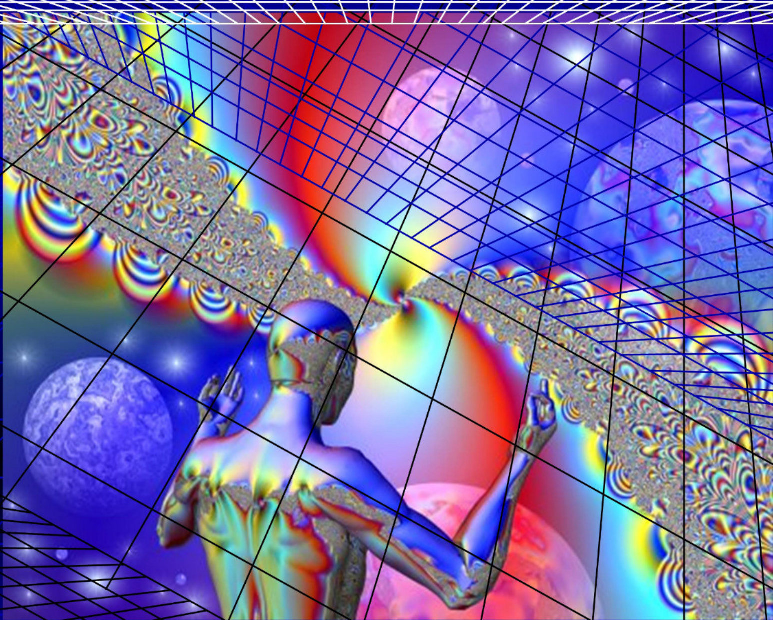
MIND AND QUANTUM PHYSICS



Eduardo Mendes Machado,Ph.D.

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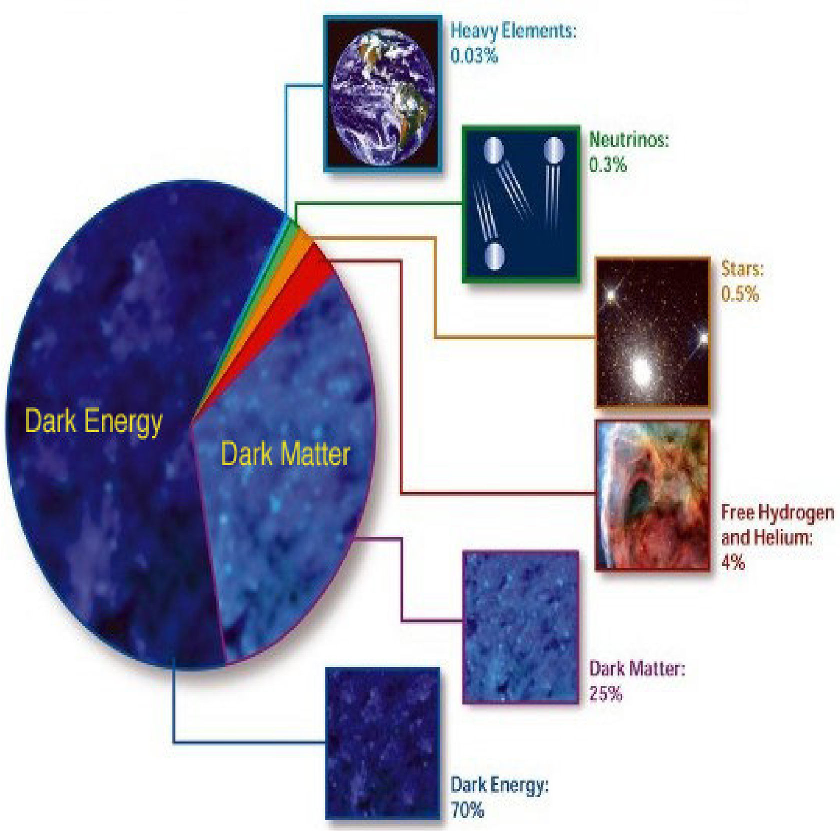
MIND AND QUANTUM PHYSICS

"One seldom recognizes the devil when he places his hand on your shoulder."
Albert Speer

Particle physics aims to answer the BIG questions about the Universe by studying space and matter at its smallest level
If a atom was the size of a large city(100 Km by 80 Km),each atomic nucleus is the size of a house with 300 square meters, each proton and neutron would be the size of a person, and each quark and electron would be smaller than a tiny freckle.
Where's all the rest of the mass ?????
It's incorporated in the binding energy associated with the gluons !
And what this energy? Is called strong energy , but is the responsible for the atoms agglutination structure, but for me is the most tactile God manifestation.
98% of atomic mass comes from gluons !!!!
Atoms are 99.999% empty space, Protons & Neutrons are 99.999% empty space.

The entire universe is almost all empty space,
only 0,03%is matter composed by atoms
where99,999% are empty space !
Forces are a huge part of our existence!



Our Conscious Mind Could Be An Electromagnetic Field

Are our thoughts made of the distributed kind of electromagnetic field that permeates space and carries the broadcast signal to the TV or radio. Professor Johnjoe McFadden from the School of Biomedical and Life Sciences at the University of Surrey in the UK believes our conscious mind could be an electromagnetic field.

“The theory solves many previously intractable problems of consciousness and could have profound implications for our concepts of mind, free will, spirituality, the design of artificial intelligence, and even life and death,” he said.

Most people consider "mind" to be all the conscious things that we are aware of. But much, if not most, mental activity goes on without awareness. Actions such as walking, changing gear in your car or peddling a bicycle can become as automatic as breathing.

The biggest puzzle in neuroscience is how the brain activity that we're aware of (consciousness) differs from the brain activity driving all of those unconscious actions.

When we see an object, signals from our retina travel along nerves as waves of electrically charged ions. When they reach the nerve terminus, the signal jumps to the next nerve via chemical neurotransmitters. The receiving nerve decides whether or not it will fire, based on the

number of firing votes it receives from its upstream nerves.
In this way, electrical signals are processed in our brain before being transmitted to our body. But where, in all this movement of ions and chemicals, is consciousness? Scientists can find no region or structure in the brain that specializes in conscious thinking. Consciousness remains a mystery.
“Consciousness is what makes us 'human,' Professor McFadden said. “Language, creativity, emotions, spirituality, logical deduction, mental arithmetic, our sense of fairness, truth, ethics, are all inconceivable without consciousness.” But what’s it made of?
One of the fundamental questions of consciousness, known as the binding problem, can be explained by looking at a tree. Most people, when asked how many leaves they see, will answer "thousands." But neurobiology tells us that the information (all the leaves) is dissected and scattered among millions of widely separated neurones.
Scientists are trying to explain where in the brain all those leaves are stuck together to form the conscious impression of a whole tree. How does our brain bind information to generate consciousness?
What Professor McFadden realized was that every time a nerve fires, the electrical activity sends a signal to the brain's electromagnetic (em) field. But unlike solitary nerve signals,

information that reaches the brain's em field is automatically bound together with all the other signals in the brain. The brain's em field does the binding that is characteristic of consciousness.
What Professor McFadden and, independently, the New Zealand-based neurobiologist Sue Pockett, have proposed is that the brain's em field is consciousness.
The brain's electromagnetic field is not just an information sink; it can influence our actions, pushing some neurons towards firing and others away from firing. This influence, Professor McFadden proposes, is the physical manifestation of our conscious will.
The theory explains many of the peculiar features of consciousness, such as its involvement in the learning process.
Anyone learning to drive a car will have experienced how the first (very conscious) fumblings are transformed through constant practice into automatic actions.
The neural networks driving those first uncertain fumblings are precisely where we would expect to find nerves in the undecided state when a small nudge from the brain's em field can topple them towards or away from firing. The field will "fine tune" the neural pathway towards the desired goal. But neurons are connected so that when they fire together, they wire together, to form stronger connections. After practice, the influence of the field will become dispensable. The activity will

be learnt and may thereafter be performed unconsciously.
One of the objections to an electromagnetic field theory of consciousness is, if our minds are electromagnetic, then why don't we pass out when we walk under an electrical cable or any other source of external electromagnetic fields? The answer is that our skin, skull and cerebrospinal fluid shield us from external electric fields.
“The conscious electromagnetic information field is, at present, still a theory. But if true, there are many fascinating implications for the concept of free will, the nature of creativity or spirituality, consciousness in animals and even the significance of life and death.
"The theory explains why conscious actions feel so different from unconscious ones - it is because they plug into the vast pool of information held in the brain's electromagnetic field,” Professor McFadden concluded.
The University of Surrey is one of the UK’s leading professional, scientific and technological universities with a world class research profile and a reputation for excellence in teaching and research.

Controlling Your Thoughts

Are we what our thoughts make of us? Then the question is, What in our mind creates thought? "All that we are, is the result of what we have thought." - Dhammapada[1] (Code of Ethics).
What in our minds controls our thoughts and as a result alters, directs our course of action in life, for the better or for the worse? Our minds will construct miniature models of reality - from our dreams, our ideals, our goals in life. Based on these created models we reason, explain things and also anticipate events. Centuries back, Greek philosophers proposed that our minds carry 'impressions' similar to objects seen in the outside world. When we look in the external world with our God given physical eyes, we give meaning to what we have seen - with our Inner eye which is a complex network of mental models[2]. This Inner

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[1] The Dhammapada consists of 423 verses in Pali uttered by the Buddha on some 305 occasions for the benefit of a wide range of human beings. These sayings were selected and compiled into one book as being worthy of special note on account of their beauty and relevance for moulding the lives of future generations of Buddhists. They are divided into 26 chapters and the stanzas are arranged according to subject matter.

[2] The inner mind operates in a world of interior impressions. Its meaningful reality consists of the ideas and images of that world. Everything there seems immediate and self-evident. The inner world is populated by our everyday dreams, fantasies and memories. It may also be the arena of telepathic awareness and spiritual vision, and the place

eye looks inward and rearranges our thoughts and feelings under the light of our Intellect. It unifies all our experiences and prompts us to action towards realizing our dreams, ideals, goals in life. In our usual day to day hectic life, we do not pause to introspect. In times of stress, despair, pain or agony, we do have some fundamental questions to ask of ourselves. Who am I? What is life, and it's purpose? Why do I suffer so much? We do find our answers by looking through the Inner eye. By correcting the mental models we improve Inner vision. This process of improving Inner vision requires a quiet place, free from all sense distractions, and also ample time. In life some things cannot be hurried. Opening and cultivating the Inner eye is one of these. We must look into our inner world, not just the outer. Guided by the Intellect, our Inner eye looks deep into our unconscious mind which is the reservoir of incredible power and wisdom. Self restraint, poise and discipline of body and mind will enable us to access this vast resource within us

You are no greater than your thoughts

Two thousand five hundred years earlier, Buddha delivered a similar message: We are what we think. All that we are arises with our thoughts. With our thoughts we make the world. . . . What we are today comes from our

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where we may encounter past life memories or near-death experiences.

thoughts of yesterday, and our present thoughts build our life of tomorrow: Our life is the creation of our mind.

As adults, we can operate our minds like aircraft, either manually or on autopilot. When we run our minds on autopilot, our thoughts control us. But when we use our minds manually, we control our thoughts. And when we control our thoughts, we control their outcomes, or as Ralph Waldo Emerson wrote, Sow a thought and you reap an action; sow an act and you reap a habit; sow a habit and you reap a character; sow a character and you reap a destiny.

So, how do we reap a destiny? How do we escape from the threatening jungle we live in and arrive at the Garden of Eden? How do we change our Pandoras Box into a treasure chest? How do we control our thoughts? You may be surprised to learn that it is not difficult. If we follow a simple plan, which I will describe in the next paragraph, we will start on an exciting adventure. On the other hand, if we do not follow the plan, the chariot were riding in will either crash or not get very far because the wild stallions (our thoughts and emotions) are pulling it in different directions! However, once we tame and control the stallions, we can take our chariot to the destination of our choice. Have you ever wondered why you exist? You are here not because of what you are, but because of what you can become.

The life we now lead was created by our thoughts. If we would like to improve our life, we will have to improve our thoughts. Or, as James Allen wrote, He who would be useful, strong, and happy must cease to be a passive receptacle for the negative, beggarly, and impure streams of thought; and as a wise householder commands his servants and invites his guests, so must he learn to command his desires and to say, with authority, what thoughts he shall admit into the mansion of his soul.
In other words, if we are to improve, we must become aware of our thoughts and control them, rather than having our thoughts control us. How do we do that? One way is by following the procedure outlined below.

1. Get a cheap pad of paper or a notebook. Spend 15 minutes, longer if necessary, to analyze your average day. What you are looking for is one hour of wasted time each day. Once you have found it, plan to use that time to work on controlling your thoughts, their outcomes, and your life.

2. Did you set aside one hour each day? If so, you are ready to begin opening your mind)and examining your thoughts. You will need your notepad and at least an hour a day for one week. On the first day, write on the top of page one, What do I think of myself? Next, carefully and neatly list everything that comes to mind. For

example: I am attractive. I am overweight. I am shy. I am too sensitive. I am a good parent. I am lazy. And so on. You have set aside an hour, so use it. List everything that comes to mind. Try to come up with a list of 150 items or more. If you cant do it in one hour, complete the list the following day.
Once the list is complete, add a plus sign next to every positive statement and a minus sign next to every negative statement. I am intelligent would be a positive statement and I am lazy would be a negative statement. As you are not in the habit of examining your thoughts, this exercise will help reveal the contents of your mind. Suppose you discover 75% of your thoughts are negative, that would suggest you are losing at least 75% of your potential! Before you can control your thoughts, you must become aware of them, which is just what this exercise is designed to help you do.

3. On the second or third day return to your list. Every statement that includes the verb to be is inaccurate and needs to be corrected. For example, if you wrote I am lazy, that is wrong. Why? Because the verb to be means to have the essence of, or to equal. Thus, I am lazy means I = lazy. Which is not true. What you mean to say is, I sometimes behave in a lazy manner. There is a big difference in those two thoughts, and the difference affects your self-esteem. Do not allow the verb to be to cloud your thoughts. Get in the habit of precise thinking. Even where other verbs

are used, you need to reevaluate what you wrote and make it more accurate. For instance, I lack confidence is not accurate enough; what you mean to say is, In my opinion, I lack confidence. By focusing on the truth, it helps you realize that your negative thought is only an opinion, and opinions can be changed!

4. On the next day, return to your list and dig deeper into your mind by asking the questions who, what, where, when, how, and why. Thus, if you wrote, I sometimes behave in a lazy manner, WHEN do you do so? WHY do you do so? HOW do you do so? You get the idea. This exercise is designed to help you better understand yourself. Answer these questions for as many of the statements on your list as possible. True, it is a big project, but it has a big payoff; mainly, a new, better you.

5. Over the next following days, add new questions and make new lists. Questions such as, What do I think of life? What do I think of my family? What do I think of my job? If you diligently follow these exercises, you will get a clear view of your present state of mind. After a week of focusing on the contents of your mind, awareness of your thoughts should automatically appear at other times of the day. When this begins to happen, encourage it by pausing and taking control. Lets say you are at work and suddenly catch yourself thinking, Darn it! This

guy gets on my nerves! All right, you caught the thought, now STOP. Label the thought. Is it good? Is it going to help to make your life better? The answer is no. So, CHANGE THE THOUGHT. For example, change it to, How can I better understand this person and grow to appreciate him or her more? This new way of looking at things can lead to better understanding, harmony in the workplace, and a new friend. In other words, you can create a better life, a better you, by taking charge of your thoughts.

As you practice being aware of your thoughts, you will grow more and more skillful. Whenever you find yourself harboring a negative thought, imagine it is a weed; pluck it out of your mind and immediately replace it with a positive thought. A bar of iron costs $5, made into horseshoes its worth $12, made into needles its worth $3,500, made into balance springs for watches, its worth $300,000. Similarly, a person made into someone who has control over their thoughts has immeasurable value and infinite potential. All it takes is a pad of paper and a pencil to begin!

Consciousness and the mind as a fifth dimension of reality

Since the introduction of Descartes' dualism in the seventeenth century, the mind and the physical world have been viewed as disconnected entities. Yet qualities of mind such as awareness, purposeful action, organization, design, and even decision-making are present within the structure of matter and within the dimensions of space and time.

The space-time continuum of scientists generally ignores the realm of the mind, though phenomena such as imaginary numbers, used by Einstein to combine space with time, are concepts that only exist in the mind. Marc Seifer contends that the inadequacy of four-dimensional models to account for our experience of mental phenomena points to the consciousness of the mind as a higher organizing principle, a fifth dimension where thoughts are as real and quantifiable as our familiar physical world. He shows that because thought enables us to move backward and forward through time--reflecting on the past and making plans for the future--this fifth dimension of mind breaks the laws of relativity, thereby transcending the speed of light. His extensive study of this fifth dimension ranges from relativity and ether theory to precognition, telepathy, and synchronicity, all from the perspective of the conscious universe.

The shift from scientific materialism to a multidimensional worldview in harmony with the world's great spiritual traditions.

Our world is in a Macroshift. The reality we are experiencing today is a substantially new reality--climate change, global corporations, and industrialized agriculture--challenging us to change with our rapidly changing world, lest we perish.

Science's cutting edge now views reality as broader, as multiple universes arising in a possibly infinite meta-universe, as well as deeper, extending into dimensions at the subatomic level. Aspects of human experience that had previously been consigned to the domain of intuition and speculation are now being explored with scientific rigor and urgency. There has been a shift in the materialistic scientific view of reality toward the multidimensional worldview of multiple interconnected realities long known by the world's great spiritual traditions. By understanding the interconnectedness of our changing world as well as our changing "map" of the world, we can navigate with insight, wisdom, and confidence.

What scientists are now finding at the outermost frontiers of every field is overturning all the basic premises concerning the nature of matter and reality. The universe is not a world of separate things and events but is a cosmos that is connected, coherent, and bears a profound resemblance to the visions held in the earliest

spiritual traditions in which the physical world and spiritual experience were both aspects of the same reality and man and the universe were one. The findings that justify this new vision of the underlying logic of the universe come from almost all of the empirical sciences: physics, cosmology, the life sciences, and consciousness research. They explain how interactions lead to interconnections that produce instantaneous and multifaceted coherence--what happens to one part also happens to the other parts, and hence to the system as a whole. The sense of sacred oneness experienced by our ancestors that was displaced by the unyielding material presumptions of modern science can be restored, and humanity can once again feel at home in the universe.
Michael Talbot (1953-1992), was the author of a number of books highlighting parallels between ancient mysticism and quantum mechanics, and espousing a theoretical model of reality that suggests the physical universe is akin to a giant hologram. In The Holographic Universe, Talbot made many references to the work of David Bohm and Karl Pribram, and it is quite apparent that the combined work of Bohm and Karl Pribram is largely the cornerstone upon which Talbot built his ideas.
Every action and all matter that has developed in the universe conforms to what we know as reality. The idea that our universe passes like a giant's dream, or like a product of a very complex virtual reality program, more closely resembles an

ingenious science fiction script than the crude and imperfect world in which we move every day. However, the reality that we perceive seems to be contrary to scientific logic, if we bear in mind that matter hardly exists. The construction blocks of visible matter are atoms, which are merely small nuclei lost in the middle of a great spacial emptiness, surrounded by nearly invisible particles (electrons) that orbit them at magnificent speeds. If our bodies were to be put under a powerful microscope, what would be seen would probably be a sea of sand grains in perpetual motion.

According to recent research in the field of quantum physics, all of what we know as matter—the solid cement of what appears to be what our reality is composed of—could be nothing more than quantum fluctuations in the middle of the empty universe.

A group of physicists led by Dr. Stephen Durr from the John Von Neumann Institute in Germany confirmed that the sum of the three subatomic particles that make up protons and neutrons (called quarks) barely represent 1 percent of their total mass.

Such evidence suggests that the rest of the nuclear mass would be consist of gluons, ephemeral particles that bubble in the middle of the emptiness, which function to maintain the unity among the trio of quarks inside protons and neutrons. This fact suggests the hypothesis that our tangible reality might be mere fluctuations of emptiness or purely nothing.

The Outer Truth[3]

What we see with our physical eyes is greatly reduced to a convenient scope. Possessing a pair of eyes that could see only microscopic particles would make it impossible for us to move in a world with objects so large, as the objects with which we generally interact are composed of billions and billions of microscopic particles. According to biologist Richard Dawkins, rocks only feel hard and impenetrable to our hands because they can't penetrate each other. For us, it is useful to have notions of hardness and solidity as it helps us navigate our world.
Navigating in an illusory reality, we have to accept that somewhere in the Universe another reality can be found. There could be a gigantic slumber, a crazy bubble, or God, if you will.

