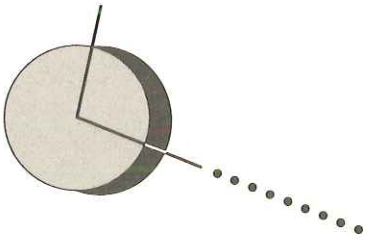
ART & PHYSICS

PARALLEL VISIONS IN SPACE, TIME, AND LIGHT



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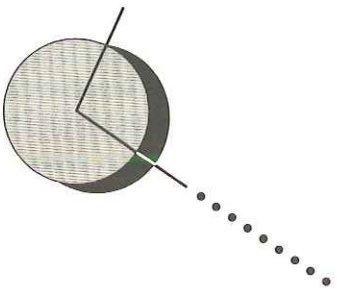
The purpose of art is to lay bare the questions which have been hidden by the answers.

James Baldwin

Physics is a form of insight and as such it's a form of art.

David Bohm



CHAPTER 1

ILLUSION / REALITY

Art and physics are a strange coupling. Of the many human disciplines, could there be two that seem more divergent? The artist employs image and metaphor; the physicist uses number and equation. Art encompasses an imaginative realm of aesthetic qualities; physics exists in a world of crisply circumscribed mathematical relationships between quantifiable properties. Traditionally, art has created illusions meant to elicit emotion; physics has been an exact science that made sense. Even the stereotypical proponents of each endeavor are polar opposites. In college, the hip avant-garde art students generally do not mingle with their more conventional counterparts in the physics department. By casual juxtaposition, these two fields seem to have little in common: There are few if any references to art in any standard textbook of physics; art historians rarely interpret an artist's work in light of the conceptual framework of physics.

Yet despite what appear to be irreconcilable differences, there is one

fundamental feature that solidly connects these disciplines. Revolutionary art and visionary physics are both investigations into the nature of reality. Roy Lichtenstein, the pop artist of the 1960s, declared, "Organized perception is what art is all about."[1] Sir Isaac Newton might have said as much for physics; he, too, was concerned with organizing perceptions. While their methods differ radically, artists and physicists share the desire to investigate the ways the interlocking pieces of reality fit together. This is the common ground upon which they meet.

Paul Gauguin once said, "There are only two kinds of artists—revolutionaries and plagiarists."[2] The art discussed in this book will be that created primarily by revolutionaries, because theirs is the work that heralds a major change in a civilization's worldview. And in parallel fashion, although the development of physics has always depended upon the incremental contributions of many original and dedicated workers, on a few occasions in history one physicist has had an insight of such import that it led to a revision in his whole society's concept of reality. The poet Rainer Maria Rilke referred to this sort of transcendent insight as a "conflagration of clarity,"[3] allowing certain artists and physicists to see what none before them had ever imagined, and it is they—the revolutionary artist and the visionary physicist—who will be paired in the coming pages.

Émile Zola's definition of art, "Nature as seen through a temperament,"[4] invokes physics, which is likewise involved with nature. The Greek word *physis* means "nature." Beginning with this common ground as a point of departure, I will describe the connections and differences between these two seemingly disparate ways our perceptions of nature are organized.

The physicist, like any scientist, sets out to break "nature" down into its component parts to analyze the relationship of those parts. This process is principally one of reduction. The artist, on the other hand, often juxtaposes different features of reality and synthesizes them, so that upon completion, the whole work is greater than the sum of its parts. There is considerable crossover in the techniques used by both. The novelist Vladimir Nabokov wrote, "There is no science without fancy and no art without facts."[5]

Insofar as science is the subject, I shall concentrate in this book on physics as it has developed during the last several hundred years. Nevertheless, the reader should keep in mind that present-day physicists wear a mantle that has been passed down through the ages. Physicists are the modern representatives of a distinguished tradition that winds its way back through the first scientists, Christian theologians, natural philosophers, pagan priests, and Paleolithic shamans, the exceptional of whom have

contributed pieces to fill in the infinite jigsaw puzzle of nature. The first physicist was probably the one who discovered how to make a fire.

