two completely different theories? The question gnaws at the very soul of all physicists. Moreover, the two theories do not describe all of the physics. So, future research aims at filling in the holes. The biggest quest for physicists today is finding a single consistent theory that includes the theory of relativity and quantum mechanics.

Four reflections refer to four books. The books provide a survey of the search for a single theory that would unite the theory of relativity with quantum mechanics. The first step uninitiated readers take is to read a book written by a professional physicist. Many professional physicists write publically accessible books and essays explaining their views on the topic. But, modern physics can seem like a capricious subject, where the practitioners dabble in their own special language that reads like gobbledygook to the layman. I have tried to boil down the subtle and sophisticated ideas into plain language.

The first book is a summary of what is known about the Universe, discusses what is still unknown, the prospects for the future and the difficulties in uncovering a unified theory and whether such a theory is even possible or desirable. It has five chapters. Chapter 1 reviews unification in physics. Chapter 2 discusses Einstein’s attempt at unification and the development of quantum mechanics. Chapter 3 discusses the role of quantum field theory, the standard model, examines symmetry in modern physics, surveys the shortcomings of the standard model and describes some of the theoretical attempts to go beyond it. Chapter 4 examines the practical challenges of uniting quantum mechanics with general relativity. It begins by examining the difficulties in reconciling the smooth fabric of space-time with the discrete energies of the quantum theory and then moves to a discussion of the lack of complete determinism in quantum processes vs. determinism in relativity. Next, the holistic nature of quantum possesses is covered, where a discovery is made of the impossibility of describing the electron as either wave-like or particle-like until it interacts with its environment vs. relativity, where complete knowledge of the status of a system is required. Moving on, a discussion of the measurement problem in quantum mechanics is given. The chapter concludes with the EPR argument and Bell’s Theorem with its logical ramifications. Chapter 5 deals with the philosophy of unification. Two issues are of particular interest from a physics standpoint: is the mind independent of the existence of the body? This is often referred to as the ‘mind/body’ problem. And does an external world exist independently of our perception of it? The chapter examines what some of the greatest thinkers of the past had to say on these questions.

A deeper understanding of physics requires grasping sophisticated mathematical concepts. Virtually all of physics is written in the language of mathematics.
Mathematics seems to possess some mysterious quality useful in describing physical processes. No one really knows why it is so useful, but virtually everyone agrees that it is. So for those daring souls that can spend the time and energy, the second book, entitled “Logic and Mathematics”, introduces readers to the mathematical concepts necessary for grasping current theoretical thinking in physics.

There is no simple method for teaching math. Confusion necessarily arises because names in mathematics are temporary and can refer to a myriad of mathematical objects. Mathematicians often employ inconsistent or nonhomogeneous notational methods. Math concepts are built upon more fundamental concepts, and the learner can become lost if foundational concepts are skipped or not understood first hand.

I have attempted to address each of these learning issues in the book. To facilitate communication, when naming, I’ve enclosed the name in single quotes (‘xxxxx’). When using the name, I have eliminated the single quotation marks. For example, given an ‘a’ and a ‘b’, then $a = b$ is typically the way sentences read in the book. A disclaimer: I have not succeeded in being entirely consistent with this approach. I can only hope that there is not too much confusion and that the context will make the usage clear.

I attempted to use the same notational method throughout the book, but I failed. There does not seem to be a way around inconsistent notational usage. As much as possible, I’ve written mathematical sentences in the form: $\forall A \exists B (A, B \in R \rightarrow B > A)$. Whenever possible, I denote vectors with angle brackets i.e. $|a\rangle$. For functions, I use the notation $A \rightarrow B$ or $f(x)$, which is the commonly employed notational approach.

I have divided up the sections of the book so that only one concept is covered per section. Moreover, I have literally begun at the beginning. I start from the logical foundations of mathematics and move ever so slowly to more advanced topics. Finally, at the risk of being redundant, for the most part, I have not numbered equations. When necessary, I repeat equations. I hope this is something the learner will appreciate.

Anyone tempted to write on mathematical subjects quickly gains an appreciation for the words of C. N. Yang, who lamented that there were only two kinds of modern mathematics books: “those you could not read past the first page and those you could not read past the first sentence.” But to gain a deeper understanding of physics, I can offer no other advice but to simply slog through it. The book is difficult. The saving grace is that none of the topics must be understood in any great depth. You’ll gain far more from it than you might expect.