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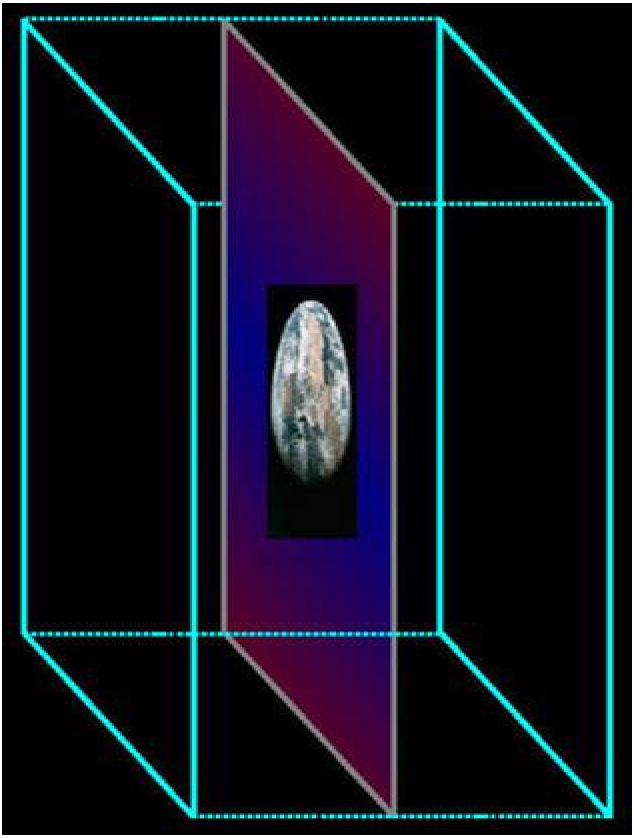
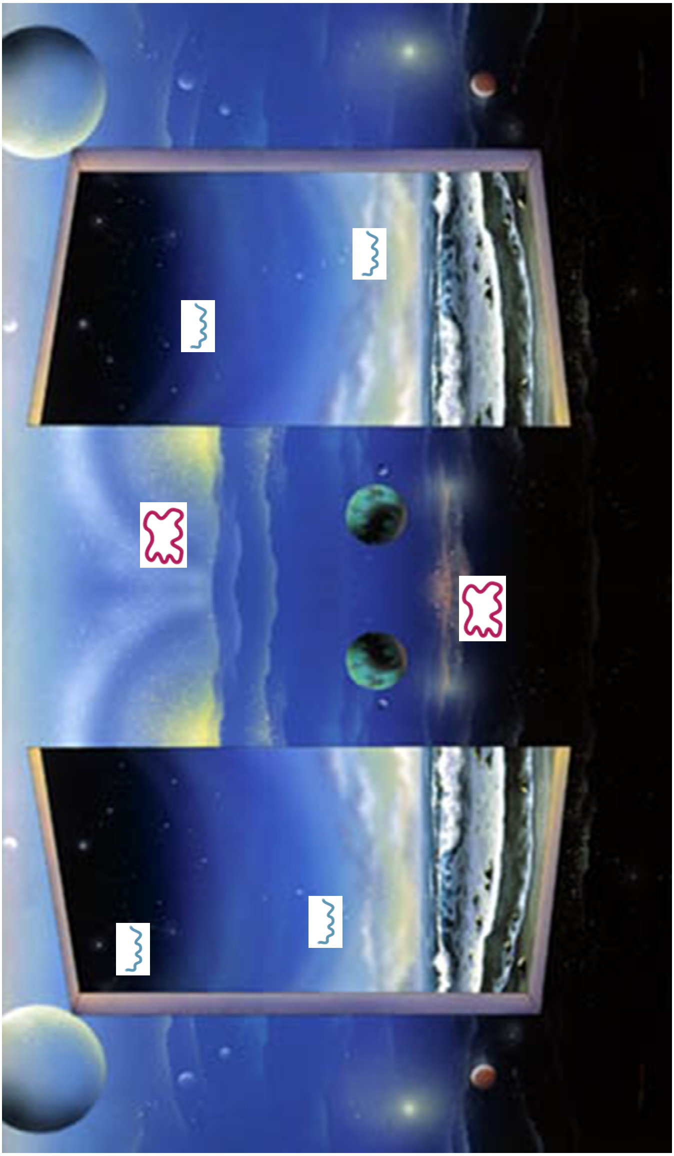
[3] The outer mind is at home in the physical, social, interactive environment of our lives. Working ceaselessly to make things happen, to accomplish what it wants to accomplish, to relate to others as it wishes to relate, to handle life's situations as it chooses, the outer mind is a true citizen of the world, and, like it or not, the outer mind cannot escape this involvement. The world is its home, its theatre of operations, the place where it lives, and the job of the outer mind is to find the best way to deal with worldly affairs.

Since the reality of particles cannot be more than smoke and shadows, it could be that the real existence of all objects in the cosmos resides in one or more parallel spaces. Many scientists speculate that, just like a three-dimensional object can project a two-dimensional shadow over the ground, a multidimensional universe (like the case of the String Theory) could cast a shadow in three-dimensional space.



If this theory is correct, every object and organism in this world would not be more than a gross representation of objects and organisms in a more “real” universe. Coinciding with this theory, the existence of an extracorporeal mind in another dimension might be the ideal explanation for why we have memory, as the atoms in our brains are replaced hundreds of time throughout the course of our lives. According to Steve Grand, author of “Creation: Life and How to Make It,” none of the atoms that make up our bodies today would have been in our bodies during an event in our childhood that we remember.



Grand suggests that matter moves from one place to another and reunites momentarily so that you can be you. Therefore, you aren't the matter of which you are made. This would imply that our real bodies are in the space that we cannot comprehend—while a virtual body, a mere container, would be what is in what we call reality.

The quantum theory, as it is now constituted, presents us with a very great challenge, if we are at all interested in such a venture, for in quantum physics there is no consistent notion at all of what the reality may be that underlies the universal constitution and structure of matter. Thus, if we try to use the prevailing world view based on the notions of particles, we discover that the 'particles' (such as electrons) can also manifest as waves, that they move discontinuously, that there are no laws at all that apply in detail to the actual movements of individual particles and that only statistical predictions can be made about large aggregates of such particles. If on the other hand we apply the world view in which the world is regarded as a continuous field, we find that this field must also be discontinuous, as well as particle-like, and that it is as undermined in its actual behaviour as is required in the particle view of relation as a whole. (**David Bohm**, On Quantum Theory, Wholeness and the Implicate Order, 1980)

In relativity, movement is continuous, causally determinate and well defined, while in quantum mechanics it is discontinuous, not causally determinate and not well defined. Each theory is committed to its own notions of essentially static and fragmentary modes of existence (relativity to that of separate events, connectable by signals, and quantum mechanics to a well-defined quantum state). One thus sees that a new kind of theory is needed which drops these basic commitments and at most recovers some essential features of the older theories as abstract forms derived from a deeper reality in which what prevails in unbroken wholeness.

At present quantum physicists tend to avoid the issue by adopting the attitude that our overall views concerning the nature of reality are of little or no importance. All that counts in physical theory is supposed to be the development of mathematical equations that permit us to predict and control the behavior of large statistical aggregates of particles. Such a goal is not regarded as merely for its pragmatic and technical utility: rather, it has become a presupposition of most work in modern physics that prediction and control of this kind is all that human knowledge is about.

One is led to a new notion of unbroken wholeness which denies the classical idea of analyzability of the world into separately and existing parts … We have reversed the usual classical notion that the independent ‘elementary

parts’ of the world are the fundamental reality, and that the various systems are merely particular contingent forms and arrangements of these parts. Rather, we say that inseparable quantum interconnectedness of the whole universe is the fundamental reality, and that relatively independent behaving parts are merely particular and contingent forms within this whole.
The main problem with modern physics is that quantum mechanics gives only the probability of an experimental result. Neither the decay of an atomic nucleus nor the fact that it decays at one moment and not another can be properly pictured within the theory. It can only enable you to predict statistically the results of various experiments.
Physics has changed from its earlier form, when it tried to explain things and give some physical picture. Now the essence is regarded as mathematical. It's felt the truth is in the formulas. Now they may find an algorithm by which they hope to explain a wider range of experimental results, but it will still have inconsistencies. They hope that they can eventually explain all the results that could be gotten, but that is only a hope.
Einstein's objection was not merely that it was statistical. He felt it was a kind of abstraction; quantum mechanics got correct results but left out much that would have made it intelligible. I came up with the causal interpretation (that the electron is a particle, but it also has a field around

it. The particle is never separated from that field, and the field affects the movement of the particle in certain ways). Einstein didn't like it, though, because the interpretation had this notion of action at a distance: Things that are far away from each other profoundly affect each other. He believed only in local action.

The most radical change in the notion of order since Isaac Newton came with quantum mechanics. The quantum-mechanical idea of order contradicts coordinate order because Heisenberg's uncertainty principle made a detailed ordering of space and time impossible. When you apply quantum theory to general relativity, at very short distances like ten to the minus thirty-three centimeters, the notion of the order of space and time breaks down. Physics is more like quantum organism than quantum mechanics. I think physicists have a tremendous reluctance to admit this. There is a long history of belief in quantum mechanics, and people have faith in it. And they don't like having this faith challenged.

Classical physics says that reality is actually little particles that separate the world into its independent elements. Now I'm proposing the reverse, that the fundamental reality is the enfoldment and unfoldment, and these particles are abstractions from that. We could picture the electron not as a particle that exists continuously but as something coming in and going out and then coming in again. If these various condensations are close together, they approximate a track. The electron itself can never be separated from the whole of space, which is its ground. It seems that people are ready to wait twenty years for results if you've got formulas. If there are no formulas, they don't want to consider it. Formulas are means of talking utter nonsense until you understand what they mean. Every page of formulas usually contains six or seven arbitrary assumptions that take weeks of hard study to penetrate.

Younger physicists usually appreciate the implicate order because it makes quantum mechanics easier to grasp. By the time they're through graduate school, they've become dubious about it because they've heard that hidden variables are of no use because they've been refuted. Of course, nobody has really refuted them. At this point, I think that the major issue is mathematics. In supersymmetry theory[4] an interesting piece of mathematics will attract attention, even without any experimental confirmation. When I was a boy a certain prayer we said every day contained the words to love God with all your heart all your soul, and all your mind. My understanding of these words, that is, this notion of wholeness - not necessarily

[4] All particles can be classified as fermions, such as the electron and quarks, or bosons, such as the photon and graviton. A fundamental characteristic distinguishing these two classes is that they carry different quantum-mechanical spin.

directed toward God but as a way of living - had a tremendous impact on me.

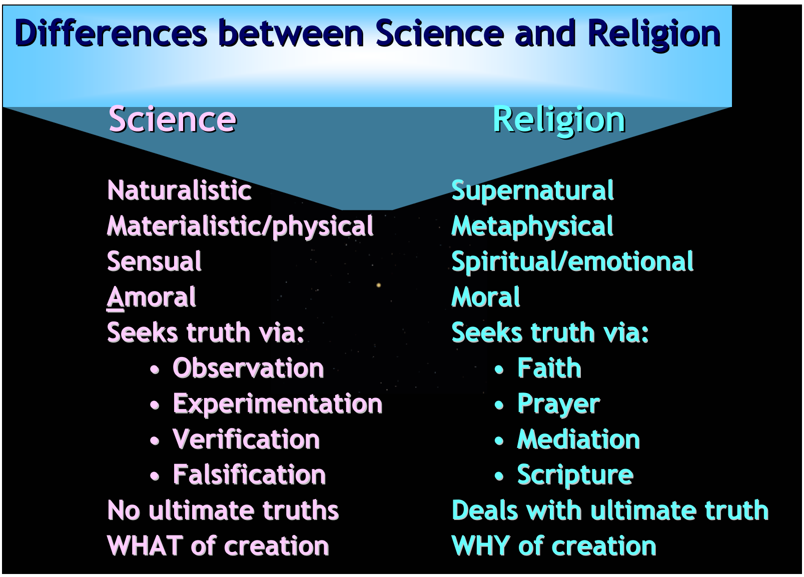
I also felt a sense of nature being whole very early. I felt internally related to trees, mountains, and stars in a way I wasn't to all the chaos of the cities.

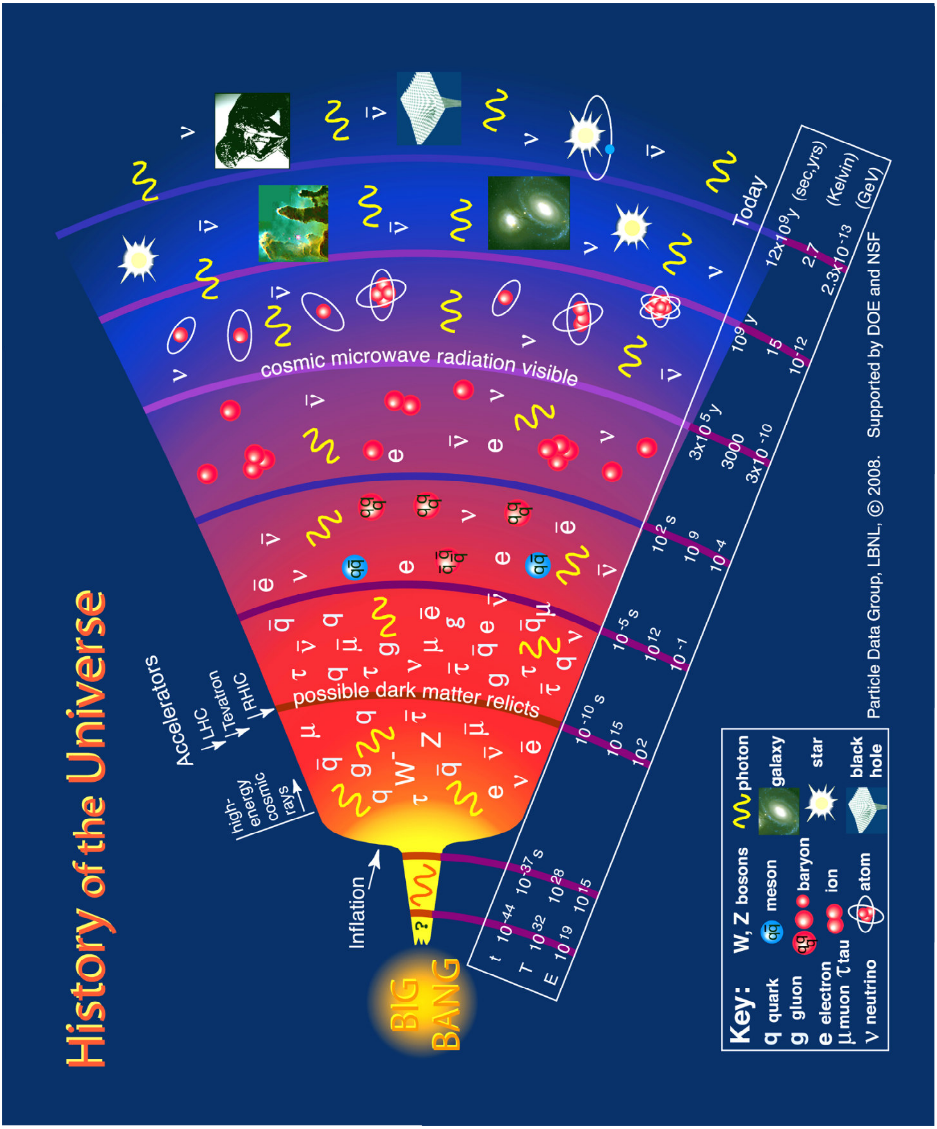
When I first studied quantum mechanics I felt again that sense of internal relationship - that it was describing something that I was experiencing directly rather than just thinking about. The notion of spin particularly fascinated me: the idea that when something is spinning in a certain direction, it could also spin in the other direction but that somehow the two directions together would be a spin in a third direction. I felt that somehow that described experience with the processes of the mind. In thinking about spin I felt I was in a direct relationship to nature. In quantum mechanics I came closer to my intuitive sense of nature.

Basically, what quantum theory says is that fundamental particles are empty of inherent existence and exist in an undefined state of potentialities. They have no inherent existence from their own side and do not become 'real' until a mind interacts with them and gives them meaning. Whenever and wherever there is no mind there is no meaning and no reality. This is a similar conclusion to the Mahayana Buddhist teachings on sunyata.[5]

[5] Is frequently translated as emptiness.

The ultimate manifestation of quantum sunyata is when quantum theory is applied to the entire universe. According to some cosmologists, the universe began as a quantum fluctuation in the limitless Void (Hartle-Hawking hypothesis). The universe remained as a huge quantum superposition of all possible states until the first primordial mind observed it, causing it to collapse into one actuality. This fascinating theory is discussed in The Participatory Anthropic Principle.

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atom
photon
galaxy
star
black hole
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Buddhism and Quantum Physics

Nagarjuna's Concept of Reality

Nagarjuna[6] had been the most important Buddhist philosopher of India. According to Etienne Lamotte his lifetime was in the second part of the 3rd century after Christ. His philosophy is of topical interest. Till this day it determines the modes of thought of all Tibetan Buddhist traditions. About his life we have no assured knowledge but various legends which I won't go into detail about. But the authenticity of 13 of his works is assured by scientific research. The Dane Chr. Lindtner endeavored to analyze and to translate these 13 works.

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[6] Indian monk and philosopher, founder of the Madhyamika school of Buddhism. Born into a Brahman family, he underwent a spiritual conversion when he studied the doctrines of Mahayana Buddhism. His Fundamental Wisdom of the Middle Way and The Dialectical Method are critical analyses of false views about how existence arises, the means of knowledge, and the nature of reality. He established the concept of sunyata — emptiness, or the lack of an absolute reality behind the changing forms of existence

Nagarjuna's main work, *Mulamadhyamaka-karika* [MMK][7] is translated into German, English, French and other European languages. Nagarjuna is the founder of the philosophical school called *Madhyamaka*, middle way. The middle way represents a spiritual and philosophical way that tries to avoid extreme metaphysical concepts, in particular the concepts of substantial and subjective mindsets in their different modes. These two extremes are sometimes called '*eternalism*' and '*nihilism*'. In his main work [MMK] the middle way is expressed as follows:

[*Pratityasamutpada*] the dependent arising is what we call [*sunyata*] substancelessness. But this is nothing but a dependent concept [*prajnapti*]. [*sunyata*] Substance-less-ness constitutes the middle way.

Nagarjuna's philosophy consists mainly of two aspects. On the one hand of a demonstration of his own concept of reality [*sunyata, pratityasamutpada*]. According to this concept the fundamental reality has no firm core and consists not of independent substantial

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7 Mulamadhyamaka-karikas

Fundamentals of the Central Philosophy of Buddhi components but of two-body-systems. Their material and immaterial bodies interact with each other. This concept of reality is opposed to one of the key words of traditional Indian metaphysics in a dichotomous way: [*svabhava*] own being. On the other hand it consists of indications of inner contradictions of four extreme concepts of reality, which are presented in principle only. But it is facile to realize to which modes of thought these principles refer to and this is important because it specially deals with our extreme metaphysical modes of thought. They do not let us know reality. This is not only a discussion about the traditional metaphysics of India. These four extreme approaches I put in relation to substantial, subjective, holistic and instrumentalistic modes of thought in modern world. In order to undermine these modes of thought effectively we have to recognize them firstly. Without a claim of completeness I will give a brief outline of these four extreme concepts:

Substantialism

In Europe, the substantial modes of thoughts are in the center of traditional metaphysics, beginning with pre-Socratic philosophers [like Parmenides and Heraclitus] and Plato, up to Immanuel Kant. According to traditional metaphysics, substance or own being is something immobile, eternal, independent, and existing by itself. Substance is the justification for the existence of all things, the immaterial foundation of the world we are living in. In traditional metaphysics the highest substance can be understood as God or as a divine being. Since Kant's so called 'Copernican revolution' the ambition of philosophy is not any longer to know things. Rationality as a media of cognition has become the ambition of philosophy and by that, the traditional metaphysic has lost ground in the modern world. The central concepts of traditional metaphysics like being, substance, reality etc. are replaced by reduced mindsets: From now on, atoms, elementary particles, energy, fields of force, laws of nature, symmetries, etc. are considered to be the justification of the existence for anything.

Subjectivism

By subjectivist modes of thought, I understand the turning point to the subject that had been introduced by Ren' Descartes. According to this doctrine, mind is the primary substance and everything else is nothing but contents, form or creation of consciousness. The height of this kind of subjectivism is described by the idealism of Berkeley. The ideas of Kant can be considered as a moderated subjectivism or idealism. Since Ren' Descartes, the primary substance is the center of modern philosophical thought. It give evidence and certainty. Modern sciences had doubts about this, however, these doubts did not lead to a new and complementary concept of reality but to a calamitous separation between philosophy and natural sciences. It has sharpened the dualism and keeps it very busy.

Holism

The third approach tries to avoid the calamitous either-or-scheme of the first two approaches by consolidating both bodies, subject and object, into a whole. From now on, there are no longer parts but only one identity, all is one [Parmenides]. The whole is an absolute and mysterious one; it becomes an independent unity that exists independently from its parts. The ensemble is understood as something concrete as if it was a concept of experience. As a philosophical tenor of all great periods in European history of philosophy, this approach is connected with names like Aristotle, Thomas Aquinas, Leibniz, Schelling and perhaps Hegel. In quantum physics holism is represented by David Bohm.

Instrumentalism

The 4th approach consists in a refusal or ignorance of the existence of subject and object. Instead of favoring one or the other or both ones, this metaphysical approach refuses both. The question about reality is insignificant or meaningless. Instrumentalism is very modern, intelligent [for example in the person of Ernst Cassirer], and sometimes captious. It is not easy to get free from it. It consists as a continuation of the so called 'Copernican turn' to consider thinking as thinking in models or as an information process, and it does not bother about which phenomena the information is given. That is a problem, instrumentalism has inherited from subjectivism. The philosopher Donald Davidson wrote about it: "*If the decision for the Cartesian approach is made, it seems as if you are unable to indicate of which evidence your proofs are*". Instrumentalism is a collective term of concepts. It denotes different scientific approaches that agree with considering all human knowledge or general conceptions, phrases, and theories not as a realistic reproduction of the structure of reality, but as a result of human interactions with nature. The successful theoretical and practical orientation is the aim of the interaction. For instrumentalism, theories are not a description of the world but an instrument for a systematic order and explanation of observations and predictions of facts. The instrumentalist approach is outlined by the physician Anton Zeilinger. Zeilinger states in an interview: "*In classical physics we speak of a world of things that exists somewhere outside and we make a description of this nature. In quantum physics we have learned to be very careful. Ultimately physical sciences are not sciences of nature but sciences of statements about nature. Nature itself is always a*

construction of mind. Niels Bohr puts it like this: There is no world of quantum, there is only a quantum mechanical description".
Nagarjuna presents these four extreme concepts of reality in a scheme that is called in Sanskrit: *catuscoti* and in Greek: *tetralemma*. These are four assumptions which Nagarjuna does not accept. In a very short form they could be expressed in the following way:

Things do not arise substantially: Neither out of themselves, nor out of something else, nor out of both, nor without a cause. Behind this scheme there are, as mentioned before, four extreme concepts of reality that can be related to substantial, subjective, holistic, and instrumentalist modes of thoughts.

It is difficult to find a modern human being that does not agree to some extend with one of these 4 approaches. This shows that Nagarjuna's philosophy is up-to-date. Nagarjuna did not only decline (1) the substantial mode of thought in order to end up in (2) subjectivism, though it is often claimed against him. He did not decline the scheme of either-or modes of thought in order to end up at the approach of (3) holism, identity, or wholeness - how benevolent interpreters use to criticize him. He did not decline holism in order to end up at (4) instrumentalism, as assumed by many modern interpreters who succeed the philosopher Ludwig Wittgenstein. Why not?,

because exactly these metaphysical concepts had systematically been declined by Nagarjuna. Already the first verse of the MMK points out not only the whole dilemma but the whole tetralemma of our modes of thought: "*Neither from itself nor from another, nor from both, nor without a cause does anything whatever anywhere arises*".
This verse can be understood as the main statement of the lamadhyamaka-karika [MMK]: The refusal of four extreme metaphysical approaches that cannot agree upon the idea of the dependent existing of things. In this case the remaining of the MMK would be nothing but a commentary about this first verse. Therefore a careful examination is appropriate.
What is the statement of the verse? That nothing can be found, that there is nothing, or that nothing exists? Was Nagarjuna a nihilist? Did he deny the world that we are living in? Did he deny what is evident? Did he deny that everywhere there were things to be found that came into existence? We are obliged to argue: If a thing did not arise out of itself, it must have arisen out of something else, if we understand by the notion 'to arise' the empiric arising of things. What is the meaning of 'to arise'? In another text Nagarjuna himself gives some indications for the understanding of this concept. He writes in his work *Yuktisastika* (YS):

"(That which has arisen dependently on this and that has not arisen substantially [*svabhavatah*].) What has not arisen substantially, how can it literally [*nama*] be called 'arisen'?. What originates due to a cause and does not abide without [certain] conditions but disappears when the conditions are absent, how can it be understood as 'to exist'?"