I single out physics in particular because in this century all the other "hard" sciences have learned that they are anchored to this rock. Chemistry had its beginning in the attempt to identify and separate the elements, and it came to be fused to the laws that govern atomic events. Astronomy began as a fascination with heavenly movements and advanced to an inquiry into the arrangement of the solar system. Today, in studying the galaxies, astrophysicists address the laws that govern forces and matter. From its origins in Aristotelian taxonomy, biology has evolved to the study of the physical interaction of atoms in molecular biology. Physics, formerly one branch among many, has in this century become enthroned as the King of the Sciences.

In the case of the visual arts, in addition to illuminating, imitating, and interpreting reality, a few artists create a language of symbols for things for which there are yet to be words. Just as Sigmund Freud in his *Civilization and Its Discontents* compared the progress of a civilization's entire people to the development of a single individual, I propose that the radical innovations of art embody the preverbal stages of new concepts that will eventually change a civilization. Whether for an infant or a society on the verge of change, a new way to think about reality begins with the assimilation of unfamiliar images. This collation leads to abstract ideas that only later give rise to a descriptive language.

For example, observe any infant as it masters its environment. Long before speech occurs, a baby develops an association between the image of a bottle and a feeling of satisfaction. Gradually the baby accumulates a variety of images of bottles. This is an astounding feat considering that a bottle viewed from different angles changes shape dramatically: from a cylinder to an ellipse to a circle. Synthesizing these images, the child's emerging conceptual faculties invent an abstract image that encompasses the idea of an entire group of objects she or he will henceforth recognize as bottles. This step in abstraction allows the infant to understand the idea of "bottleness." Still without language, the baby can now signal desire by pointing.

Then at a certain moment, in that part of the brain called Broca's area, the connections between synapses attain a critical number, tripping the switch that suddenly lights up the magical power of language. This word factory, noisily chugging away, generates sounds that will replace and even eclipse the earlier images. As soon as the baby connects the bottle's image with the word "bottle," this word begins to blot out the image, so much

so that as adults we are rarely aware that when we engage in abstract thinking, we are not thinking in images. Concepts such as "justice," "freedom," or "economics" can be turned over in the mind without ever resorting to mental pictures. While there is never final resolution between word and image, we are a species dependent on the abstractions of language, and in the main, the word eventually supplants the image.

When we reflect, ruminate, reminisce, muse, and imagine, generally we revert to the visual mode. But in order to perform the brain's highest function, abstract thinking, we abandon the use of images and are able to carry on without resorting to them. It is with great precision that we call this type of thinking "abstract." This is the majesty and the tyranny of language. To affix a name to something is the beginning of control over it. After God created Adam, the very first task He instructed Adam to perform was the naming of all the animals. God informed Adam that by accomplishing this feat he would gain dominion over all the beasts and fowl. Note that God didn't teach Adam anything as practical as how to make a fire or fashion a spear. Instead, He taught him to name. Words, more than strength or speed, became the weapons that humans have used to subdue nature.

Because the erosion of images by words occurs at such an early age, we forget that in order to learn something radically new, we need first to imagine it. "Imagine" literally means to "make an image." Witness the expressions we use when struggling with a new idea: "I can't picture it," "Let me make a mental model," and "I am trying to envision it." If, as I propose, this function of imagination, so crucial to the development of an infant, is also present in the civilization at large, who then creates the new images that precede abstract ideas and descriptive language? It is the artist. In the following pages, I shall demonstrate how revolutionary art can be understood as the preverbal stage of a civilization first contending with a major change in its perception of the world. In order to elaborate this thesis, I shall examine art, not only as an aesthetic that can be pleasing to the eye, but as a Distant Early Warning system of the collective thinking of a society. Visionary art alerts the other members that a conceptual shift is about to occur in the thought system used to perceive the world. John Russell, the art critic, observed: "There is in art a clairvoyance for which we have not yet found a name, and still less an explanation."[6]

Despite each discipline's similar charge, there is in the artist's vision a peculiar prescience that precedes the physicist's equations. Artists have mysteriously incorporated into their works features of a physical description of the world that science later discovers.