The first chapter of Book II examines the origins of logic and mathematics and their relationship to physics. Chapter 2 discusses logic as the anatomy of an argument and then proceeds to examine both propositional logic and the predicate calculus followed by chapter 3 which discusses sets and relations. Chapter 4 involves a discussion of number systems. All the usual number systems, the natural, the integers, the rational, real and complex numbers are covered in some detail along with their topological aspects and propensity for measurability. Chapter 5 discusses algebra. An ‘algebra’ is
defined as a set of elements along with at least one binary operation. When any two elements of the set are operated on, the result is another element of the set, followed by an examination of the abstract theory of groups in chapter 6. Chapter 7 continues with a discussion of additional abstract algebraic structures: rings, integral domains, division rings and fields. Chapter 8 moves on to the slightly less abstract topics of linear algebra and vector spaces then progresses in Chapter 9 to a discussion of inner product spaces. Then there is a natural progression into higher forms: bilinear and multi-linear forms with an introduction to tensors and tensor notation. Chapters 10, 12, 13 and 14 are the analysis chapters, real, vector, tensor and complex in that order. The usual topics are covered: limits, continuity, the divergence and convergence of sequences and series, differentiation and integration. Squeezed in between is a chapter on the theory of representations, Lie groups and Lie algebras – a harshly difficult subject, but indispensable because of its extensive application in quantum mechanics. This is followed by a discussion of differential equations and Fourier analysis in chapter 16. Chapter 17 covers the calculus of variations. The subject is important because the Lagrangian formulation, which depends on the calculus of variations, provides the equations of motion in the generalization of Newtonian mechanics and there are Lagrangian formulations sprinkled throughout quantum field theory. Finally, the last chapter covers the theory of surfaces. The treatment of the subject is quiet extensive concluding with a derivation of Einstein’s equations for the gravitations field.

The third book uses the techniques learned in Book II to describe modern physics. Book III continues the learning objectives associated with Book II. Names are put in single quotes, notational usage is standardized as far as possible and themes are covered one section at a time. The discussion begins at the beginning, starting with the rudimentary notions of ‘space’, ‘time’ and ‘matter’, then moving on to explain the nature of dimensions, dimensional analysis and the fundamental concepts of ‘motion’ and ‘rest’. Chapter 2 discusses the physics of the simplest system, the motion of a single ridged body. Various physical concepts associated with a single ridged body are discussed. Chapter 3 covers the physics of ‘gaseous’ or ‘fluidic’ substances whose center of mass cannot be readily located. The ideas of ‘mass’ and ‘force’ associated with a ridged body are replaced by the concepts of ‘density’ and ‘pressure’ associated with less ridged substances. Chapter 4 discusses ‘heat’, which is the physics of the internal changes of a substance, rather than how a substance responds when acted upon by external forces or pressures and replaces terms like ‘force’, ‘kinetic energy’ and ‘acceleration’ with ‘temperature’, ‘internal energy’ and ‘entropy’. Chapter 5 reports on electricity and magnetism, while chapter 6 discusses light and optics. Both geometrical and physical optics are covered. Chapter 7 shows how Newton and Maxwell used the basic notions of ‘space’, ‘time’ and ‘matter’ to develop a theory of non-relativistic physics, where physical objects generally move much slower than light speed. Chapter 8 shows how non-relativistic physics can be generalized, making it easier to solve certain kinds of problems. Both the Hamiltonian and Lagrangian formalisms are discussed. Chapter 9 discusses the special theory of relativity, where, if things move close to the speed of light, deviations from non-relativistic physics are realized. Moreover, the theory of special relativity gives a theoretical justification for the physics of electromagnetism. Chapter 10 covers the general theory of relativity, which provides
a theory of gravity and is responsible for the physics at large scales, while Chapter 11 covers non-relativistic quantum mechanics, which is responsible for the physics at small scales. The book then moves to quantum field theory, which, in chapter 12, provides a quantum theory consistent with the special theory of relativity. Chapter 13 discusses the standard model of particle physics. Although the standard model is not entirely theoretical, it provides an explanation for three of the four known fundamental forces of Nature, electrodynamics and the strong and weak nuclear forces. It does not include gravity, the fourth of the fundamental forces. Finally, the last chapter provides an introduction to string theory.

In the process of learning about physics and mathematics a surprising thing happened. I began formulating my own ideas about the direction research in physics should take in the future. Those ideas are documented in the fourth book. My approach probably won't be found in the ivory towers of advanced research institutions. To most physicists, the answers to “physics questions” depend on understanding the nature of the external world gained through hypothesizing a physical concept, like strings, loops, twistors or some other creative idea, formulating a theory, then seeing whether the theory passes the test of experimental scrutiny. I take a different approach. Since the theory of relativity and quantum mechanics are extraordinarily successful in their respective domain of applicability, there must be some level of truth to them. But the two theories are logically inconsistent. So my hypothesis is that the mathematics used to describe physical systems is the wrong mathematics. My approach attempts to discover a logical approach that supports both theories. That approach is documented in Book IV.

In conducting the research, I tried to follow my nose as best I could. The approach I take is a radical departure from accepted methods. The results are surprising, sometimes shocking and certainly controversial. On the other hand, I can't find anything wrong with the equations. They seem correct.

The method I use results in something called ‘number interference’. Number interference permits doing physics using complex numbers. As the theory progresses, it predicts the existence of dark-light, light that cannot be detected using physical instruments. This comes about as a direct result of number interference. The theory employs only one constant, the universal gravitational constant ‘\( G \)’. Planck’s constant, the speed of light and electric charge are all derived from equations that contain \( G \). Hence, Planck’s constant, the speed of light and electric charge come about as limits of functions. They are not constants in this theory, results sure to be controversial. The logic of the theory applies to physics on both the large and small scales. The theory predicts that modern physics fails to account for a fundamental force. The force is small, proportional to \( G \). The examination goes on to show how the theory of relativity can be derived from a more fundamental theory. The theory predicts that time is synonymous with spatial expansion. Without time, the Universe would not expand. When the theory is applied to small scale physics, it predicts that the fundamental wave function associated with quantum mechanics is a constant, a shocking result.