By the concepts of 'emergence', 'arising' or 'existence' Nagarjuna has not meant the empiric but the substantial emergence, arising or existence. When in many passages of his book *Mulamadhyamaka-karika* [MMK 7.29] Nagarjuna tells that things do not arise, that they do not exist [MMK 3.7, MMK 5.8, MMK 14.6], that they are not to be found [MMK 2.25, MMK 9.11], that they are not [MMK 15.10], that they are unreal [MMK 13.1], the obvious meaning is: Things do not arise substantially, they do not exist out of themselves, their independence cannot be found and in this sense they are substantially unreal. Only the idea of substantial arising of things, only an absolute and independent existence, not the empirical existence of things is refused by Nagarjuna. He is explaining this in MMK 15.10 where he states: "'*It exists*' implies grasping after eternity: '*It does not exist*' implies the philosophy of annihilation. Therefore, a discerning person should not decide on either existence or non-existence."

For Nagarjuna the expression -to exist- has the meaning 'to exist substantially'. His issue is not the empirical existence of things but the metaphysical idea of a permanent duration and of a substance of circumstances: Only the idea of an own being, without participation to something else, is disapproved by Nagarjuna. Objects do not arise out of themselves, they do not exist absolutely, their permanent being is not to be found, they are not independent but they are dependently arising.

If many interpretations make the assertion that Nagarjuna is refusing the empirical existence of objects, they make an inadmissible generalization that moves Nagarjuna near to subjectivism, nihilism or instrumentalism. Such interpretations originate from metaphysical approaches that have difficulties to recognize the empirical existence of objects in the world we are living in. That does not at all apply to Nagarjuna.

How does Nagarjuna prove the dependent arising of things? The starting point of the MMK is the duality of things, their double-side-nature. These fundamental two-body-systems cannot be taken apart; they constitute a system of two material or immaterial components that complement each other. One component does not exist without the other one; one forms the counterpart to the other one. In the MMK, Nagarjuna is dealing with such concrete two-body-systems as for instance: a thing and its conditions, a walking person and the way to be walked, a seeing person and the seen

object, cause and effect, existence and its characteristics, a passion and a passionate person, arising and conditions of arising, actor and action, fire an fuel.
In this way, we are conducted to the centre of Nagarjuna's philosophy that consists in his concept of reality. In the just mentioned first ten chapters of his *Mulamadhyamaka-karika* [MMK], but also in the other chapters, Nagarjuna highlights mainly one single idea: Both, material or immaterial bodies of a two-body-system are not one identical but they do not break up into parts.
The most important characteristic of a thing is its dependence of others and the absence of substance that results from it, the impossibility to exist individually and independently. This is the meaning of *sunyata*: things are without an own being and without independence, the fundamental reality does not consists of single, isolated material or immaterial components, things arise only in dependence of other things, they do not arise substantially because an independent thing cannot be dependent.
A thing is not independent of the conditions and a thing and its conditions are not one. A walking person does not exist without the way to be walked and both are not one. A seeing person is not identical with the seen object. There is no cause without an effect and vice versa. The concept 'cause' has no meaning without the counterpart: the concept of an 'effect'. Both, cause

and effect are not one but they do not break up into two independent and separated concepts. Without a characteristic we cannot speak about an existence and vice versa. How could there be a passionate person without passion? When there are no conditions of arising there is no arising, none of it is existing out of itself, and none is subsisting through itself. Without an action there is no actor, without fuel there is no fire. The components of a two-body-system do not exist by themselves, they are not one and they are not independent from each other, therefore they are not 'real'. For such two bodies and for double concepts the consistence and the existence are dependent of the other component. One arises with the other one and one disappears just as the other. That is why a thing arises substantially, neither out of itself, nor out of another one, nor out of both, nor without a cause. The fundamental reality has no firm core but consists of systems of interacting bodies.
This concept of reality is initially an idea; only a reference to the reality that cannot be described with words. Whoever can speak about reality as it is, without concepts, does not know the reality. Referring to Nagarjuna, the yogic realization of reality without substance, the realization of dependent arising, the experience of reality as it is, requires for the Buddhist tradition a high spiritual realization; it requires giving up extreme approaches, the dissolution of the whole dualistic modes of thought. It is initially the dichotomous

mode of thought, our way to think in dualistic contradictions, which hinders us to realize reality as it is. To realize *sunyata* means to become free from all entanglements to this world. Nirvana simply is another word for this.

Interpretations

The first question for the philosophy of Nagarjuna was about reality, it was not the question about mind or about the origin of knowledge. This kind of subjectivism might apply rather to the philosophical school of *Yogacara*. But the interpretations of the most important works of Yogacara are controversial because they can be understood in an ontological sense that is denying the external world and is adopting the view of idealism or in an epistemic sense for the study of the nature of knowledge where perception is a projection of mind. What is named in Yogacara '*alayavijna*', the fundamental mind, or in Tantric Buddhism 'clear light' or '*Mahamudra*' is referring to the knowledge of reality, not to reality itself. Nagarjuna's philosophy is referring to reality itself. An all embracing position of this question is presented by Tarab Tulku Rinpoche in 2003. He says: "*So we can call this basic 'energy' for a fundamental underlying 'mind-field'. This means, in accordance with Ancient Inner Science that everything existing partakes in a fundamental 'mind-field', which is the basic 'substance' from*

which basis mind in a more individual way and the individual body develop".
In order to show that Nagarjuna does not speak just about concepts without substance but also about objects without substance, I compare his concept of reality to the physical concept of reality in quantum physics. Physics is not only about concepts but also about the conditions of physical reality. Directly physics creates nothing but models of reality, it examines only realities that are created by human mind but we should not go so far to consider all our perceptions and models of thought to be pure coincidence. The constructions of our mind are not directly identical with reality but normally they are no pure coincidence and not deceptive (Irvin Rock). Behind our models are empirical objects and approximately there is a structural similarity between a good physical model and the physical reality that corresponds to it.

The Metaphysical Foundations of Quantum Physics

This is no presentation or criticism of quantum physics but a discussion of the metaphysical mindsets that underlie quantum physics. The concept of reality in quantum physics can be expressed by the key words: *complementarity, four interactions*, and *entanglements* [entanglements will not be explained in this book. According to Roger Penrose "*Quantum*

entanglement is a very strange type of thing. It is somewhere between objects being separate and being in communication with each other" (Roger Penrose, *The Large, the Small and the Human Mind*, Cambridge University Press 2000, p.66)]. In the long prehistory of Quantum Physics it could not be proved experimentally whether the smallest elements of light are particles or waves. Many experiments argued in favor of one or the other assumption. Photons are sometimes acting as waves and sometimes as particles. This behavior was named a wave-particle-dualism. The idea of dualism used to be understood as a logic contradiction: only one or the other could apply but paradoxically both appeared. Photons cannot be both. These are the expectations according to atomism. According to atomism a scientific explanation consists in a reduction of a contradictory object into its permanent components or its mathematical laws. This is the fundamental dualistic concept that modern atomism and modern physics have adopted from ancient Greek philosophy of nature: substance and permanence can not to be found in objects of perception in the world we are living in, but in the elementary elements of objects and in mathematical order. These material and immaterial foundations keep the world together; they do not change while everything else is changing.
According to atomism it should be possible to reduce an object to its independent elements or to

its mathematical laws or to its simple and fundamental principles and according to these the fundamental elements should be either particles or waves, not both.
What is to be understood by independent elements? Plato made the difference between two forms of being. In the second part of his 'Parmenides' he distinguished between single objects, which exist exclusively by partaking and insofar they have no own being and ideas, that have an own being. Traditional metaphysics adopted this dualism from Plato. An independent own being is characterized in traditional metaphysics as something that, as an existing thing, is not dependent from anything else (Descartes), existing by itself, subsisting through itself (More), which is completely unlimited by others and free from any kind of foreign command (Spinoza), and exists by itself without anything else (Schelling). Albert Einstein was following this metaphysical tradition when he wrote: For the classification of things that are introduced in physics, it is essential that these things require for a certain time an independent existence, as far as these things lay 'in different parts of space'. Without the assumption of such an independent existence [of '*So-seins*' as Einstein called it, this expression can be translated by a word like 'likeness' or 'to be like this'] of things being distant from each other in space, physical thought in the usual sense would not be possible.

This idea of an independent reality was projected to the fundamental elements of the material world by atomism. For atomism, a scientific explanation means to reduce the vicissitude and variety of objects and conditions to its permanent, stable, independent, undividable elements, or mathematical laws. According to the expectations of atomism all changes of nature can be explained as separation, connection and movements of unchanged and independent atoms or still more elementary components. They and their mathematical laws are the core or fundamental reality of objects. They keep the world together. The question whether the fundamental objects are particles or waves was an explosive issue: the traditional concepts of reality, that had been made available by metaphysics, were at stake. Maybe the fundamental reality could not be grasped by traditional concepts of reality. Of which value of explanation was atomism, if it should turn out that there are no independent atoms or elementary particles and that objects have no stable core? Are quantum objects objective, subjective, both, or none of both? What is reality? Is there a difference between the quantum world and the world we are living in?
Niels Bohr. In 1927, the physicist Niels Bohr introduced the concept of complementarity into quantum physics. According to this concept the picture of wave and the picture of particle are not two pictures that contradict and exclude each

other but two (contradictory) pictures that complete each other, only concertedly they can give a complete description of physical phenomena. According to Bohr, complementarity meant that in the quantum world it is impossible to speak about independent and objective quantum objects because they are in an interactive relation with each other, as well as with the instrument of measurement. Bohr considered the interaction between the object and the instrument of measurement as an inseparable element of quantum objects, because the interaction itself is important for the existence of some features of these objects: some measurements set photons as particles and destruct the interference that characterizes objects as waves. Other measurements set objects as waves. That was the new concept of reality by Niels Bohr. Bohr did not transform the concept of complementarity into the instrumentalist conclusion: there were no quantum objects [at least when his argumentation was one of a physician's view. However, when he talked on a metaphysical level about quantum physics, he took the position of an instrumentalist approach]. In a physical sense the fundamental physical reality consists for Niels Bohr of interacting complementary quantum objects.
Interaction in the standard quantum model. In the meantime the concept of the four interactions was introduced to the standard quantum model. These four elementary interactions do not permit the

reduction of quantum objects to their elements as Democritus proposed. Interactions, the forces that act between the quantum objects, cropped up to the elementary particles. As elementary objects, not single independent objects were being established, but two-body-systems, multi-body-systems or complete assembles of elementary particles. Between its components, forces of interaction are effective which keep the components together. They are parts of the components. Mostly they are forces of attraction. In the case of electro-magnetic forces they are also repulsive. It is possible to think of the interactions between the elementary particles as an exchange of elementary particles. The physicist Steven Weinberg writes about this: "Today we come within reach of a standardized view of nature, if we think in concepts of elementary particles and interactions between them. (...) Best known are gravitation and electro-magnetism that belong to the daily world of experience because of their range. Gravitation keeps our feet on earth and planets on their path. The electro-magnetic interactions between electrons and atomic nucleus are responsible for all well known chemical and physical qualities of usual solid bodies, liquids, and gases. The two nucleus powers belong to a different category in respect to reach and familiarity. The 'strong' interaction that keeps protons and neutrons inside the nucleus together has a reach of about 10-13 centimeters. So it goes down in daily life and even in the realm of an atom [10-8 centimeters]. The 'weak' interaction is the least familiar. It has such a short reach [less that 10-15 centimeters] and is so weak, that it probably does not keep anything together". Sometimes explanations go very far into difficult and subtle details. How does an electron interact with another quantum object if it exists of one part only? Which part it should emit if it exists of one part only? There is an answer to these questions by the concept of interactions. An electron does not exist of one single part only, because the interaction is a part of the electron. In an article about super gravitation of 1978 the two physicians Daniel Z. Freedman and Pieter von Nieuwenhuizen write about it: "The observed mass of electrons can be described as the sum of a 'naked mass' and the 'self-energy' that is based on the interaction of the electron with its own electro-magnetic field. Individually none of these parts are observable". The knowledge of quantum physics about the particles that carry the interactions, shall be mentioned here in the words of the physicist Gerhard't Hooft. He writes, "that an electron is surrounded by a cloud of virtual particles, which are permanently emitted and absorbed. This cloud does not exist of photons only, but of pairs of charged particles, for example electrons and their anti-particles, the positrons. (...) "Even a quark is surrounded by a cloud of gluons and pairs of quark-anti-quark." Individual, isolated, independent quarks were never been observed.

This phenomenon is named confinement. This means quarks are captives, they cannot appear as a single quark but as a pair or a trio only. If you try to separate quarks by force, there will appear new quarks between them, which unify into pairs and trios. Claudio Rebbi and other physicists reported: "Between quarks and gluons inside an elementary particle, permanently additional quarks and gluons appear which disappear again after a short time". These clouds of virtual particles represent or produce interactions.
We now arrived at the center of quantum physics. It consists of a new physical concept of reality, that does no more consider single and independent elements as the fundamental reality but two-body-systems or two states of quantum objects or two concepts like earth & moon, proton & electron, proton & neutron, quark & anti-quark, wave & instrument of measurement, particle & instrument of measurement, twin photons, superposition, spin-up & spin-down, matter & anti-matter, elementary particle & field of force, law of nature & matter, symmetry & anti-symmetry etc. These systems do not break up into independent parts. They cannot be reduced into two separated independent bodies or states with one part being fundamental and the other one deduced, as it is the case with substantialism's and subjectivism's either-or-scheme. Together they are not a mysterious unity, they are not 'one' and identical as holism tries to convince us. Furthermore, we cannot claim that

they are nothing but constructed mathematical models and that no physical reality corresponds to them, what has been claimed by instrumentalism. Exactly the latter is claimed by Stephen Hawking who does not consider himself as an instrumentalist but as a positivist. In a discussion with the mathematician Roger Penrose, Hawking said: "I am a positivist who believes that physical theories are just mathematical models we construct; and that it is meaningless to ask if they correspond to reality, just whether they predict observations".
It is not meaningless to ask for the correspondence between model & object. If a model of thought is accurate it has a structural similarity with the phenomenon that it constructs, otherwise it can lead to calculations without any meaningful physical explanation, because they cannot correspond to any reality. Physically, Physically, a fundamental reality is not a one-body-system but a two-body-system or an assemble of bodies that surrounds the central or the 'naked' body. Between quantum particles there is an interaction that is part of these particles. That's the way it is but all our metaphysical schemes put up a real struggle. This 'cloud' does not correspond to our traditional metaphysical expectation of everything that should represent order and should be fundamental. How can 'clouds' be that which we are used to call the basic elements of matter? How can this little vibrating thing be what

generations of philosophers and physicists were looking for? Is this supposed to be all? From the little 'cloud' we try to filter with metaphysical interpretations what has substance and what maintains. Completely for the purpose of Plato's substance metaphysics Werner Heisenberg called elementary particles 'the idea of matter'. The philosopher and physicist Carl Friedrich von Weizs'cker named mathematics 'the essence of nature'. According to the physicist Herwig Schopper, fields of force are the ultimate reality. Some of us like to consider the fundamental reality as a whole [holism] and according to others all is nothing but a construction and no reality correspond to this construction [instrumentalism]. Why all these extreme metaphysical positions? Just because we cannot easily admit that complex interactions of the world we are living in, have a foundation that is a complex reality by itself. It is impossible to get out of the entanglement of this world by quantum physics. It is impossible to find an elemental quantum object that is independent from other quantum objects or from its own parts. It is impossible to dissolve the double-sided character of quantum objects. The fundamental physical reality consists of 'clouds' of interacting quantum objects.

Results. Reality is nothing static, firm or independent. It does not consist of single, isolated material or immaterial factors, but of systems of dependent bodies. Most of the systems consist of more than two bodies but there are no systems that consist of less than those two bodies. In quantum physics we call such fundamental two-body-systems earth & moon, electron & positron, quark & anti-quark, elementary particle & field of force. his systems walking person & way to be walked, fire & fuel, action & actor, seer & object of seeing. Both of these models describe two body-systems which have objects that are separate and at the same time in communication with each other. They are neither identical with each other, nor do they break up into parts. The bodies are not independent and individually none of these parts are observable because in their state of existence they are dependent from each other and cannot exist independently. They are entangled by interactions, even in a far distance. One body cannot be reduced to the other. The systems have a fragile stability that is based upon four well known, sometimes not completely known and sometimes completely unknown interactions [in the case of entangled and separated photons] and mutual dependencies of their components.

What is reality? We are used to being on our feet on terra firma and to see fugacious clouds in the sky. The concept of reality in the philosophy of Nagarjuna and the physical concepts of complementarities and interactions in quantum physics, tell us something different that could be expressed as follows: all is build upon sand and even not the grains of sand have a solid core or nucleus. Their stability is based on instable interactions of their components.

Universe is estimated to be 15 billion years old (15,000,000,000 years)
Agnostic biophysicist Dr. Harold Morowitz wondered…
Suppose you break all chemical bonds in the simplest organism (a bacteria) and put those atoms under ideal chemical conditions…
Question: How long would it take for it to reassemble?
Answer: $10^{100,000,000,000}$ years!
Written out completely, that would be:
1,000,000,000,000,000,000,000,000,000,000,000
,000,000,000,000,000,000,000,000,000,000,000,
000,000,000,000,000,000,000,000,000,000,000,0
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0,000,000,000,000,000,000,000,000,000,000,000
,000,000,000,000,000,000,000,000,000,000,000,
000,…(on and on)
A thousand sets of Encyclopedia Britannicas filled with zeros!!

$10^{100,000,000,000}$ yrs is impossible because…
Hydrogen atom would decay after [~1033 years]
500,000,000,000,000,000,000,000,000,000,000 yrs
Heat death of the universe will occur at 80,000,000,000 years
But the Big Bang restricts the age of the universe to be <50,000,000,000 years

Clearly not enough time for atoms to randomly combine together to form even a simple bacteria!

Mulamadhyamaka-karikas

Fundamentals of the Central Philosophy of Buddhism

Section 1
An Analysis of Conditioning Causes (Conditions)
In 14 verses

1.
Never are any existing things found to originate
From themselves, from something else, from both, or from no cause.

2.
There are four conditioning causes
A cause (hetu) (1), objects of sensations (2), "immediately preceding condition," (3) and of course the predominant influence (4), there is no fifth.

Mulamadhyamakakarika I.3.
Certainly there is no self-existence (svabhava) of existing things in conditioning causes, etc;
And if no self-existence exists, neither does "other-existence" (parabhava).

Mulamadhyamakakarika I.4.
The efficient cause (kriya – primary condition, root cause, motive) does not exist possessing a conditioning cause,
Nor does the efficient cause exist without possessing a conditioning cause.
Conditioning causes are not without efficient causes,
Nor are there conditioning causes which possess efficient causes.

Mulamadhyamakakarika I.5.
Certainly those things are called "conditioning causes" whereby something originates after having come upon them;
As long as something has not originated, why are they not so long (i.e. during that time) "non-conditioning-causes" ?

Mulamadhyamakakarika I.6.
There can be a conditioning cause neither of a non-real thing (1) nor of a real thing (2).
Of what non-real thing is there a conditioning cause? And if it is already real, what use is a cause?

Mulamadhyamakakarika I.7.
If an element (dharma) occurs which is neither real nor non-real (4) nor both real- and-non- real (3),
How can there be a cause which is effective in this situation?

Mulamadhyamakakarika I.8.
Just that which is without an object of sensation is accepted as a real element;
Then if there is an element having no object of sensation, how is it possible to have an object of sensation?

Mulamadhyamakakarika I.9.
When no elements have originated, their disappearance is not possible.
Therefore it is not proper to speak of an "immediately preceding condition"; for if something has already ceased, what cause is there for it.

Mulamadhyamakakarika I.10.
Since existing things which have no self-existence are not real,
It is not possible at all that: "This thing 'becomes' upon the existence of that other one."

Mulamadhyamakakarika I.11.
The product does not reside in the conditioning causes, individually or collectively,
So how can that which does not reside in the conditioning cause result from conditioning causes?

Mulamadhyamakakarika I.12.
Then the "non-real" would result from those conditioning-causes.

Why then would a product not proceed also from non-causes?

Mulamadhyamakakarika I.13.
On the one hand, the product consists in its conditioning causes;
on the other hand, the causes do not consist of themselves.
How can a product resulting from conditioning causes not consisting of themselves be consisting of those causes?

Mulamadhyamakakarika I.14.
Therefore, that product does not consist in those causes; yet it is agreed that a product does not consist of non-causes.
How can there be a conditioning cause or non-cause when a product is not produced?

MMK of Nagarjuna, Section 2
An Analysis of "Going to" (Change or Movement)
In 25 verses

Mulamadhyamakakarika II.1.
Nargarjuna: That which is already gone to (gatam – goer after the going - iii)
is not that which is "being gone to" (gamyate);
more so, "that which is not yet gone to" (agatam – goer before the going - i)
is certainly not that "being gone to." (gamyate)
Also, the "present going to" (gamyamana – actual

goer - ii)
without "that which is already gone to" and "that which is not yet gone to"
is not "being gone to".

Mulamadhyamakakarika II.2.
An opponent objects:
Where there is activity (cesta - visible activity) there is a "process of going" (gatis – real going process), and that activity (visible activity) is in the "present going to" (gamyamane - ii).
Then "process of going" (gatis - real going process) is inherent in the "present going to" (gamyamane - ii) since the activity (visible activity) is not in "that which is already gone to" (iii) nor in "that which is not yet gone to." (i)

Mulamadhyamakakarika II.3.
Nargarjuna answers:
How will the "act of going" (gamanam - visible activity & displacement) of "present going to" (gamyamana - ii) be produced,
Since both kinds of the "act of going" (visible activity & displacement) as applied to an active process and to the activity of going through space simply are not produced (i.e. originating) in the "present going to" (ii)?

Mulamadhyamakakarika II.4.
Having the "act of going" (gamanam - visible activity & displacement) of "present going to" (gamyamanasya - ii) has necessarily resulted in a

lack of "the present going to" (ii) of the "process of going" (gati - real going process),
For the "present going to" (gamyamana - ii) is the "being gone to" (gamyate).