The artist, with little or no awareness of what is going on in the field of physics, manages to conjure up images and metaphors that are strikingly appropriate when superimposed upon the conceptual framework of the physicist's later revisions of our ideas about physical reality. Repeatedly throughout history, the artist introduces symbols and icons that in retrospect prove to have been an avant-garde for the thought patterns of a scientific age not yet born. Few art historians have discussed this enigmatic function of art in depth. Robert Hughes, another art critic, explains why it is so often overlooked:

> The essence of the *avant-garde* myth is that the artist is a precursor; the truly significant work of art is the one that prepares the future. The transitional focus of culture, on the other hand, tends to treat the present (the living artist) as the culmination of the past.[7]

All too often, when reading about the work of exceptional artists, we are told about the past styles that influenced their work. Their pedigrees are traced backward to former artists, and rarely is their work explained in terms of how they anticipated the future.

A large segment of present society, unable to comprehend art's vision, dismisses the importance of art. Marshall McLuhan, in his seminal work, *Understanding Media*, asks:

> If men were able to be convinced that art is precise advance knowledge of how to cope with the psychic and social consequences of the next technology, would they all become artists? Or would they begin a careful translation of new art forms into social navigation charts? I am curious to know what would happen if art were suddenly seen for what it is, namely, exact information of how to rearrange one's psyche in order to anticipate the next blow from our own extended faculties . . .[8]

Revolutionary art in all times has served this function of preparing the future.

Both art and physics are unique forms of language. Each has a specialized lexicon of symbols that is used in a distinctive syntax. Their very different and specific contexts obscure their connection to everyday language as well as to each other. Nevertheless, it is noteworthy just how often the terms of one can be applied to the concepts of the other. "Volume," "space,"

"mass," "force," "light," "color," "tension," "relationship," and "density" are descriptive words that are heard repeatedly if you trail along with a museum docent. They also appear on the blackboards of freshman college physics lectures. The proponents of these two diverse endeavors wax passionate about elegance, symmetry, beauty, and aesthetics. The equal sign in the formulas of the physicist is a basic metaphor used by many artists. While physicists demonstrate that A equals B or that X is the same as Y, artists often choose signs, symbols, and allegories to equate a painterly image with a feature of experience. Both of these techniques reveal previously hidden relationships.

Niels Bohr, a founder of quantum physics, was intrigued by the relationship between physics and language and observed:

> It is one of the basic presuppositions of science that we speak of measurements in a language that has basically the same structure as the one in which we speak of everyday experience. We have learned that this language is an inadequate means of communication and orientation, but it is nevertheless the presupposition of all science. . . . For if we want to say anything at all about nature—and what else does science try to do?—we must somehow pass from mathematical to everyday language.[9]

Vincent van Gogh addressed the same concern when in frustration he wrote to his brother Theo about his inability to articulate his feelings in words, "Really, we can speak only through our paintings."[10]

Revolutionary art and visionary physics attempt to speak about matters that do not yet have words. That is why their languages are so poorly understood by people outside their fields. Because they both speak of what is certainly to come, however, it is incumbent upon us to learn to understand them.

In the parable of the Tower of Babel, early humankind attempted in a grand collaborative effort to build a tower to reach the heavens. Yahweh, looking down from the clouds, became so incensed that ordinary mortals should think they were capable of such a godlike feat that He summarily garbled the speech of every worker and so brought the construction to a halt.

History has been the record of our agonizingly slow resumption of work on this mythic public monument to knowledge. Gradually, the parochial suspicions that had been abetted by large numbers of local dialects have given way to the more universal outlook of modern humankind. Currently

this work in progress is the creation of a global commonwealth. The worldwide community of artists and scientists is and has been in the forefront of this coalescence, offering perceptions of reality that erase linguistic and national boundaries. Reconciliation of the apparent differences between these two unique human languages, art and physics, is the next important step in developing our unifying Tower.

To better understand the connection between art and physics, we must first ask, "How do we know the world?" Plato, in his famous cave analogy, proposed that we are all like prisoners chained to a low wall in a cave, unable to turn around and witness firsthand the activities of real people conducting their lives before a large fire on the ledge behind. Instead, because of the constraints imposed by our manacles, we can see only our own shadows mingled with the ghostly shadows these free people cast onto the opposite wall that we as prisoners must face. Our perceptual apparatus condemns us to believe these flickering images of things and people are the "real" things, and it is only from this secondhand information that we can deduce the nature of reality.