Mulamadhyamakakarika II.5.
Recognizing the "act of going" (visible activity & displacement) of "present going to" (ii) results in two kinds of "acts of going" (gamanadvaya - visible activity & displacement):
One by which there is "present going to" (gamyamana - ii), the other which is the "act of going" (gamana - visible activity & displacement).

Mulamadhyamakakarika II.6.
Two "goers" (gantarau) would fallaciously follow as a consequence of two "acts of going," (visible activity & displacement)
Since certainly the "act of going" (visible activity & displacement) is not produced without a "goer".

Mulamadhyamakakarika II.7.
If there is no going (gamana) (i.e. gamana equals "act of going") without a "goer" (gantara),
How will the "goer" (ganta / self-existing subject) come into being when there is no "going" (gamana) (i.e. gamana equals "act of going")?

Mulamadhyamakakarika II.8.
The "goer" does not go (move);
consequently a "non-goer" certainly does not go

(move).
What third possibility goes (moves) other than the "goer" and "non-goer"?

Mulamadhyamakakarika II.9.
It is said: "The 'goer' goes" (moves) How is that possible,
When without the "act of going" (gamana - visible movement) no "goer" is produced?

Mulamadhyamakakarika II.10.
Those who hold the view that the "goer" "goes" (moves) must falsely conclude
That there is a "goer" without the "act of going" (visible activity & displacement) since the "act of going" (visible activity & displacement) is obtained (icchata) by a "goer."

Mulamadhyamakakarika II.11.
If the "goer" "goes" (moves), then two acts of going (visible activity and displacement) erroneously follow;
One is that by which the "going on" (ganta) is designated, and the second is the real "goer" (ganta / self-existing subject) who "goes"(moves).

Mulamadhyamakakarika II.12.
The "state of going to" (gatum) is not begun in "that which is already gone to" (gatam - iii), nor in "that which is not yet gone to" (agatam - i);
Nor is the "state of going to" begun in "present

going to" (gamyamana - ii).
Where then is it begun?

Mulamadhyamakakarika II.13.
"Present going to" (ii) does not exist previous to the beginning of the "act of going," (visible activity and displacement)
nor does "that which is already gone to" (iii) exist where the "act of going" (visible activity and displacement) should begin.
How can the "act of going" (visible activity and displacement) begin in "that which is not yet gone to" (i) ?

Mulamadhyamakakarika II.14.
It is mentally fabricated what is "that which is already gone to" (gatam - iii), "present going to" (gamyamana - ii) and "that which is not yet gone to" (agatam - i);
Therefore, the beginning of the "act of going" (visible activity and displacement) is not seen in any way.

Mulamadhyamakakarika II.15.
A "goer" does not remain unmoved (na tistati); then certainly the "non-goer" does not remain unmoved.
What third possibility other than "goer" and "non-goer" can thus remain unmoved?

Mulamadhyamakakarika II.16.
It is said that a "goer" continues to be a "goer".

But how can that be possible,
Since a "goer"(ganta / self-existing subject) lacking the "act of going" (gamanam - visible activity and displacement) is simply not produced?

Mulamadhyamakakarika II.17.
The "goer" does not continue to be a goer as a result of "present going to" (ii) or "that which is already gone to" (iii) or "that which is not yet gone to,"(i)
For then the act of going (gamana - visible activity and displacement) would be origination while the "process of going" (gati - real going process) would be the same as cessation.

Mulamadhyamakakarika II.19.
And if the "act of going" (visible movement) and the "goer" are identical,
The fallacy logically follows that the "person acting" (kartus) and the action (karma) are identical.

Mulamadhyamakakarika II.20.
Alternatively, if the "goer" is different from the "process of going" (gati - - real going process),
The "act of going" (gamana - visible activity and displacement) would exist without the "goer" and the "goer" would exist without the "act of going." (visible activity & displacement)

Mulamadhyamakakarika II.21.
Neither the identity nor the essential difference is

established (siddhi) regarding the two conceptions "goer" and "act of going" (visible activity and displacement).
If these two alternatives are not established, in what way is this problem to be understood?

Mulamadhyamakakarika II.22.
The "goer" is defined by that which is in the "process of going" (real going process);
he does not go to that destination which is determined by the "process of going" (real going process)
because there is no prior "process of going." (gati - real going process)
Indeed someone goes somewhere.

Mulamadhyamakakarika II.23.
The "goer" does not go to that destination other than that "process of going" (real going process)- by which he is defined as "goer",
Because when one goes somewhere (i.e. else) two "processes of going" (real going processes) cannot be produced.

Mulamadhyamakakarika II.24.
A real "goer" does not motivate three kinds of "acts of going:" real, non-real, and real-and-non-real;
Nor does a non-real "goer" motivate three kinds of motion.

Mulamadhyamakakarika II.25.
Also, a real-non-real "goer" does not motivate three kinds of motion.
Therefore,
the "process of going" (gati - real going process),
the "goer" (ganta /self-existing subject)
and "a destination to be gone to" (gantavyam)
do not exist (inherently).

MMK of Nagarjuna, Section 3
An Analysis of "Vision" and Other Sense-Faculties (the sense-fields) In 9 verses

Mulamadhyamakakarika III.1.
Vision, hearing, smelling, tasting, touching and thought
Are the six sense faculties.
The area of their concern is that which is seen heard, smelled and so forth.

Mulamadhyamakakarika III.2.
Certainly vision does not in any way see its own self.
Now if it does not see its own self, how can it possibly see something else?

Mulamadhyamakakarika III.3.
An understanding of vision is not attained through the example of fire which, itself, burns.
On the contrary, that example of fire together with vision is refuted by the analysis of "present

going to," "that which is already gone to," and "that which is not yet gone to."

Mulamadhyamakakarika III.4.
When no vision occurs, nothing whatsoever is being seen.
How, then, is it possible to say: Vision sees?

Mulamadhyamakakarika III.5.
Therefore, vision does not see, and "no-vision" does not see.
Nevertheless, it is explained that also the "seer" is to be known only by his vision.

Mulamadhyamakakarika III.6.
There is no "seer" with vision or without vision;
Therefore, if there is no "seer," how can there be vision and the object seen?

Mulamadhyamakakarika III.7.
As the birth of a son is said to occur presupposing the mother and the father,
Knowledge is said to occur presupposing the eye being dependent on the visible forms.

Mulamadhyamakakarika III.8.
Since the "object seen" and the vision do not exist (independently, on their own),
there is no four-fold consequence: knowledge, etc. cognitive sensation, affective sensation, and "desire".
Also, then, how will the acquisition (upadana) of

karma and its consequences i.e., existence, birth, aging, and death be produced?

Mulamadhyamakakarika III.9.
Likewise hearing, smelling, tasting, touching and thought are explained as vision.
Indeed one should not apprehend the "hearer," ".


Many scientists are seeing for the first time that Somebody must be behind it all.
And because many scientists are seeing design everywhere they look...
some are seeing a Designer.
And are being drawn into the Third Heaven - the presence of God.

2

QUANTUM REALITY

"Things are not as they appear to be. Nor are they otherwise."
—The Lankavatara Sutra

"*Quantum physics tells us 'the world is very big and very mysterious. Mechanism is not the answer, but I'm not going to tell you what is.' "*
—from What the Bleep Do We Know!?

A basketball appears in ten places at once. Amanda sees herself through the eyes of someone she has become. Time stands still, and particles become waves. *What the Bleep Do We Know!?* invites us to bend our minds around the startling discoveries of quantum physics and to entertain the possibility that things are not as they appear to be. As the *Lankavatara Sutra* says, neither are they otherwise. In fact, according to quantum physics, things are not even "things," they are more like possibilities. According to

physicist Amit Goswami, “Even the material world around us—the chairs, the tables, the rooms, the carpet, camera included—all of these are nothing but possible movements of consciousness.” What are we to make of this? “Those who are not shocked when they first come across quantum theory cannot possibly have understood it,” notes quantum physics pioneer Niels Bohr.
Before we can consider the implications of quantum mechanics, let’s make sure we understand the theory.

What Is Quantum Mechanics?

Quantum mechanics, the latest development in the scientific quest to understand the nature of physical reality, is a precise mathematical description of the behavior of fundamental particles. It has remained the preeminent scientific description of physical reality for 70 years. So far all of its experimental predictions have been confirmed to astounding degrees of accuracy.
To appreciate why quantum mechanics continues to astound and confound scientists, it is necessary to understand a little about the historical development of physical theories. Keeping in mind that this brief sketch oversimplifies a very long, rich history, we may consider that physics as a science began when Isaac Newton and others

discovered that mathematics could accurately describe the observed world. Today the Newtonian view of physics is referred to as classical physics; in essence, classical physics is a mathematical formalism of common sense. It makes four basic assumptions about the fabric of reality that correspond more or less to how the world appears to our senses.

These assumptions are reality, locality, causality, and continuity.

Reality refers to the assumption that the physical world is objectively real. That is, the world exists independently of whether anyone is observing it, and it takes as self-evident that space and time exist in a fixed, absolute way.

Locality refers to the idea that the only way that objects can be influenced is through direct contact. In other words, unmediated action at a distance is prohibited.

Causality assumes that the arrow of time points only in one direction, thus fixing cause-and-effect sequences to occur only in that order.

Continuity assumes that there are no discontinuous jumps in nature, that space and time are smooth.

Classical physics developed rapidly with these assumptions, and classical ways of regarding the world are still sufficient to explain large segments of the observable world, including chemistry, biology, and the neurosciences. Classical physics got us to the moon and back. It works for most things at the human scale. It is common sense.

But it does not describe the behavior of all observable outcomes, especially the way that light and, in general, electromagnetism works. Depending on how you measure it, light can display the properties of particles or waves. Particles are like billiard balls. They are separate objects with specific locations in space, and they are hard in the sense that if hurled at each other with great force, they tend to annihilate each other accompanied by dazzling displays of energy. In contrast, waves are like undulations in water. They are not localized but spread out, and they are soft in that they can interact without destroying each other. The wave-like characteristic also gives rise to the idea of quantum superposition, which means the object is in a mixture of all possible states. This indeterminate, mixed condition is radically different than the objects we are familiar with. Everyday objects exist only in definite states. Mixed states can include many objects, all coexisting, or entangled, together.
How is it possible for the fabric of reality to be both waves and particles at the same time? In the first few decades of the twentieth century, a new theory, Quantum Mechanics, was developed to account for the wave-particle nature of light and matter.

This theory was not just applicable to describing elementary particles in exotic conditions, but provided a better way of describing the nature of physical reality itself.
Einstein's Theory of Relativity also altered the Newtonian view of the fabric of reality, by showing how basic concepts like mass, energy, space, and time are related. Relativity is not just applicable to cosmological domains or to objects at close to light-speeds, but refers to the basic structure of the fabric of reality. In sum, modern physics tells us that the world of common sense reveals only a special, limited portion of a much larger and stranger fabric of reality.

The Basics Wave-Particle Co Existence

Electrons can behave as both particles and waves. As waves, electrons have no precise location but exist as "probability fields." As particles, the probability field collapses into a solid object in a particular place and time. Unmeasured or unobserved electrons behave in a different manner from measured ones. When they are not measured, electrons are waves. When they are observed, they become particles. The world is ultimately constructed out of of elementary particles that behave in this curious way.

Heisenberg Uncertainty Principle

In classical physics, all of an object's attributes are in principle accessible to measurement. Not so in quantum physics. You can measure a single electron's properties accurately, but not without producing imprecision in some other quantum attribute.
Quantum properties always come in "conjugate" pairs. When two properties have this special relationship, it is impossible to know about both of them at the same time with complete precision. Heisenberg's Uncertainty (also know as the Indeterminacy) Principle, says that if you measure a particle's position accurately, you must sacrifice an accurate knowledge of its momentum, and vice versa. A relationship of the Heisenberg kind holds for all dynamic properties of elementary particles and it guarantees that any experiment (involving the microscopic world) will contain some unknowns.

Bell's Theorem and Non-Locality

"Local reality" is the reality that is governed by the laws of classical physics. In a local reality, influences cannot travel faster than the speed of light. In 1964 Irish physicist John Stewart Bell showed that any model of reality compatible with quantum theory must be nonlocal. For quantum physics to work, information must travel not just faster than light, but instantaneously. Nonlocality suggests that everything in the universe is connected by information that can appear anywhere else, instantaneously.

The new theories systematically challenged all of the assumptions of classical physics:

Reality faded away like the Cheshire cat because we now know that fundamental properties of the physical world are not fixed; the world changes in subtle ways depending on how we wish to observe it. The objects we encounter in everyday life do not ordinarily exhibit obvious quantum effects because the strangeness of the microscopic world is effectively smoothed out through innumerable interactions with the environment.

Indeed, classical descriptions of nature are often good enough for mundane purposes. But those descriptions are an approximation of a more fundamental quantum world, leaving open the possibility that some aspects of observation may subtly persist even into classical domains.

Locality was replaced with nonlocality, the idea that objects that are apparently separate are actually connected instantaneously through space-time. With nonlocality it is no longer true that unmediated action at a distance is not possible. In fact, such actions are required.

Causality has dissolved because the fixed arrow of time is now known to be a persistent illusion, a misapprehension sustained by the classical assumptions of an absolute space and time. We now know that sequences of events depend on the perspectives (technically called the frame of reference) of the observers.

Continuity has faded away because we now know that there are some discontinuities in the fabric of reality. Space and time are neither smooth nor contiguous.

What does the phrase “we know” mean? It means that theoretical predictions were made, based on mathematical models, and then repeatedly demonstrated in experiments. If the universe behaves according to the theories, then we are justified in believing that common sense is indeed a special, limited perspective of a much grander universe.

The portrait of reality painted by relativity and quantum mechanics is so far from common sense that it raises problems of interpretation. The mathematics of the theories are precise, and the predictions work fantastically well. But translating mathematics into human terms, especially for quantum mechanics, has remained exceedingly difficult.

The perplexing implications of quantum mechanics were greeted with shock and awe as scientists who developed it began to seriously consider its implications. Many physicists today believe that a proper explanation of reality in light of quantum mechanics and reliability — science fiction has familiarized us with ideas like starship “warp drives” requires radical revisions of one or more common-sense assumptions. And there are both theoretical and experimental reasons to believe that regarding reality, locality, causality or continuity, either one, several, or all of these are incorrect.

Given the continuing confusions in interpreting quantum mechanics, some physicists refuse to accept the idea that reality can possibly be so perplexing, convoluted, or improbable compared to common sense, that is. And so they continue to believe, as did Einstein, that quantum mechanics must be incomplete and that once "fixed" it will be found that the classical assumptions are correct after all, and then all the quantum weirdness will go away. Outside of quantum physics, there are a few scientists and the occasional philosopher who worry about such things, but most of us do not spend much time thinking about quantum mechanics at all. If we do, we assume it has no relevance to our particular interests. This is understandable and in most cases perfectly fine for practical purposes. But when it comes to understanding the nature of reality, it is useful to keep in mind that quantum mechanics describes the fundamental building blocks of nature, and the classical world is composed of those blocks too, whether we observe them or not.

The competing interpretations of quantum mechanics differ principally on which of the common-sense assumptions one is comfortable in giving up. Some of the more widely known

interpretations of quantum mechanics include the Copenhagen Interpretation,
Wholeness, Many Worlds, NeoRealism, and, as promoted by the *What the Bleep?* film,Consciousness Creates Reality.

Copenhagen Interpretation – This is the orthodox interpretation of quantum mechanics, promoted by Danish physicist Niels Bohr (thus the reference to Copenhagen, where Bohr's institute is located). In an overly simplified form, it asserts that there is no ultimately knowable reality. In a sense, this interpretation may be thought of as a "don't ask–don't tell" approach that allows quantum mechanics to be used without having to worry about what it means. According to Bohr, it means nothing, at least not in ordinary human terms.

Wholeness – Einstein's protege David Bohm maintained that quantum mechanics reveals that reality is an undivided whole in which everything is connected in a deep way, transcending the ordinary limits of space and time.

Many Worlds – Physicist Hugh Everett proposed that when a quantum measurement is performed, every possible outcome will actualize. But in the process of actualizing, the universe will split into as many versions of itself as needed to accommodate all possible measurement results. Then each of the resulting universes is actually a separate universe. Popular television shows like *Sliders* and a few scenes in *What the Bleep?* capitalize on these ideas.

Quantum Logic – This interpretation says that perhaps quantum mechanics is puzzling because our common sense assumptions about logic break down in the quantum realm. Mathematician John von Neumann developed a "wave logic" that could account for some of the puzzles of quantum theory without completely abandoning classical concepts. Concepts in quantum logic have been vigorously pursued by philosophers.

NeoRealism – This was the position led by Einstein, who refused to accept any interpretation, including the Copenhagen Interpretation, asserting that common sense reality does not exist. The neorealists propose that reality consists of objects familiar to classical physics, and thus the paradoxes of quantum mechanics reveal the presence of flaws in the theory. This view is also known as the "hidden variable" interpretation of quantum mechanics, which assumes that once we discover all the missing factors the paradoxes will go away.

Consciousness Creates Reality – This interpretation pushes to the extreme the idea that the act of measurement, or possibly even human consciousness, is associated with the formation of reality. This provides the act of observation an especially privileged role of collapsing the possible into the actual. Many mainstream physicists regard this interpretation as little more than wishful New Age thinking, but not all. A few physicists have embraced this view and have developed descriptive variations of quantum theory that do accommodate such ideas.

Science and Mysticism

Does quantum mechanics help us to understand consciousness? How does it inform our understanding of the spiritual dimensions of our experience? We must remember in our attempts to address these questions that confusion can arise when we mix metaphors with mathematics. There are clearly areas of commonality between mystical experiences of unity and what physicists describe as the quantum field. Still, the leaders of quantum mechanics—including Niels Bohr, Werner Heisenberg, and Erwin Schrodinger—rejected the idea that physics and mysticism were describing the same phenomena. In the words

of Max Planck, efforts to bring them together are "founded on a misunderstanding or, more precisely, on a confusion of the images of religion with scientific statements.
Needless to say, the result makes no sense at all."
However, it does makes sense to seek a reconciliation between science and spirituality.
As noted by Tom Huston in his review of *What the Bleep?* for *What Is Enlightenment?* magazine :
"In our postmodern and scientific age, what is the most obvious direction for a spiritually seeking soul to turn in search of Truth (with a capital T) after traditional mythic religion has been seen through and left behind? Why, it's toward science, surely, with its claim to universal truth and its mathematical certainty to ten decimal places about the inner logic of space and time. Having our spiritual beliefs backed by science lends them some degree of legitimacy, however tenuous the connection. Moreover, it seems to make those beliefs more easily defensible against the preying guards of scientific authority—that is, the skeptics and scientific materialists of our era—both when encountering such adversaries in the world at large and when the same materialist doubts arise in our own minds. . . .
That we should even feel the need to overcome the doubt of the scientific materialist worldview indicates how all-pervasive it actually is, and how thoroughly steeped in it most of us are."

Quantum physics, with its startling revelations and freakish discoveries, has successfully awakened the world from what William Blake called “Newton’s slumber.” We can no longer look at a world that appears real, local, consistent, and causal, and believe with full conviction that we are perceiving the whole of reality. Nor can we say that we know what reality we are perceiving. Until more secrets are revealed, perhaps all we can say is:
“What the bleep do we know?”

3

WHAT IS A QUANTUM THEORY?

We have been asking that question for a long time, ever since Max Planck introduced the element of discontinuity we call the quantum a century ago.

Since then, the chunkiness of Nature (or at least of our theories about it) has been built into our basic conception of the world.

It has prompted a fundamental rethinking of physical theory.

At the same time it has helped make sense of a whole range of peculiar behaviors manifested principally at microscopic levels.

From its beginning, the new regime was symbolized by Planck's constant h, introduced in his famous paper of 1900. Measuring the world's departure from smooth, continuous behavior, h proved to be a very small number, but different from zero.

Wherever it appeared, strange phenomena came with it.
What it really meant was of course mysterious. While the quantum era was inaugurated in 1900, a quantum theory would take much longer to jell. Introducing discontinuity was a tentative step, and only a first one. And even thereafter, the recasting of physical theory was hesitant and slow.

Physicists pondered for years what a quantum theory might be. Wondering how to integrate it with the powerful apparatus of nineteenth-century physics, they also asked what relation it bore to existing, “classical” theories. For some the answers crystallized with quantum mechanics, the result of a quartercentury’s labor. Others held out for further rethinking. If the outcome was not to the satisfaction of all, still the quantum theory proved remarkably successful, and the puzzlement along the way, despite its frustrations, can only be called extraordinarily productive.

INTRODUCING *h*[8]

The story began inconspicuously enough on December 14, 1900. Max Planck was giving a talk

[8] Planck’s Constant relates the energy of light photons to their frequency. It also shows up in de Broglie’s relation for the wavelength of matter waves and Schrödinger’s Equation. Thus, the number is of fundamental importance in 20th Century physics.

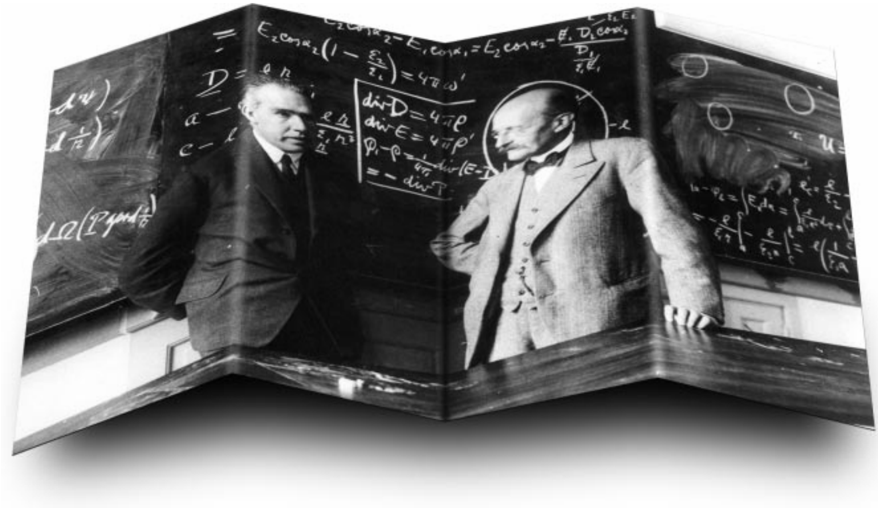
to the German Physical Society on the continuous spectrum of the frequencies of light emitted by an ideal heated body. Some two months earlier this 42-year-old theorist had presented a formula capturing some new experimental results. Now, with leisure to think and more time at his disposal, he sought to provide a physical justification for his formula.