Two thousand years after Plato, René Descartes reiterated this distinction between the inner eye of imagination and the external world of things. He split the purely mental "in here" of our consciousness *(res cogitans)* from the objective world of "out there" *(res extensa)* and declared these two realms inviolably separate. In the eighteenth century, Immanuel Kant reinforced the views of Plato and Descartes in his *Critique of Pure Reason*. Kant sadly declared that we can know the nature of things only by what filters through our senses and is processed by our mind, but we can never directly experience the *Ding an sich*: the *thing in itself*. By thus banishing us to the impenetrable tower of our thought, Kant asserted that we must all peer out at reality through the chinks of our senses. Our exasperating inability to know the world directly is one of the central existential dilemmas he perceived in the human condition. In his monumental work entitled *The World as Will and Idea*, Arthur Schopenhauer summed up this philosophical point of view in his trenchant opening sentence, "The world is my idea."

The faculty we use to grasp the nature of the "out there" is our imagination. Somewhere within the matrix of our brain we construct a separate reality created by a disembodied, thinking consciousness. This inner reality is unconnected to external space and exists outside the stream of linear time. When reminiscing about a day at the beach, we knit together elements of that day that no longer "actually" exist. We can run the events forward and backward with ease, and amend with alternate possibilities what we

believe happened. It is the bane and the balm of individual perception that "objective" reality is seen through the filter of each person's temperament: In the classic Japanese tale *Rashomon*, each person is convinced of the truth of his or her own version. Consciousness, resembling nothing so much as long columns of ants at work, must laboriously transfer the outside world piece by piece through the tunnels of the senses, then reconstruct it indoors. This inner spectral vision amounts to a mental "opinion" unique to each individual of how the world works.

When a critical mass of people agrees on one viewpoint we call that agreement a "consensus." Group consensus within the context of society leads us to form political parties, religious sects, and economic systems. Each model is based upon an accepted belief system. When an entire civilization reaches a consensus about how the world works, the belief system is elevated to the supreme status of a "paradigm," whose premises appear to be so obviously certain no one has to prove them anymore. No longer even questioned, the assumptions upon which the paradigm rests become a priori postulates. Two plus two will always be four and all right angles are equal. For believers, these assumptions constitute bedrock "truths."

"Truth," as defined by Alfred North Whitehead, "is the conformation of Appearance to Reality."[11] What makes any set of bedrock truths slippery is that every age and every culture defines this confirmation in its own way. When the time comes to change a paradigm—to renounce one bedrock truth and adopt another—the artist and physicist are most likely to be in the forefront.

Some people might object to pairing art and physics, since the artist is concerned not only with external reality but with the inner realm of emotions, myths, dreams, and the spirit as well. While art is thought to be relatively subjective, physics, until this century, scrupulously avoided any mention of the inner thoughts that related to the outer world. Physics concerned itself instead with the objective arena of motion, things, and forces. This stark difference between art and physics blurs in light of the startling revelations put forth by the quantum physicists that emerged from the fusion of the contradictory aspects of light.

In 1905 Albert Einstein proposed that light could exist in the form of a *particle*, that is, a small piece of something called a photon. For over two hundred years light had been experimentally proven to be a *wave*. Einstein's proposal implied that light had two distinct and seemingly opposing natures: a *wave*like aspect and a *particle*like aspect. At the turn of the century, what was to be a surprising feature of quantum reality amounted to a Zen

koan. This mind-knot seemed insoluble because the rules of conventional logic could not be applied.

In a bold move Niels Bohr synthesized these antithetical aspects of light in his 1926 theory of complementarity. Stating it simply, Bohr said that light was not *either* a wave *or* a particle, but was *both* a wave *and* a particle. Knowledge of both these very different aspects was necessary for a complete description of light; either one without the other was inadequate.

As it turned out, light would reveal only one aspect of its nature at a time, resembling an odd carnival peep show. Whenever a scientist set up an experiment to measure the wavelike aspect of light, the subjective act of deciding which measuring device to use in some mysterious way affected the outcome, and light responded by acting as a wave. The same phenomenon occurred whenever a scientist set out to measure the particlelike aspect of light. Thus "subjectivity," the anathema of all science (and the creative wellspring of all art) had to be admitted into the carefully defended citadel of classical physics. Werner Heisenberg, Bohr's close associate, said in support of this bizarre notion, "The common division of the world into subject and object, inner world and outer world, body and soul, is no longer adequate. . . .[12] Natural science does not simply describe and explain nature; it is part of the interplay between nature and ourselves."[13] According to the new physics, observer and observed are somehow connected, and the inner domain of subjective thought turns out to be intimately conjoined to the external sphere of objective facts.

John Wheeler, one of Bohr's students, subsequently expanded Bohr's duality, proposing that Mind and Universe, like wave and particle, constitute another complementary pair. Wheeler's theory proposes a connection between the inner realm of consciousness (Mind) and its reciprocal, the external world of the senses (Universe). According to Wheeler, Mind and Universe are inextricably integrated. The Talmud expresses this subtle relationship in an apocryphal story of a dialogue between God and Abraham. God begins by chiding Abraham, "If it wasn't for Me, you wouldn't exist." After a moment of thoughtful reflection, Abraham respectfully replies, "Yes, Lord, and for that I am very appreciative and grateful. However, if it wasn't for me, You wouldn't be known." Somehow, in one of the great mysteries of the cosmos, human consciousness is able to ask questions of nature and the answers that come back are actually comprehensible. Perhaps, as Wheeler suggests, the two, Mind and Universe, are simply aspects of a binary system. Art and physics, then, may be seen as two pincers of a claw the Mind can use to grasp the nature of Wheeler's complementary image, the Universe.

At the same time that quantum physicists began to wrestle with Bohr's theory of complementarity, which is not classically scientific and seems to border on the spiritual, the Swiss psychologist Carl Jung promulgated his theory of synchronicity, the internal corollary in human experience of this external quantum idea. Like Bohr, Jung repudiated the conventional doctrine of causality. He proposed that all human events interweave on a plane to which we are not consciously privy, so that in addition to prosaic cause and effect, human events are joined in a higher dimension by meaning. The principles of synchronicity and complementarity, bridging as they do the very separate domains of the psyche and the physical world, apply as well to the connection between art and physics. The German language encapsulates this idea in the word *zeitgeist*, which unfortunately has no single-word equivalent in English, but means "the spirit of the times." When discoveries in unrelated fields begin to appear at the same time, as if they are connected, but the thread that connects them is clearly not causal, then commentators resort to proclaiming the presence of a *zeitgeist*.

Originally using the theory of complementarity to unite the opposite and paradoxical aspects of light, Bohr went on to extend his philosophical device to include other pairs of opposites. This book is about the complementarity of art and physics and the ways these two fields intimately entwine to form a lattice upon which we all can climb a little higher in order to construct our view of reality. Understanding this connection should enhance our appreciation for the vitality of art and deepen our sense of awe before the ideas of modern physics. Art and physics, like wave and particle, are an integrated duality: They are simply two different but complementary facets of a single description of the world. Integrating art and physics will kindle a more synthesized awareness which begins in wonder and ends with wisdom.

The connections between the art of one period and the physics of a later one become more apparent when examined retrospectively, looking all the way back to classical Greece. Sometimes the lag period is several hundred years; at other times it can be decades. In this century, an auspicious conjunction between art and physics occurred in its first decade with both fields exploding into many new directions.

Art generally anticipates scientific revisions of reality. Even after these revisions have been expressed in scholarly physics journals, artists continue to create images that are consonant with these insights. Yet a biographical search of the artists' letters, comments, and conversations reveals that they were *almost never aware* of how their works could be interpreted in the light of new scientific insights into the nature of reality. In these cases to

be discussed, artists have continued to work in splendid isolation, bringing forth symbols that have helped the rest of us grasp the meaning of the new concepts even they, the artists, may not have formulated intellectually.

The same principle holds true in reverse. Upon making his discovery, the physicist is usually unaware of the artist's anticipatory images. Rarely has a physicist, discussing a new breakthrough in his science, acknowledged an influential artist who preceded him. Despite many deep friendships throughout history between artists and scientists, revolutionaries in art and visionaries in physics seem peculiarly separate. Picasso and Einstein, who I shall demonstrate shared a common vision, never even met or evinced interest in each other's work.