Planck pictured a piece of matter, idealizing it somewhat, as equivalent to a collection of oscillating electric charges. He then imagined distributing its energy in discrete chunks proportional to the frequencies of oscillation. The constant of proportionality he chose to call *h*; we would now write $\varepsilon = hf$.

The frequencies of oscillation determined the frequencies of the emitted light. A twisted chain of reasoning then reproduced Planck's postulated formula, which now involved the same natural constant *h*.

Looking back on the event, we might expect revolutionary fanfare. But as so often in history, matters were more ambiguous.

Planck did not call his energy elements quanta and was not inclined to stress their discreteness, which made little sense in any familiar terms. So the meaning of his procedure only gradually became apparent. Although the problem he was treating was pivotal in its day, its implications were at first thought to be confined.



Two theorists, Niels Bohr and Max Planck, at the blackboard.
(Courtesy Emilio Segre` Visual Archives, Margrethe Bohr Collection)

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Values of h Units

6.62606896(33)×10- 34 J·s

4.13566733(10)×10- 15 eV·s

6.62606896(33)×10- 27 erg·s

Values of h (h-bar) = h/2π Units

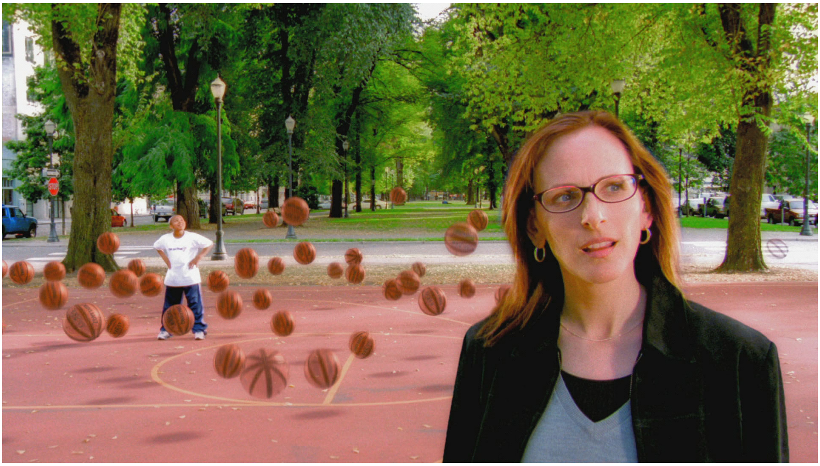
1.054571628(53)×10- 34 J·s

6.58211899(16)×10- 16 eV·s

1.054571628(53)×10- 27 erg·s

What the Bleep" Quantum Measurement

The locally-produced movie What the Bleep Do We Know is entertaining and thought-provoking, although sometimes misleading about mainstream science. It includes a scene depicting quantum measurement – when Marlee Matlin looks away, the audience sees a wave function of many basketballs behind her, but when she turns around and looks at the wave function, she sees only one basketball.



This is a movie visualization of a quantum mechanical wave function collapsing when it is measured (by Marlee Matlin's eyes, in this case). How accurately does this picture represent quantum physics? The short answer: not bad for a movie, although it is somewhat oversimplified.

4

QUANTUM MECHANICAL DUAL NATURE (Light)

All things have a dual particle/wave nature. Which property is important noticeable depends on the experiment.The light two slit experiment reveals wave nature of light.The Compton experiment, photoelectric effect reveals the particle nature of light.
De Broglie's hypothesis suggested a wave character for particles.This wave nature revealed itself in the Davisson-Germer experiment.
Also in the particle two-slit experiment.

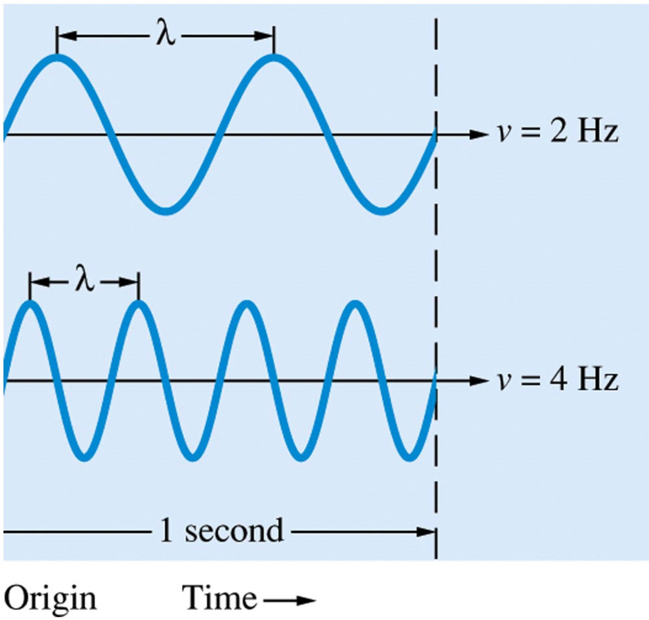
- **Wavelength** – the distance between any two adjacent identical points in a wave (given the notation λ
- **Frequency** – number of wavelengths that pass a fixed point in one unit of time (usually per second, given the notation ν). The common unit of freq is hertz (Hz, /s)
- Propagation of a wave given as

$c = \lambda\nu$

c = speed of light = 3.0 x 108 m/s in a vacuum

c is independent of λ or ν in a vacuum

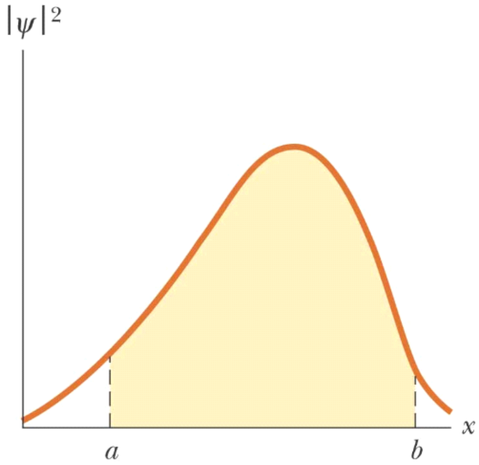
Wavelength and frequency are inversely proportional



$$\int_{-\infty}^{\infty} |\psi|^2 \, dx = 1$$

$$\int_{a}^{b} |\psi|^2 \, dx = P_{ba}$$

QUANTUM MECHANICAL DUAL NATURE
(Light)



Wave-Particle Duality is a central concept in Chemistry & Physics.All matter and energy exhibits both wave-like and particle-like properties.Duality applies to macroscopic (large scale) objects, microscopic objects (atoms and molecules), and quantum objects (elementary particles).As atomic theory evolved, matter was generally thought to consist of particles.At the same time, light was thought to be a wave. Christiaan Huygens proposed the wave theory in light. Huygen's wave theory was displaced by Isaac Newton's view that light consisted of a beam of particles. In the early 1800s Young and Fresnel showed that light, like waves, could be diffracted and produce interference patterns, confirming Huygen's view.

In the late 1800s James Maxwell developed equations, later verified by experiment, that explained light as a propagation of electromagnetic waves.
As the temperature of an object changes, the intensity and wavelength of the emitted light from the object changes in a manner characteristic of the idealized “Blackbody” in which the temperature of the body is directly related to the wavelengths of the light that it emits.
In 1901, Max Planck developed a mathematical model that reproduced the spectrum of light emitted by glowing objects.His model had to make a radical assumption (at that time):
A vibrating (oscillating) atom can have only certain quantities of energy and in turn can only emit or absorb only certain quantities of energy

Planck’s Model:

E (Energy of Radiation)
v (Frequency)
n (Quantum Number) = 1,2,3…
h (Proportionality Constant
6.626 x 10-34 J•s)
6.626 x 10-34 kg•m2/s
Atoms, therefore, emit only certain quantities of energy and the energy of an atom is described as being ***“quantized”.***
Thus, an atom changes its *energy state* by emitting (or absorbing) one or more ***quanta***

The Planck model views emitted energy as waves. Wave theory associates the energy of the light with the *amplitude* (intensity) of the wave, *not the frequency* (color).Wave theory predicts that an electron would break free of the metal when it absorbed enough energy from light of *any* color (frequency).Wave theory would also imply a *time lag* in the flow of electric current after absorption of the radiation.Both of these observations are at odds with the ***Photoelectric Effect.***

Photoelectric Effect

Flow of electric current when monochromatic light of sufficient ***frequency*** shines on a metal plate.Electrons are ejected from the metal surface, only when the *frequency* exceeds a certain threshold characteristic of the metal.
Radiation of lower frequency would not produce any current flow no matter how intense.
Violet light will cause potassium to eject electrons, but no amount of red light (lower frequency) has any effect.
Current flows immediately upon absorption of radiation.
Einstein resolved these discrepancies. He reasoned that if a vibrating atom changed energy from nhv to $(n-1)hv$, this energy would be emitted as a quantum (hv) of light energy he called a ***photon.***He defined the photon as a *Particle of Electromagnetic* energy, with energy E,

proportional to the observed frequency of the light.The energy (*hv*) of an impacting photon is taken up (absorbed) by the electron and ceases to exist.
The Wave-Particle Duality of light is regarded as complimentary views of wave and particle pictures of light.
In 1921 Albert Einstein received the Nobel Prize in Physics for discovering the photoelectric effect.
Heated gases emit line spectra (v. heated solids).
In 1885, J. J. Balmer showed that the wavelengths, l, in the visible spectrum of hydrogen could be reproduced by a simple formula (Rydberg Equation).

R = Rydberg Constant

The known wavelengths of the four visible lines for hydrogen correspond to values of n = 3, n = 4, n = 5, and n = 6.

Bohr Theory of the Hydrogen Atom

Prior to the work of Niels Bohr, the stability of the atom could not be explained using the then-current theories. How can electrons (e-) lose energy and remain in orbit?
Bohr in 1913 set down postulates to account for (1) the stability of the hydrogen atom and (2) the line spectrum of the atom.

QUANTUM MECHANICAL DUAL NATURE
(Light)

Energy level postulate:
An electron can have only specific energy levels in an atom.

Transitions between energy levels:

An electron in an atom can change energy levels by undergoing a "transition" from one energy level to another.

Bohr's Postulates

Bohr derived the following formula for the energy levels of the electron in the hydrogen atom.

$$E = -\frac{R_h Z^2}{n^2}$$

n = 1, 2, 3 ... ∞ (for H atom)
Z = nuclear charge = 1 for Hydrogen

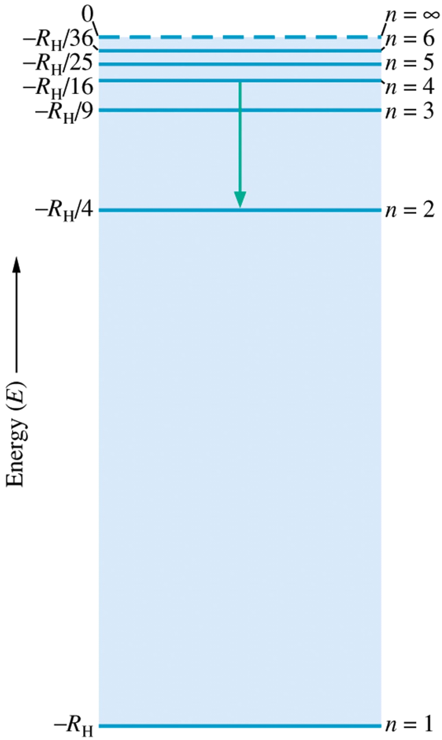
Z = nuclear charge = 1 for Hydrogen
Rh = 2.179 x 10-18 J
n = 1, 2, 3 … ∞ = principal quantum n^o.

When an electron undergoes a transition from a higher energy level to a lower one, the energy is emitted as a photon.

$$\text{Energy of emitted photon} = h\nu = E_i - E_f$$

$$E_i = -\frac{R_h}{n_i^2} \qquad E_f = -\frac{R_h}{n_f^2}$$

If we make a substitution into the previous equation that states the energy of the emitted photon, hn, equals Ei - Ef,



If we make a substitution into the previous equation that states the energy of the emitted photon, hn, equals Ei - Ef,

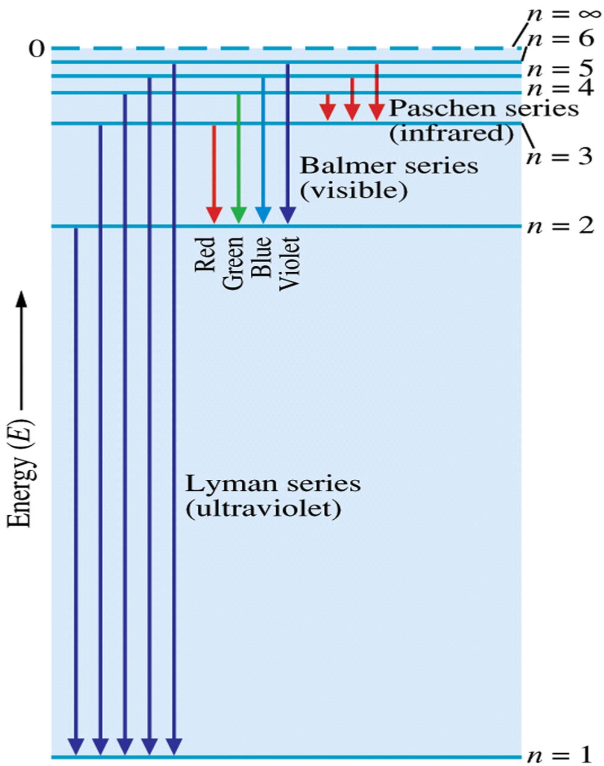
QUANTUM MECHANICAL DUAL NATURE
(Light)

$$h\nu = E_f - E_i = \left(-\frac{R_h}{n_f^2}\right) - \left(-\frac{R_h}{n_i^2}\right)$$

Rearranging:

$$h\nu = \frac{hc}{\lambda} = -R_h\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

$R_h = 2.179 \times 10^{-18}$ J



Bo
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When an electron falls from n = 3 to n = 2 energy level, a photon of red light (wavelength, 685 nm) is emitted.
When red light of this same wavelength shines on a hydrogen atom in the n = 2 level, the energy is gained by the electron that undergoes a transition to n = 3.
Bohr’s theory established the concept of atomic energy levels but did not thoroughly explain the “wave-like” behavior of the electron.
Current ideas about atomic structure depend on the principles of **quantum mechanics**, a theory that applies to subatomic particles such as electrons. Electrons show properties of both waves and particles.
The first clue in the development of quantum theory came with the discovery of the
de Broglie relation.
In 1923, Louis de Broglie reasoned that if light exhibits particle aspects, perhaps particles of matter show characteristics of waves.
He postulated that a particle with mass ***m*** and a velocity ***v*** has an associated wavelength.
The equation $\boldsymbol{\lambda = h/mv}$ is called the **de Broglie relation.**
If matter has wave properties, why are they not commonly observed?
The de Broglie relation shows that a ball (0.145 kg) moving at about 60 mph (27 m/s) has a wavelength of about 1.7 x 10-34 m.

.

$$\lambda = \frac{6.626 \times 10^{-34} \frac{kg \bullet m^2}{s}}{(0.145\ kg)(27\ m/s)} = 1.7 \times 10^{-34} m$$

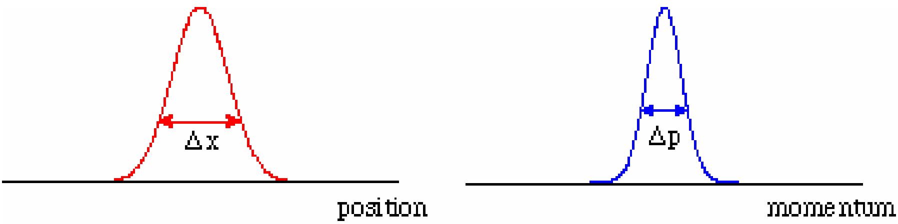
This value is so incredibly small that such waves cannot be detected.
Electrons have wavelengths on the order of a few picometers (1 pm = 10-12 m).

5

THE UNCERTAINTY PRINCIPLE

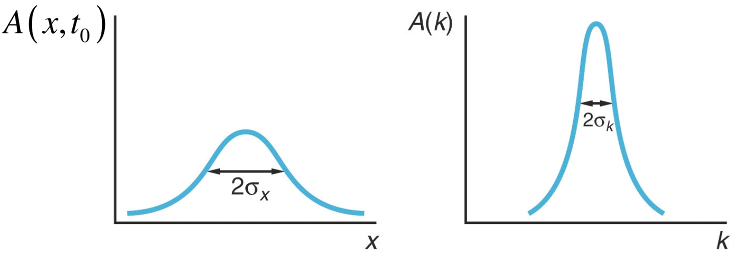
"The more precisely the position is determined, the less precisely the momentum is known in this instant, and vice versa".

Werner Heisenberg, 1927

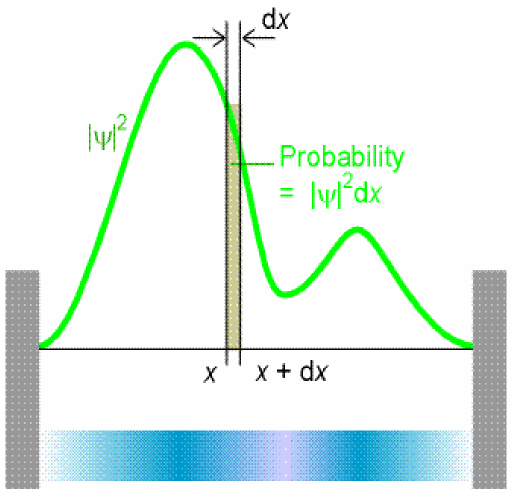


According to the statistical interpretation of the wave function, the probability to find the particle within Δx is proportional to

$$\left|\Psi(x,t)\right|^2 dx = \Psi_0 e^{i(\omega t - kx)} \Psi_0 e^{-i(\omega t - kx)} dx = \Psi_0{}^2 dx$$



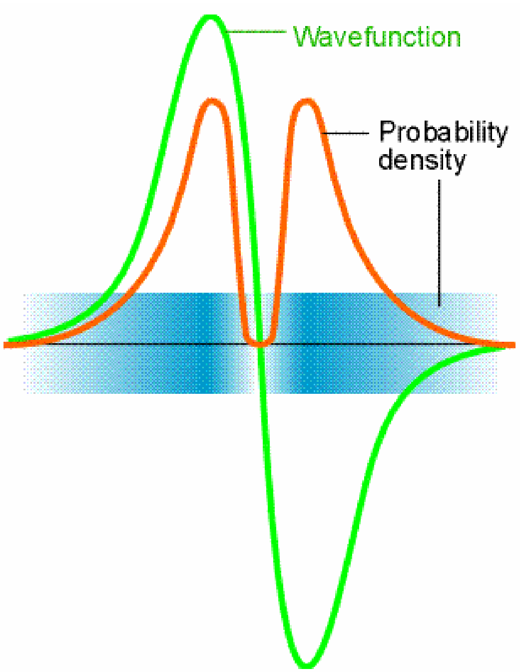
Because of the ***dispersion*** of dB waves, the packet will spread with time. Again, it doesn't mean that the particle itself spreads out with time, rather, the probability of finding the particle away from a moving center of the distribution ***A*(*x,t*)** grows with time.



Example of a 1-dimensional system

$|\psi(r)|2 = \psi(r)\psi^*(r)$ is a ***probability density***. It is always positive!

Wave function may have negative or complex values.



<u>The position x and the momentum px</u>

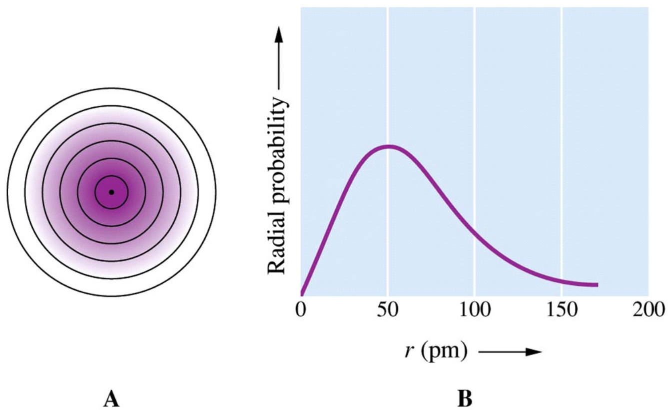
$$\Delta p_x \, \Delta x \geq \frac{\hbar}{2}$$

<u>The time and the energy</u>

$$\Delta t \, \Delta E \geq \frac{\hbar}{2}$$

If a system stays in a state during a time Δt, the energy of this system cannot be determined more accurately than with an error ΔE
Acceptance of the dual nature of matter and energy ($E = mc2$) and the “Uncertainty” Principle culminated in the field of Quantum Mechanics:
Wave Nature of objects on the Atomic Scale
Erwin Schrodinger developed quantum mechanical model of the Hydrogen atom
Atom has certain allowed quantities of energy
Electron’s behavior is wavelike, but its exact location is impossible to know
Electron’s matter-wave occupies 3-dimentional space near nucleus
Wave experiences continuous, but varying influence from the nuclear charge.

Probability of Finding an Electron in a Spherical Shell About the Nucleus:



Each electron is described by 4 quantum numbers
Principal quantum number (n)
Angular momentum quantum number (l)
Magnetic quantum number (ml)
Spin quantum number (ms)
The first three quantum numbers define the wave function of the electrons atomic orbital.
The fourth quantum number refers to the spin orientation of electrons.

The principal quantum number(n)

Represents the "shell number" in which an electron "resides".

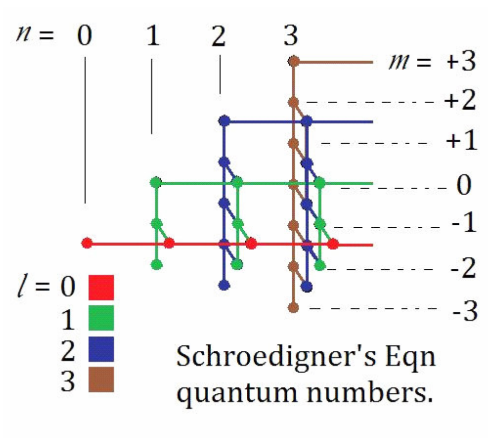
Quantum number on which the energy of the electron principally depends.
The smaller n is, the *smaller* the orbital.
The smaller n is, the *lower* the energy of the electron.
n can have any positive value from 1, 2, 3, 4,…∞, and represents the period number in the periodic chart.

The angular momentum quantum number (l) distinguishes "sub shells" within a given shell that have different shapes.
Each main "shell" is subdivided into "sub shells."
Within each shell of quantum number n, there are n sub shells, each with a distinctive shape.
(I) can have any integer value from 0 to n - 1
The different subshells are denoted by letters.