Since the visual arts do not exist independently of music, drama, poetry, literature, philosophy, and architecture, I will weave these fibers into the fabric of this thesis where appropriate. However, the principal thread of this book is the visual arts of Western civilization against the backdrop of physics. This skein can be followed through ancient Mesopotamia, Egypt, Greece, and then on to Rome. The thread seems to have been broken during the disruption of the Dark Ages, but in that nocturnal period it still spun on virtually unobserved into Europe, reemerging in the Middle Ages until, like a phoenix rising, it reappeared resplendent in the Renaissance. The culture we call Western tradition then spread its net ever wider until it has encompassed all of Europe and the Americas.

In order to create a context in which to discuss the individual works of the artist and how they relate to the theories of the physicist, we need to start with ancient Greece, where many of the premises of our present-day value and thought systems originate. Not unlike the great founders of the major religions of the world, the early Greek thinkers began their inquiry by assuming that the variegated manifest universe arose from a cosmic unitary principle. Each of them attempted to trace all experience back to one primordial element. Around 580 B.C., Thales of Miletus, the first philosopher, declared that it was water. Heraclitus almost immediately disagreed, announcing that the original element was fire. Soon other voices cast their votes for air or earth. In one of the first great syntheses of science (and, I might add, one of the first known compromises), Empedocles proposed that perhaps there was not just one primordial element but rather four. If at the root of reality there were four different essences, then all of existence could be explained as some combination of the basic building blocks of water, fire, earth, and air. This idea "felt" right to the college of early philosophers perhaps because the number four universally evokes a sense of foundation. Whether it is the four points on a compass, the four

corners of a square, or the four legs to a table, there is in this cardinal number an expectation of fundamental completeness.

One hundred years after Empedocles, however, Aristotle was not quite satisfied with this scheme. He observed that all things here on earth are in varying states of flux and argued that something was missing. Influenced by Plato's concept of an eternal ideal, Aristotle posited that, in addition to the tetrad proposed by Empedocles, there must be a fifth essence, a *quintessence*, that is constant and immutable and somehow connects the other four. Since the celestial constellations seemed unchanging in their unwavering courses across the sky, he proposed that the quintessence was composed of the stuff of stars.

Although we have discarded the early Greeks' quaint notions in the latter half of the twentieth century, this ancient scheme retains an uncanny familiarity. In our present paradigm we still acknowledge four basic constructs of reality: space, time, energy, and matter. Space and time constitute the gridwork within which we conduct our lives, while inside their frame, energy, matter, and various combinations thereof create our world of appearance. These four elemental constructs form a mandala of totality. All perceptions created in the dream room of our minds are constructed from these four building blocks.

In looking to the light from the stars, Aristotle's speculation was close to the reality of twentieth-century physics. The quintessence, we have learned, is not the stars, but rather light itself. This, too, is fitting. Elusive and enigmatic, this fifth essence has engendered wonder and reverence throughout history. Whether it was the miracle of fire or the life-giving rays from the sun, light in and of itself has always been the most mysterious element. It has been accorded a prominent place in all religions of the world, and discoveries in modern physics revealed that it was the unique nature of light that held the key to unlocking the secrets of the other four. Both the fields of quantum mechanics and relativity arose out of two unresolved questions about the nature of light. Further, Einstein discovered that the speed of light was an invariant and immutable number. In some strange way light is the link connecting space, time, energy, and matter. The symbol for the speed of light in physics, c, plays a prominent role in the key equations connecting the other four.

In the coming chapters we shall principally explore the interrelationships of space, time, and light. The reason for coning down to these three elements is to narrow the focus for a more manageable discussion. A book about art by itself contains many currents and characters. Similarly, the history of physics shares this diversity. When trying to integrate one in

terms of the other the thesis is in danger of sinking into a morass of names, dates, and movements. Space, time, and light were the three constructs revised by Albert Einstein in his 1905 special theory of relativity. They will be the key characters in the synthesis ahead. However, quantum mechanical conceptions, mass-energy equivalence and field theories, the other equally important physics revolutions, will be touched upon whenever it is pertinent.