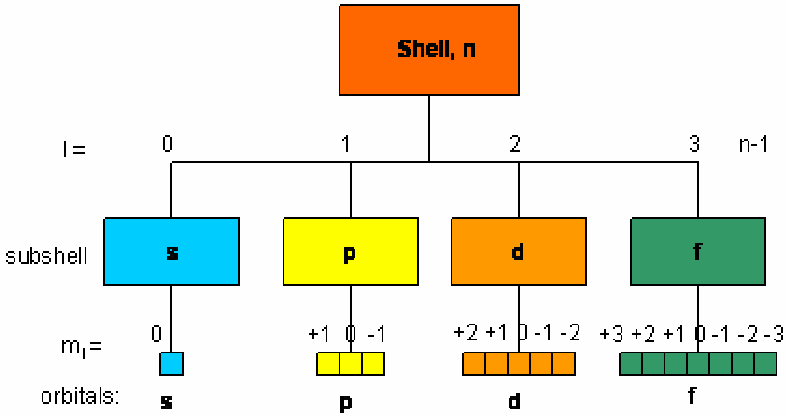
Letter	**s**	**p**	**d**	**f**	**g**	**…**
l	**0**	**1**	**2**	**3**	**4**	**….**

The magnetic quantum number (ml) distinguishes orbitals within a given sub-shell that have different shapes and orientations in space.
Each sub shell is subdivided into "orbitals," each capable of holding a pair of electrons.
ml can have any integer value from -l to +l.
Each orbital within a given sub shell has the same energy.
The spin quantum number (ms) refers to the two possible spin orientations of the electrons residing within a given orbital.
Each orbital can hold only two electrons whose spins must oppose one another.
The possible values of ms are:

+1/2 and –1/2

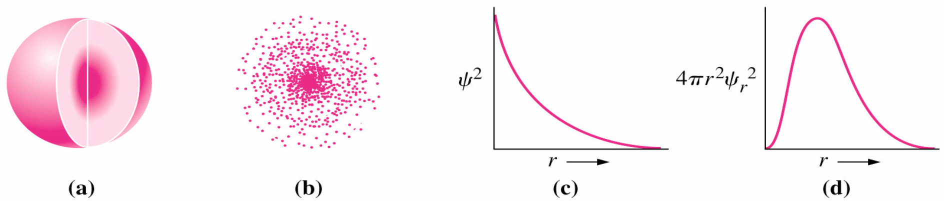


Quantum Numbers



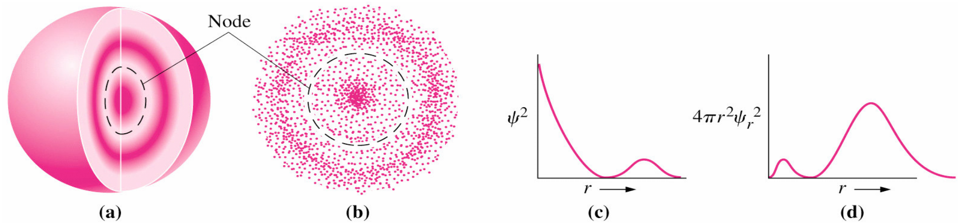
Quantum Number	**Sym bol**	**Values**	**Meaning**
principal	n	1,2,.... ..	Determine size and energy level. For H, energy depend only on n. (Shell)
angular mom.	l	0,1,... ,n -1	Determine 3D shape of orbitals: 0 =s, 1=p, 2=d, 3=f (Subshell l = 0,1,2,3,.)
magnetic	m_l	-l, l-1, ... -l	Spatial orientation of orbitals.
spin magnetic	m_s	+1/2; -1/2	spin state of electron

1s Orbital ($n = 1, l = 0, m_l = 0$)

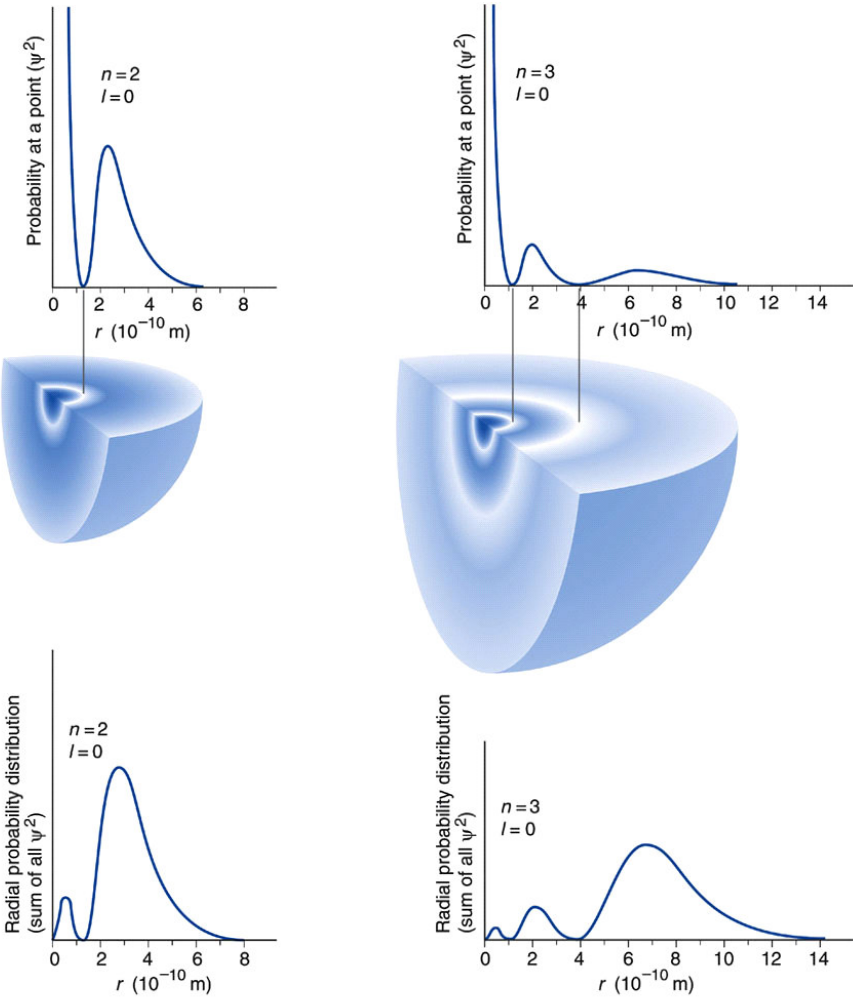


(a) Boundary surface diagram (encloses **90% probability** of the total electron)
(b) Two-dimensional **cross-section dots** plot
(c) Plot of an electron probability **(ψ2)** versus distance from the nucleus **(r)**, at a **given point**
(d) Plot of total electron probability **(4πr2ψ2)** versus distance from the nucleus **(r)**, the peak corresponds to the most probable radius for the electron.

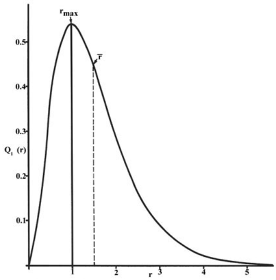
2s Orbital ($n = 2, l = 0, m_l = 0$)



- Two regions of high electron probability, both being spherical
- **Node**: the region of **zero electron probability**

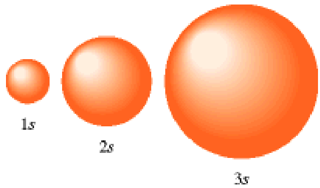


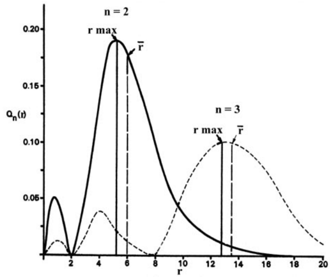
B 2*s* orbital **C 3*s* orbital**



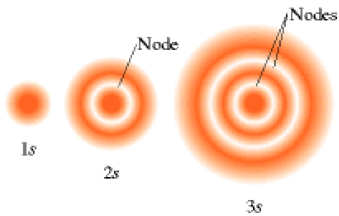
1*s* orbital ψ^2

spherical

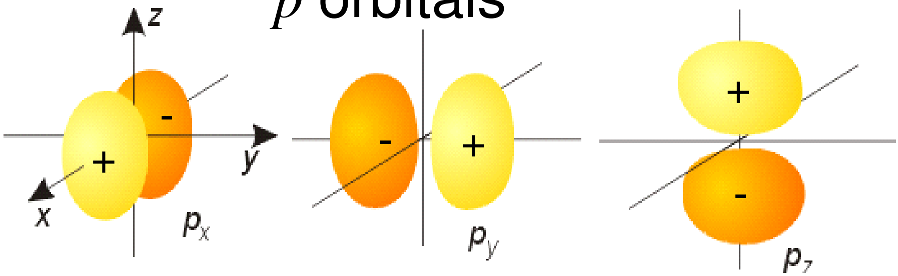




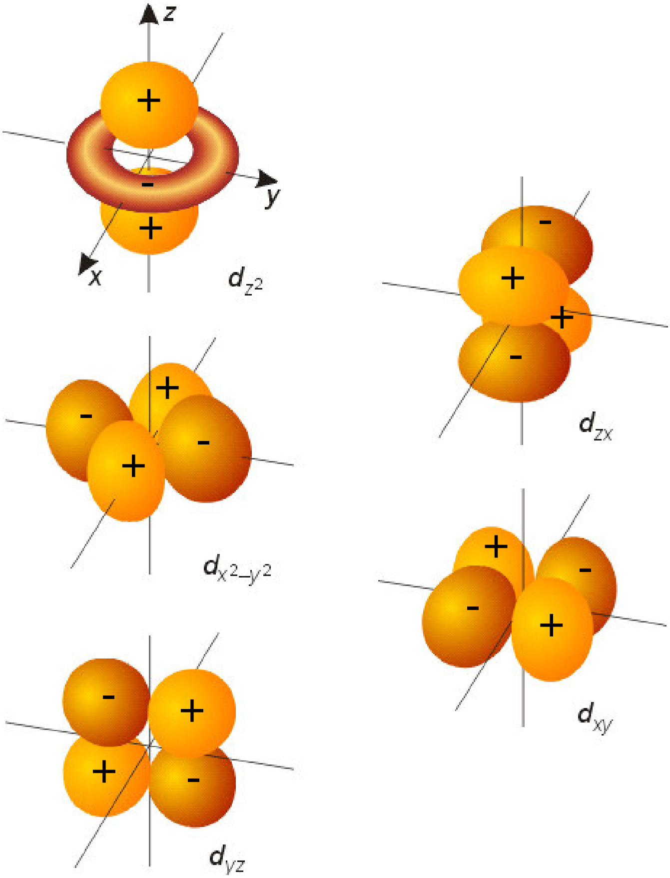
2*s* and 3*s* ψ^2

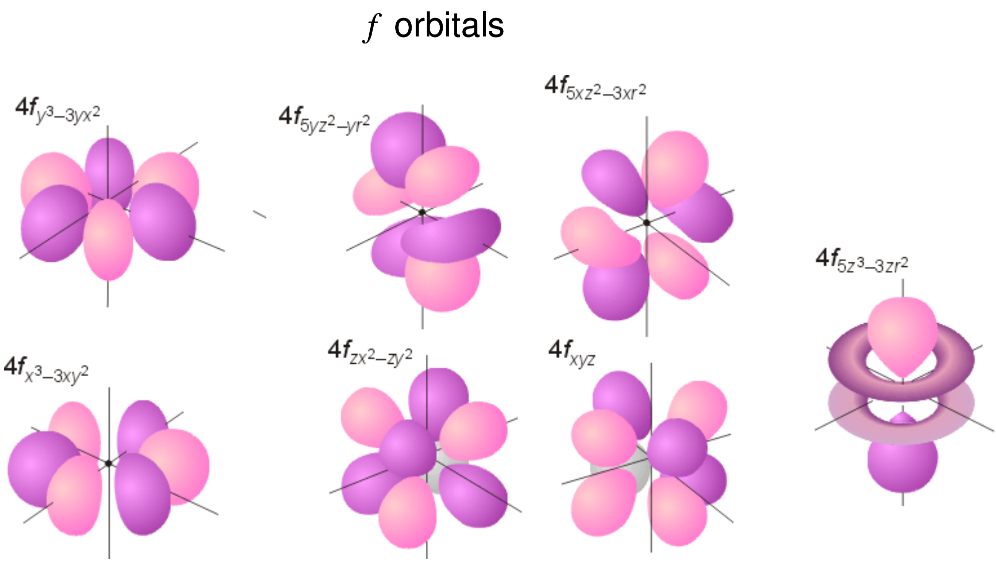


p orbitals



d orbitals





f orbitals
4f$_{y^3-3yx^2}$
4f$_{5yz^2-yr^2}$
4f$_{5xz^2-3xr^2}$
4f$_{5z^3-3zr^2}$
4f$_{x^3-3xy^2}$
4f$_{zx^2-zy^2}$
4f$_{xyz}$

6

THE ANTHROPIC PRINCIPLE

First suggested in 1973 in a paper by astrophysicist and cosmologist Brandon Carter from Cambridge University.
It is an attempt to explain the observed fact that the fundamental constants of physics and chemistry are just right (Goldilocks factors) or fine-tuned to allow the universe and life as we know it to exist.
The seemingly arbitrary and unrelated constants in physics have one strange thing in common – these are precisely the values you need if you want to have a universe capable of producing life. If the elements were not just right, we would not be here to observe (and make discoveries about) the earth and the universe.

Number of Stars

+1%	Tidal interactions disrupt planetary orbits
- 1%	Heat produced insufficient for life

Parent Star Birth Date

More recent: Not yet stable burning phase
Less recent: Stellar system would not yet contain enough heavy elements

Parent Star Age

Older: Luminosity of star would change too quickly
Younger: Luminosity of star would change too quickly.

Parent Star Distance from Center of Galaxy:

Farther: Quantity of heavy elements would be insufficient to make rocky planets.
Closer: Stellar density and radiation too great.

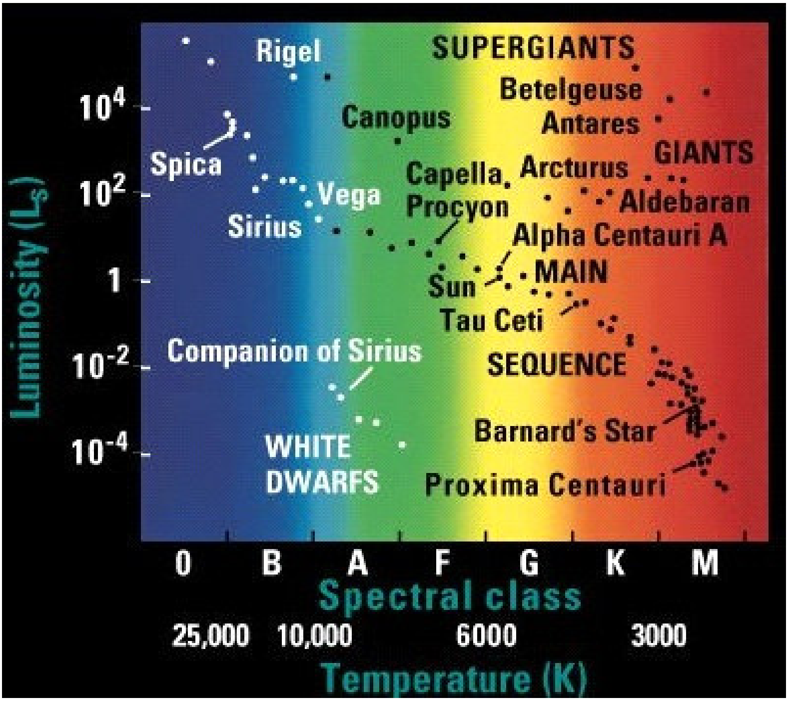
Parent Star Mass:

Greater: Luminosity of star would change too quickly; star would burn too rapidly
Lesser: Range of distances appropriate for life would be too narrow; tidal forces would disrupt the rotational period for a planet at the right distance.

Parent Star Color

Redder: Photosynthetic response insufficient.

Bluer: Photosynthetic response insufficient



Surface Gravity

Stronger: Too much ammonia and methane in the atmosphere

Weaker: Atmosphere would lose too much water

Distance From Parent Star

Farther: Too cool for stable water cycle
Closer: Too warm for stable water cycle

Thickness of Crust

Thicker: Too much oxygen would be transferred from the atmosphere to the crust

Thinner: Volcanic and tectonic activity would be too great

Rotation Period

Longer: Diurnal temperature differences would be too great
Shorter: Atmospheric wind velocities would be too great

Gravitational Interaction With a Moon

Greater: Tidal effects on the oceans, atmosphere, and rotational period would be too severe.
Less: Planet's orbital obliquity would change so Much as to cause climatic instabilities.

Magnetic Field

Stronger: Electromagnetic storms would be too severe.

Weaker: Inadequate protection from hard
stellar radiation.

Axial Tilt

Greater: Surface temperatures would be too great
Less: Surface temperatures would be too great

Reflectivity (Albedo)

Greater: Runaway ice age would develop
Less: Runaway greenhouse effect would
develop

Oxygen to Nitrogen Ratio:

Carbon Dioxide and Water Vapor Levels:

Greater: Runaway greenhouse effect would
develop
Less: Greenhouse effect would be insufficient

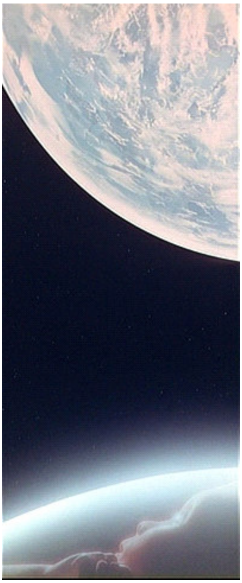
Ozone Level:

Greater: Surface temperatures would be too low
Less: Surface temperature would be too high:
Too much UV radiation at the surface

Atmospheric Electric Discharge Rate:

Greater: Too much fire destruction
Less: Inadequate nitrogen fixing in the soil

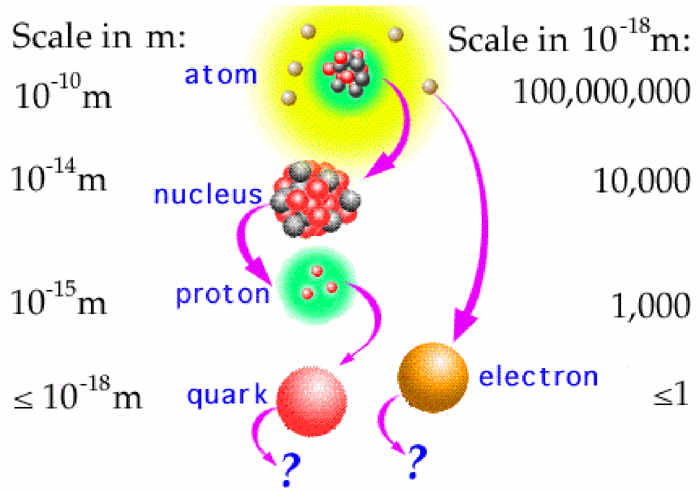
- The Universe seems right for life
  - Space is ‘flat’
  - Atom stability is right
  - Gravity works as 1/r2
- How to explain these coincidences?
  - If intelligent life weren’t possible, we wouldn't be here to think about it.
  - Our the universe is designed for life.
  - "If we weren't here, the universe couldn't exist."



7

THE STANDARD MODEL: “Ingredients for a Universe”

Particle physics, like I have previously said, aims to answer the BIG questions about the Universe by studying space and matter at its smallest level
If a helium atom was the size of a large city, each proton and neutron would be the size of a person, and each quark and electron would be smaller than a tiny freckle.



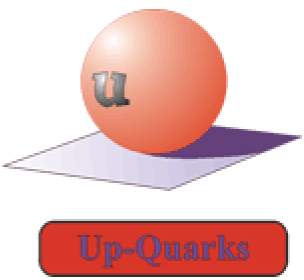
An *elementary particle* is a point particle without structure that is not constructed from more elementary entities.
With the advent of particle accelerator in the 1950's many new elementary particles were discovered.
There are three pairs of quarks[9].
The up and down are the constituents of : protons = uud and neutrons = udd, and make up most matter.
The other particles are produced in energetic subatomic collisions from cosmic rays or in accelerators like Fermilab.
The quarks are not capable of independent existence, and are found only as groups, making up larger particles (called "bound states").
There are 6 quarks, called up, down, charm, strange, bottom and top. The "everyday" quarks are the up and down quarks. For each quark there is an anti-quark.
The quarks have mass and electric charge. The electric charges are either $+\frac{2}{3}$ or $-\frac{1}{3}$ for quarks, and $-\frac{2}{3}$ or $+\frac{1}{3}$ for the matching anti-quarks.
They also have spin of $\pm\frac{1}{2}$. There is also another property called "colour" charge, which comes in

---

[9] Murray Gell-Mann had just been reading *Finnegan's Wake* by James Joyce which contains the phrase "*three quarks for Muster Mark*".
He decided it would be funny to name his particles after this phrase.
Murray Gell-Mann had a strange sense of humor!

3 varieties, red, green and blue. The anti-quarks have anti-colours: anti-red, anti-green and anti-blue.

The “bound states” must be colour-neutral.
This means that only two types of groupings are possible; 3 quarks (or 3 anti-quarks), or a quark-antiquark pair. The particles of the first type are called baryons, and the most familiar examples are the proton and the neutron. The second type is the mesons. Together they are called hadrons.
As a consequence of this, the bound states can only have integral charges (0, ±1, ±2).
There are also other rules, for example about spin, which must also be obeyed.
Example: The proton has a charge of +1. It is a baryon, so it is made up of 3 quarks.
Since the up quark has a charge of $+\frac{2}{3}$ and the down quark has a charge of $-\frac{1}{3}$, the only way to make up a proton is uud. ($\frac{2}{3} + \frac{2}{3} - \frac{1}{3} = 1$).
The quarks will be one each of rgb, making the proton colour-neutral, and all the rules are satisfied.



Discovered: SLAC (1968)

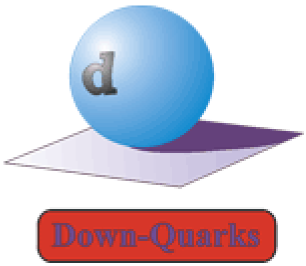
Mass: 1.5–3.3 MeV/c2[1]

Decays into: Stable

Electric charge: +2/3 e

Color charge: Yes

Spin: 1/2



Discovered: SLAC (1968)

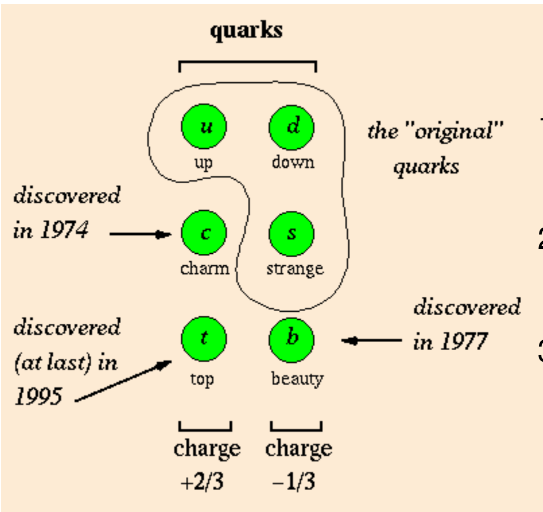
Mass: 3.5–6.0 MeV/c2[1]

Decays into: Stable

Electric charge: - 1/3 e

Color charge: Yes

Spin: 1/2

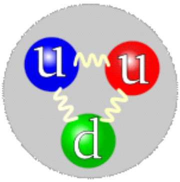


1st generation

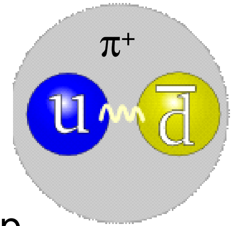
2nd generation

3rd generation

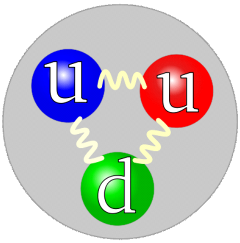
Baryon = 3 quarks and
Meson = quark + antiquark



p

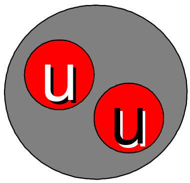


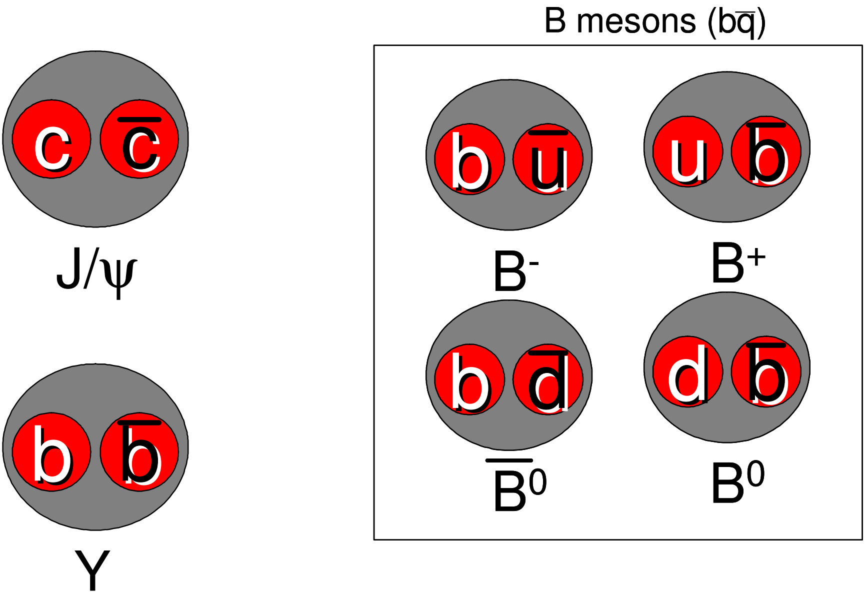
proto
p



Strong forces "glue" quarks together in bound states

pion
π



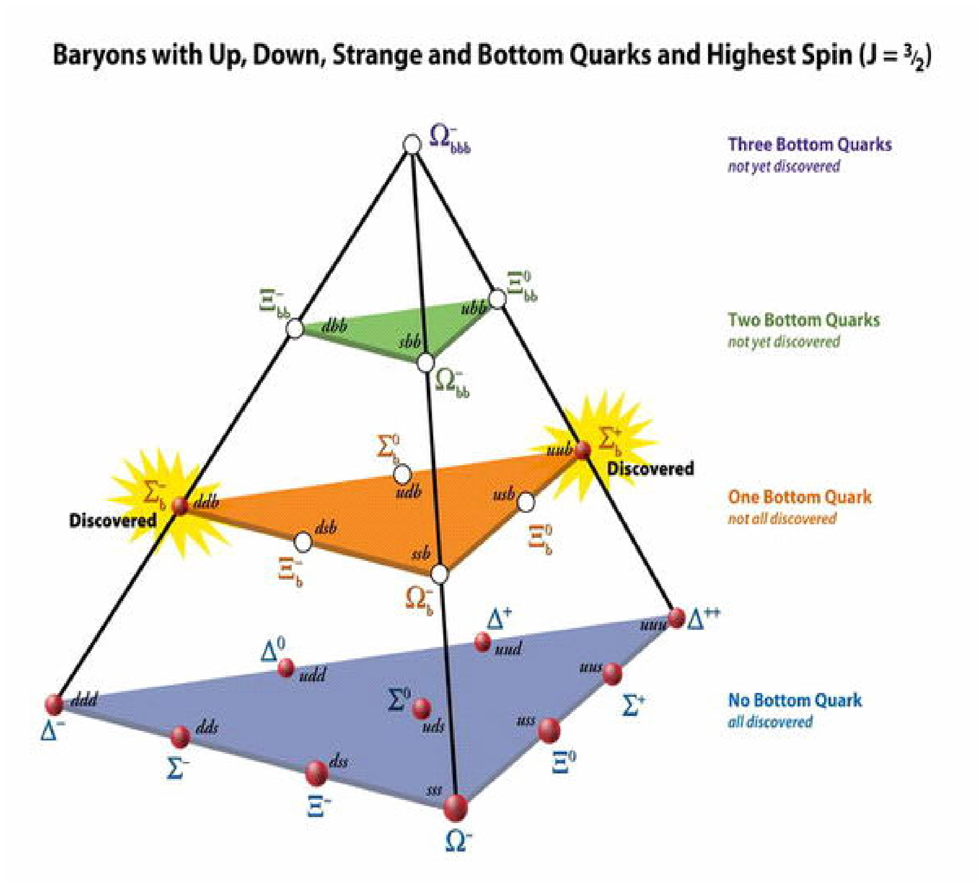


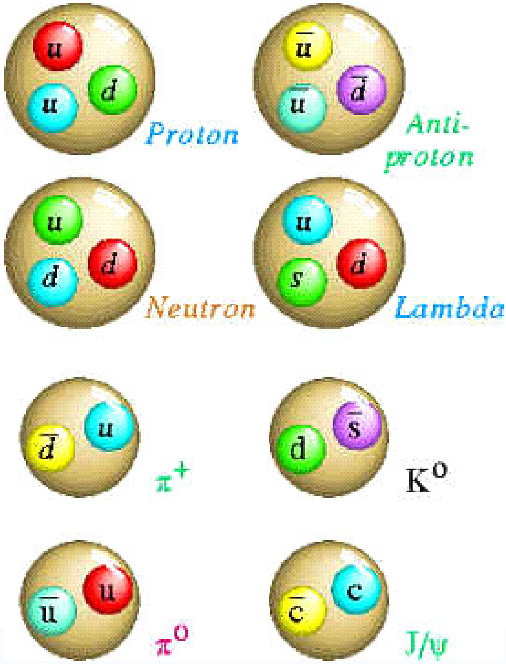
"Young man, if I could remember
the names of these particles,I would have been a botanist!"
E.Fermi to his student
L. Lederman (both Nobel laureates)

Baryons qqq and Antibaryons $\bar{q}\bar{q}\bar{q}$ Baryons are fermionic hadrons. These are a few of the many types of baryons.					
Symbol	**Name**	**Quark content**	**Electric charge**	**Mass GeV/c^2**	**Spin**
p	proton	**uud**	1	0.938	1/2
$\bar{\mathbf{p}}$	antiproton	$\bar{\mathbf{u}}\bar{\mathbf{u}}\bar{\mathbf{d}}$	–1	0.938	1/2
n	neutron	**udd**	0	0.940	1/2
Λ	lambda	**uds**	0	1.116	1/2
Ω^-	omega	**sss**	–1	1.672	3/2

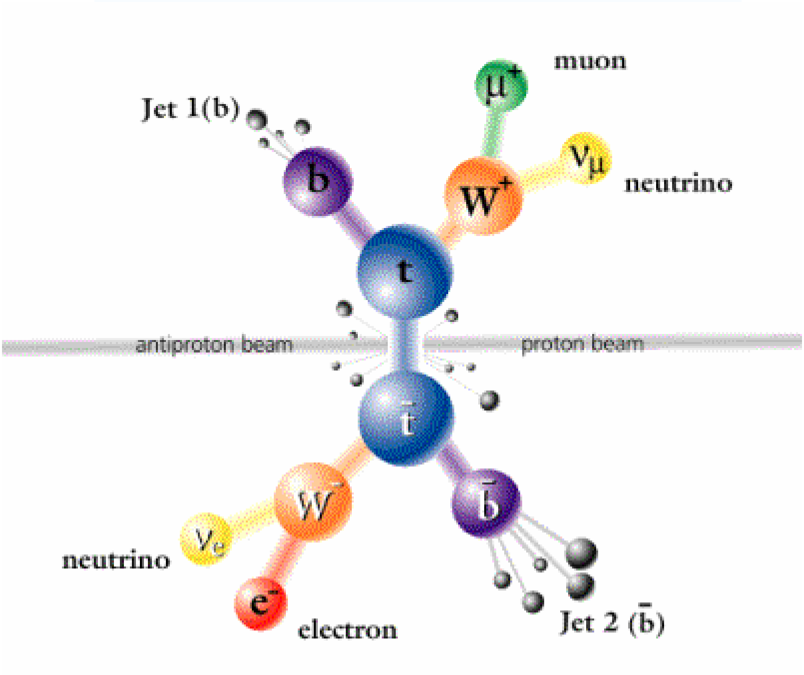
Of the 24 quarks and leptons in the Standard
Model, only
3 are necessary to build atoms and all chemical
elements: u, d, e–

Mesons $q\bar{q}$ Mesons are bosonic hadrons These are a few of the many types of mesons.					
Symbol	**Name**	**Quark content**	**Electric charge**	**Mass GeV/c^2**	**Spin**
π^+	pion	$\mathbf{u}\bar{\mathbf{d}}$	+1	0.140	0
$\mathbf{K}^-$	kaon	$\mathbf{s}\bar{\mathbf{u}}$	–1	0.494	0
ρ^+	rho	$\mathbf{u}\bar{\mathbf{d}}$	+1	0.776	1
B^0	B-zero	$\mathbf{d}\bar{\mathbf{b}}$	0	5.279	0
η_c	eta-c	$\mathbf{c}\bar{\mathbf{c}}$	0	2.980	0

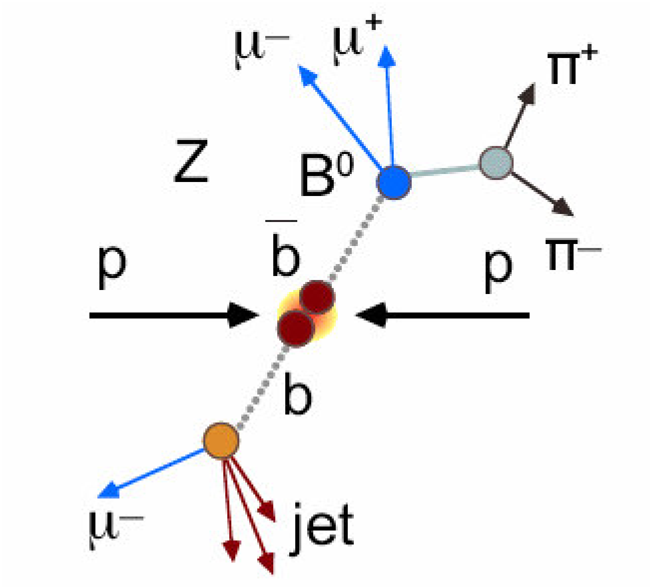

Baryons with Up, Down, Strange and Bottom Quarks and Highest Spin (J = 3/2)
Three Bottom Quarks
not yet discovered
Two Bottom Quarks
not yet discovered
One Bottom Quark
not all discovered
No Bottom Quark
all discovered
Discovered
Discovered
Ω^-_{bbb}
Ξ^-_{bb}
Ξ^0_{bb}
Ω^-_{bb}
dbb
ubb
sbb
Σ^-_b
Σ^0_b
Σ^+_b
Ξ^-_b
Ξ^0_b
Ω^-_b
ddb
udb
uub
dsb
usb
ssb
Δ^-
Δ^0
Δ^+
Δ^{++}
Σ^-
Σ^0
Σ^+
Ξ^-
Ξ^0
Ω^-
ddd
udd
uud
uuu
dds
uds
uus
dss
uss
sss



The **top quark** or **t quark** (from its symbol, *t*) is an elementary particle and a fundamental constituent of matter. Like all quarks, the top quark is an elementary fermion with spin-1/2, and experiences all four fundamental interactions: gravitation, electromagnetism, weak interactions, and strong interactions. It has an electric charge of $+\frac{2}{3}$, and is the most massive of all observed elementary particles. (The Higgs boson, which may be as massive, has not yet been experimentally observed.) It has a mass of 173.1±1.3 GeV/c^2, which is about the same mass as an atom of tungsten. The antiparticle of the top quark is the **top antiquark** (sometimes called antitop quark or simply antitop), which differs from it only in that some of its properties have equal magnitude but opposite sign.The top quark interacts primarily by the strong interaction but can only decay through the weak force. It almost exclusively decays to a W boson and a bottom quark, but it can also sometimes decay into a strange quark, and on the rarest of occasions, into a down quark. The Standard Model predicts its lifetime to be roughly 5×10^{-23} s.



Bottom quark,theorized by Makoto Kobayashi and Toshihide Maskawa (1973),discovered by Leon M. Lederman et al. (1977).
Mass: 4.20GeV/c2,decays into: Charm quark, up quark electric charge: −1⁄3 e.

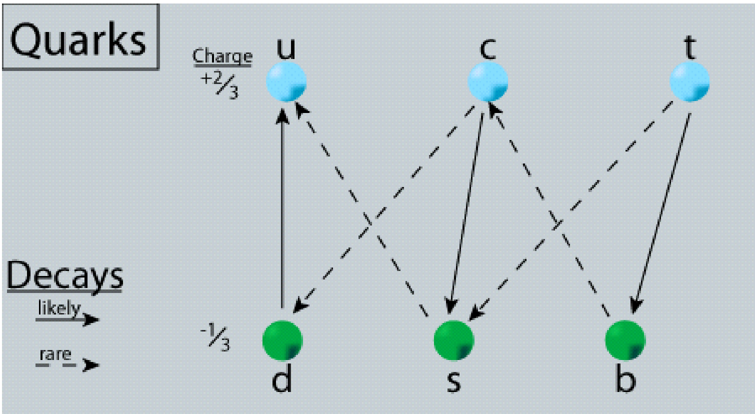


The charm quark or **c quark** (from its symbol, *c*) is the third most massive of all quarks, a type of elementary particle, and a major constituent of matter. Charm quarks are found in hadrons, which are subatomic particles made of quarks. Example of hadrons containing charm quarks include the J/ψ meson (J/ψ), D mesons (D), charmed Sigma baryons (Σ_c), and other charmed particles, Discovered: Burton Richter et al. (SLAC)(1974);Samuel Ting et al. (BNL) (1974);Mass: 1.2707 and decays into: strange and down

The **strange quark** or **s quark** (from its symbol, *s*) is the third-lightest of all quarks, a type of elementary particle, and a major constituent of matter. Strange quarks are found in hadrons, which are subatomic particles made of quarks. Example of hadrons containing strange quarks include kaons (K), strange D mesons (D_s), Sigma baryons (Σ), and other strange particles

Theorized by Murray Gell-Mann (1964) and George Zweig (1964),mass: 70–130 MeV/c2

Decays into: Up quark.



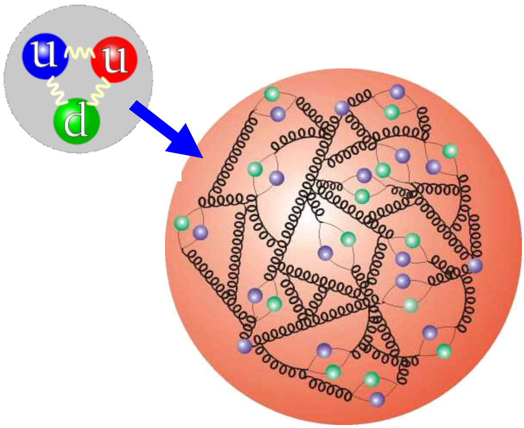
Example: t → b (~10^{-23} [s])
b → c (~10^{-12} [s])
c → s (~10^{-12} [s])
s→u (~10^{-7}-10^{-10} [s])

Quark	**Date**	**Where**	**Mass [GeV/c2]**	**Comment**
up, down	-	-	**~0.005, ~0.010**	Constituents of hadrons, most prominently, proton and neutrons.
strange	1947	-	**~0.2**	discovered in cosmic rays
charm	1974	SLAC/ BNL	**~1.5**	Discovered simultaneously in both *pp* and *e+e-* collisions.
bottom	1977	Fermi-lab	**~4.5**	Discovered in collisions of protons on nuclei
top	1995	Fermi-lab	**~175**	Discovered in pp collisions

HADRONS

Hadrons interact through strong forces.
There are two classes, mesons and baryons,as we have seen.
Hadrons are *not* elementary particles. They are made of quarks.
The forces which hold the protons and neutrons together in thenucleus are VERY strong. They interact via the STRONG FORCE.
Protons and neutrons are among a class of particles called "hadrons"(Greek for strong).
Hadrons interact very strongly with other hadrons.

Hadronization (process of forming hadrons)
1972: Proton = uud
2008: Proton = uud + gluons + q-antiquark pairs



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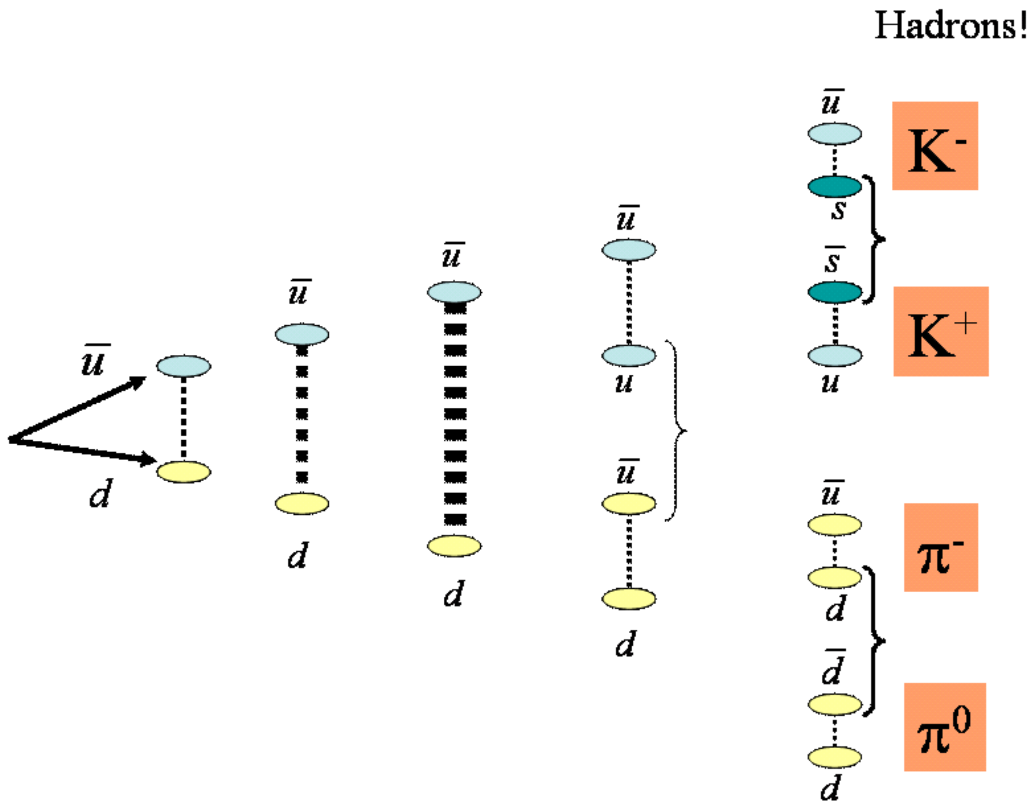
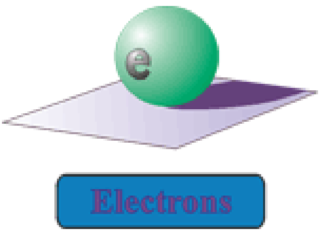

Hadrons!
$\bar{u}$
K-
s
$\bar{s}$
K+
u
$\bar{u}$
π-
d
$\bar{d}$
π0
d
$\bar{u}$
u
$\bar{u}$
d
$\bar{u}$
d
$\bar{u}$
d
$\bar{u}$
d

Leptons

Leptons interact through weak inter-actions, but not via the strong force.
All leptons have spin of 1/2. There are six kinds of lepton: electron e-, muon m-, and tau t -, and 3 neutrinos ne, nm, nt
Leptons were originally named because they were “Light-particles”, but we now know the Tau is twice as heavy as a proton.
Neutrinos were originally thought to be massless, but they probably have a small mass
In Beta decay a neutron decays into a proton plus an electron.
If decay energy shared by proton and emitted electron, energy of electron would be unique, but observed electrons have a range of energies must be a third particle involved: the neutrino Third particle must have no charge or mass, as they are accounted for by the He nucleus and electron.



Discovered: J. J. Thomson (1897)

Mass: 9.10938215(45)×10- 31 kg

5.4857990943(23)×10- 4
u[1,822.88850204(77)]- 1 u]

0.510998910(13) MeV/c2

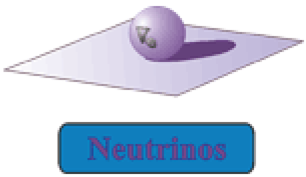
Electric charge: - 1

- 1.602176487(40)×10- 19 C

Magnetic moment: - 1.00115965218111 μB

Spin: 1⁄2

Neutrinos[10]



Discovered: νe: Clyde Cowan, Frederick Reines, F. B. Harrison, H. W. Kruse, A. D. McGuire (1956)

νμ: Leon Lederman, Melvin Schwartz and Jack Steinberger (1962)

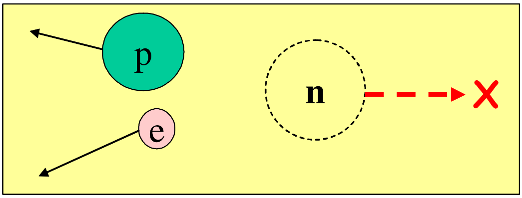
ντ: DONUT collaboration (2000)

Types: 3 – electron neutrino , muon neutrino and tauon neutrino

Fermion	Symbol	Mass
Generation 1		
Electron neutrino	νe	< 2.2 eV
Electron antineutrino	νe	< 2.2 eV
Generation 2		
Muon neutrino	νμ	< 170 keV
Muon antineutrino	νμ	< 170 keV
Generation 3		
Tauon neutrino	ντ	< 15.5 MeV
Tauon antineutrino	ντ	< 15.5 MeV

[10] The Standard Model of particle physics assumed that neutrinos are massless, although adding massive neutrinos to the basic framework is not difficult. Indeed, the experimentally established phenomenon of neutrino oscillation requires neutrinos to have nonzero masses

1934: To account for the "unseen" momentum in neutron decay:



$$n \rightarrow p + e^- + X$$

Fermi proposed that the unseen momentum (X) was carried off by a particle dubbed the neutrino (ν).

1956: Existence of the neutrino confirmed by puttinga detector near to a prolific source of neutrinos, a nuclear reactor, and observing

$n+p \rightarrow e^+ + n$ (Nobel Prize)

Muons

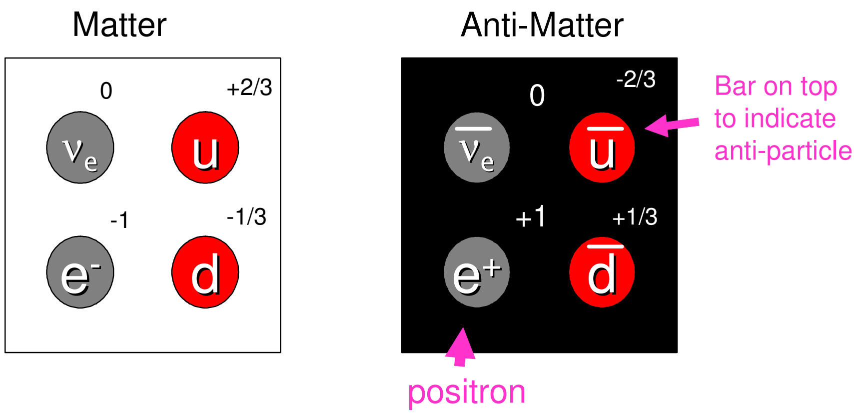
It was discoveredin cosmic ray experiments (1937).

It was also used in the experimental test of time dilation.

We find that a muon behaves almost identical to an electron, except its mass is about 200 times more than the electron's mass.

m=0.51 MeV/c^2 m=106 MeV/c^2

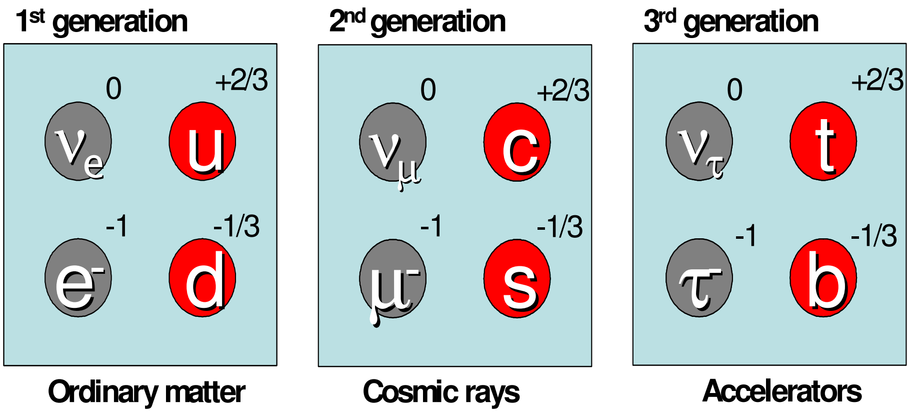
In **1975**, researchers at the Stanford Linear Accelerator discovered a **third charged lepton**, with a mass about **<u>3500 times</u>** that of the electron. It was named the **t-lepton**.
In **2000**, first evidence of the t's partner, the **tau-neutrino (nt)** was announced at Fermi National Accelerator Lab.
For every fundamental particle of matter there is an anti-particle with same mass and properties but opposite charge



Family	Leptons	
	Q = -1	Q = 0
1	e^-	ν_e
2	μ^-	ν_μ
3	τ^-	ν_τ

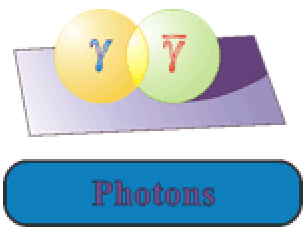
Anti-Lepton	
Q = +1	Q = 0
e^+	$\bar{\nu}_e$
μ^+	$\bar{\nu}_\mu$
τ^+	$\bar{\nu}_\tau$

Quarks and **leptons** are the most fundamental particles of nature that we know about.
Up & **down quarks** and **electrons** are the constituents of ordinary matter.
The other quarks and leptons can be produced in cosmic ray showers or in high energy particle accelerators.
Each particle has a corresponding antiparticle.



3 generations in everything similar but the mass

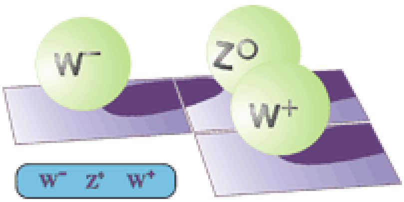
Photons



EMF = Electro Magnetic Force. Force-carrier quanta:
Mass in units of electron mass = 0. Spin = ±1 integer/integral. In quantum theory of radiation, the particle associated with a light wave or electromagnetic waves. Carriers of electric charge. Create electromagnetic waves. Binds electrons to nucleus. Interact with charged hadrons and leptons.

Bosons

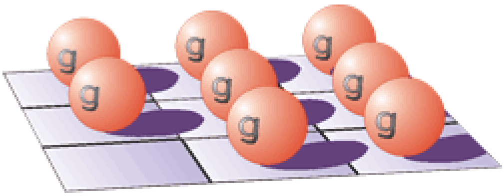
WNF = Weak Nuclear Force.Force-carrier quanta:



Mass in units of electron mass = W boson 86 GeV, Z boson 97 GeV. All spin = ±1 (2, 3, etc.) integer/integral. The W boson is intermediary bosons that mediate the weak interaction. The Z bosons are heavy neutral bosons that mediate neutral-current force. Cause radioactive decay processes of hadrons and baryons. Interact with all hadrons and leptons.

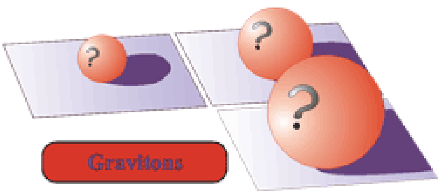
Gluons

SNF = Strong Nuclear Force; Inside Nucleons.



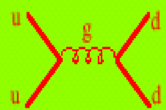
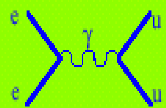
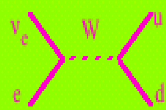
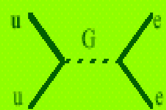
Mass in units of electron or proton mass = ±0. Spin = ???. Electrically neutral objects, that mediate the interactions between quarks within the framework of quantum chromo dynamics inside the hadrons. Particles, that carry the strong interaction between quarks. Binds quarks permanently inside hadrons. Exist and interact only inside of hadrons, as a part of the hadron, but are considered as having been observed, in the form of "jets", in accelerator experiments.

GRAVITON GLUONS (Bosons). Hypothetical.



This is a hypothetical energy quanta, which represent the matter side of gravity and which to this date has only appeared in the mathematics of the theorists. Its mass is in units of electron or proton mass = 0. Spin = ±2 integer. It is the quanta, which interacts with everything and binds planets to the suns and galaxies. It has not been detected in any experiments, and it is apparently not expected to be found anywhere, except in the mathematics of the theorists, or the QF-models for the gravitons. This is the part of General Relativity that Einstein claimed to be "written in straw."

Vector Bosons and Forces

Interaction	exchanged boson	relative strength	example
Strong	Gluon (g)	1	
Electromagnet.	Photon (γ)	$\frac{1}{137}$	
Weak	W^+, W^-, Z^0	10^{-14}	
Gravitation	Graviton (G) ?	10^{-40}	

SOLVED EXERCISES

1) Light with a wavelength of 478 nm lies in the blue region of the visible spectrum.
Calculate the frequency of this light.
Speed of Light = 3 x 108 m/s

$$c = \lambda \bullet \nu$$

$$\nu = c / \lambda = \frac{3 \times 10^{8}\ \frac{m}{s}}{478\ nm\ \frac{10^{-9}\ m}{nm}}$$

$$\nu = 6.28 \times 10^{14}\ / s = 6.28 \times 10^{14}\ Hz$$

2)The green line in the atomic spectrum of thallium has a wavelength of 535 nm. Calculate the energy of a photon of this light?

$$\text{Planck's Constant}\quad h = 6.626 \times 10^{-34}\ J \bullet s$$

$$E = \frac{h \bullet c}{\lambda}$$

$$E = \frac{6.626 \times 10^{-34}\ J \bullet s\ \times\ 3.00 \times 10^{8}\ m/s}{535\ nm\ \frac{10^{-9}\ m}{nm}}$$

$$E = 3.716 \times 10^{-19}\ J$$

3) At its closest approach, Mars is 56 million km from earth. How many minutes would it take to send a radio message from a space probe of Mars to Earth when the planets are at this closest distance?

$$\text{Time} = \text{Distance / Velocity}$$

$$\text{Time} = \left(\frac{56 \times 10^6 \text{ km} \dfrac{1000 \text{ m}}{\text{km}}}{3 \times 10^8 \left(\dfrac{\text{m}}{\text{s}}\right) \left(\dfrac{60 \text{ s}}{\text{min}}\right)} \right)$$

$$\text{Time} = 3.111 \text{ min}$$

4) From the Bohr model of the hydrogen atom we can conclude that the energy required to excite an electron from n = 2 to n = 3 is ____________ the energy to excite an electron from n = 3 to n = 4.

a. less than b. greater than

c. equal to d. either equal to or less than

e. either equal to or greater than

$$E_{2 \to 3} = h\nu = -R_h \left(\frac{1}{3_f^2} - \frac{1}{2_i^2} \right) = -2.179 \text{ x } 10^{-18} \text{ J} * (-0.139) = 3.029 \text{ x } 10^{-19} \text{ J}$$

$$E_{3 \to 4} = h\nu = -R_h \left(\frac{1}{4_f^2} - \frac{1}{3_i^2} \right) = -2.179 \text{ x } 10^{-18} \text{ J} * (-0.049) = 1.068 \text{ x } 10^{-19} \text{ J}$$

$$\therefore \text{ Ans : b} \quad E_{2 \to 3} \rangle E_{3 \to 4}$$

5) An electron in a hydrogen atom in the level n=5 undergoes a transition to level n=3. What is the wavelength of the emitted radiation?

$$E_{5\rightarrow 3} = h\nu = -R_h\left(\frac{1}{3_f^2} - \frac{1}{5_i^2}\right) = -2.179 \times 10^{-18}\ J * (0.071)$$

$$E_{5\rightarrow 3} = h\nu = -1.547 \times 10^{-19}\ J$$

Note: For computation of frequency and wavelength the negative sign of the energy value can be ignored

$$\nu = \left(\frac{E_{5\rightarrow 3}}{h}\right) = \left(\frac{1.547 \times 10^{-19}\ J}{6.626 \times 10^{-34}\ J \bullet s}\right) = 2.335 \times 10^{14}\ /s\ (Hz)$$

$$\lambda = \left(\frac{c}{\nu}\right) = \left(\frac{3.00 \times 10^{8}\ m/s}{\frac{2.335 \times 10^{14}}{s}}\right) = 1.285 \times 10^{-6}\ m$$

6) At what speed must an neutron (1.67 x 10-27 kg) travel to have a wavelength of 10.0 pm?

$$v = h/m\gamma = \left(\frac{6.626\times10^{-34}\ \frac{kg\bullet m^2}{s}}{1.67x10^{-27}\ kg * 10\ pm\left(\frac{10^{-12}\ m}{pm}\right)}\right)$$

$$v = 3.97 \times 10^{5}\ m/s$$

7) What would be the uncertainty in the position of a fly (mass = 1.245 g) that was traveling at a

velocity of 3.024 m/s if the velocity has an uncertainty of 2.72%?

Uncertainty in velocity = 2.72 % = 0.0272

$$\therefore \Delta v = 0.0272 * 3.024 \text{ m/s} = 8.225 \times 10^{-2} \text{ m/s}$$

$$\Delta x = \left(\frac{\frac{h}{4\pi}}{m\,\Delta v} \right) = \left(\frac{5.28\,10^{-35}\ \text{kg} \bullet \text{m}^2/\text{s}}{1.245\ \text{g} \left(\frac{1\ \text{kg}}{1000\ \text{g}} \right) 8.225 \times 10^{-2}\ \text{m/s}} \right)$$

$$\Delta x = 5.157 \times 10^{-33} \text{ m}$$

8) A pulse of light is launched in an optical fiber. The amplitude *A(k)* of the pulses
is peaked in the telecommunications band at the wavelength in air, λ = *1,500* nm.
The optical fiber is dispersive, with n = 1.50 + 102/λ, near λ = *1,500* nm, where λ is expressed in nm. What is the group velocity?

$$v_p = \frac{\omega}{k} = \frac{c}{n} \Rightarrow \omega = \frac{c}{n}k,\ v_g = \frac{d\omega}{dk}$$

$$\frac{d\omega}{dk} = \frac{d(\frac{c}{n}k)}{dk} = \frac{c}{n} + ck\frac{d(\frac{1}{n})}{dk} = \frac{c}{n} - ck(\frac{1}{n^2}\frac{dn}{dk}) = \frac{c}{n} - \frac{ck}{n^2}\frac{dn}{d\lambda}\frac{d\lambda}{dk}$$

$$But\ \lambda = \frac{2\pi}{k},\ so\ \frac{d\lambda}{dk} = -\frac{2\pi}{k^2}$$

$$\frac{d\omega}{dk} = \frac{c}{n} - \frac{ck}{n^2}\frac{dn}{d\lambda}\frac{d\lambda}{dk} = \frac{c}{n} - \frac{c2\pi}{n^2\lambda}\frac{dn}{d\lambda}(-\frac{2\pi}{k^2}) = \frac{c}{n} - \frac{c2\pi}{n^2\lambda}\frac{dn}{d\lambda}(-\frac{\lambda^2}{2\pi}) = \frac{c}{n} + \frac{c\lambda}{n^2}\frac{dn}{d\lambda}$$

$$\frac{d\omega}{dk} = \frac{c}{n}(1 + \frac{\lambda}{n}(\frac{-10^2}{\lambda^2})) = \frac{c}{n}(1 - \frac{10^2}{n\lambda}), \qquad n = 1.5 + \frac{10^2}{1.5 \times 10^3} = 1.567$$

9) What would be the uncertainty in the position of a fly (mass = 1.245 g) that was traveling at a velocity of 3.024 m/s if the velocity has an uncertainty of 2.72%?

$$\Delta x * \Delta p = h/4\pi$$

Δp (= mΔv) is the uncertainty in momentum
h is Planck's constant (6.626 x 10-34 kg•m2/s)

Uncertainty in velocity = 2.72 % = 0.0272

$$\therefore \Delta v = 0.0272 * 3.024 \text{ m/s} = 8.225 \times 10^{-2} \text{ m/s}$$

$$\Delta x = \left(\frac{\frac{h}{4\pi}}{m\,\Delta v} \right) = \left(\frac{5.28\,10^{-35}\ \text{kg} \bullet \text{m}^2/\text{s}}{1.245\ \text{g} \left(\frac{1\,\text{kg}}{1000\,\text{g}} \right) 8.225 \times 10^{-2}\ \text{m/s}} \right)$$

$$\Delta x = 5.157 \times 10^{-33}\ \text{m}$$

10) What would be the kinetic energy of each electron in a beam of electrons having a de Broglie wavelength of 633 nm (the wavelength of light emitted by the common helium-neon laser)?

$$K = \frac{p^2}{2m_e} = \left(\frac{h}{\lambda} \right)^2 \frac{1}{2m_e} = \frac{\left(6.6\times10^{-34} J\cdot s\right)^2}{2\left(633\times10^{-9} m\right)^2 \left(9.1\times10^{-31} kg\right)\left(1.6\times10^{-19} eV / J\right)} = 3.7\times10^{-6} eV$$

11) **.** Estimate the lowest possible kinetic energy of a neutron contained in a typical nucleus of a radius ***a*** =1×10-15m.

$$\Delta p_x \cdot \Delta x \geq \frac{\hbar}{2} \qquad p \approx \Delta p \approx \frac{\hbar}{2 \cdot a} = \frac{1.05\times10^{-34} J \cdot s}{2\left(1\times10^{-15} m\right)} = 5\times10^{-20} kg \cdot m/s$$

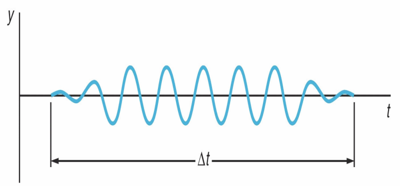
$$m_n c = \left(1.7\times10^{-27} kg\right)\left(3\times10^{8} m/s\right) = 5\times10^{-19} kg \cdot m/s$$

$$K_n \approx \frac{p^2}{2 \cdot m_n} = \frac{\left(5\times10^{-20} kg \cdot m/s\right)^2}{2\left(1.7\times10^{-27} kg\right)} = 7.4\times10^{-13} J = 4.6\times10^{6} eV \approx 5 MeV \rightarrow 5\times10^{10} K$$

12) The lifetime of a free neutron is 15 min. How uncertain is its energy?

$$\Delta E \geq \frac{\hbar}{2 \cdot \Delta t} = \frac{6.6\times10^{-16} eV \cdot s}{2\times15\times60 s} = 4\times10^{-19} eV$$

13) Truly monochromatic light corresponds to an infinitely long plane wave. What is the spread in the frequency of “monochromatic“ light after it passes through a fast shutter that forms 1-µs-long light pulses?



$$\Delta E \geq \frac{\hbar}{2 \cdot \Delta t} \quad \rightarrow \quad \Delta f \geq \frac{\hbar}{2h \cdot \Delta t} = \frac{1}{4\pi \cdot \Delta t} = \frac{1}{4\pi \cdot 1\times10^{-6}\,s} \approx 1\times10^{5}\,Hz$$

14) Calculate how long a virtual electron positron pair can exist.

The minimum amount of energy that needs to be "borrowed" to make a pair is:

$$2m_e c^2$$

By the uncertainty principle, the maximum time for which such "borrowing" can go on:

$$\Delta t \approx \frac{\hbar}{2\cdot\left(2m_e c^2\right)} = \frac{6.6\times10^{-16}\,eV\cdot s}{2\times1.02MeV} \approx 3\times10^{-22}\,s$$

15) Can we consider an electron as a relativistic particle if:

(a) its momentum is comparable to the momentum of a visible-light photon with ***hf***=2eV;

(b) its de Broglie wavelength is comparable to the size of a hydrogen atom (~0.1nm);

Calculate and explain!

a) $$v_e = \frac{p_e}{m_e} = \frac{p_{ph}}{m_e} = \frac{hf}{m_e c} = \frac{\left(2eV\right)\left(1.6\times10^{-19}\,J/eV\right)}{\left(3\times10^{8}\,m/s\right)\left(9.1\times10^{-31}\,kg\right)} = 1100\,m/s$$

non-relativistic (v<<c)

b)

$$\lambda_e = \frac{h}{p_e} = 1\times10^{-10} m \qquad p_e = 6.6\times10^{-24} kg\cdot m/s$$

$$m_e c = \left(9.1\times10^{-31} kg\right)\left(3\times10^{8} m/s\right) = 2.7\times10^{-22} m/s$$

still non-relativistic

16) An electron microscope is designed to resolve objects as small as 0.1nm. What energy electrons must be used in this instrument? Express your answer in eV.

$$p_e \approx \Delta p_e \quad \rightarrow \quad \Delta x \approx 0.1nm \quad \rightarrow \quad p \approx \Delta p \approx \frac{\hbar}{2\cdot\Delta x} = \frac{1.05\times10^{-34} J\cdot s}{2\cdot\left(1\times10^{-10} m\right)} = 5.25\times10^{-25} kg\cdot m/s$$

$$m_e c = \left(9.1\times10^{-31} kg\right)\left(3\times10^{8} m/s\right) = 2.7\times10^{-22} kg\cdot m/s$$

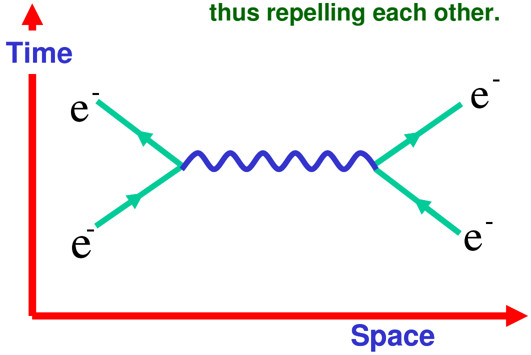
$$K = \frac{p_e^2}{2m_e} = \frac{\left(5.25\times10^{-25} kg\cdot m/s\right)^2}{2\cdot\left(9.1\times10^{-31} kg\right)\left(1.6\times10^{-19} kg\right)} \approx 1eV$$

TABLES

FEYNMAN DIAGRAMS

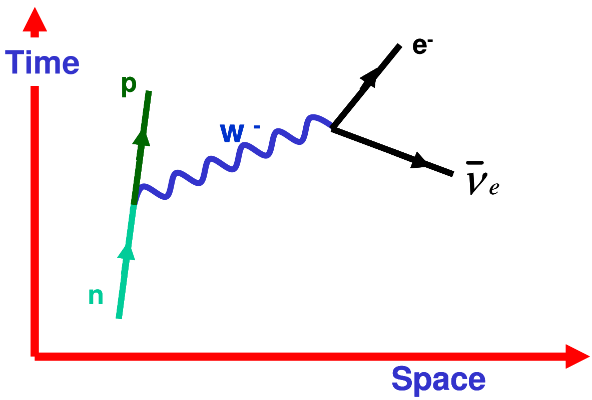
THESE ARE DIAGRAMS IN SPACE AND TIME USED TO REPRESENT VARIOUS INTERACTIONS

In the interaction below 2 electrons come together, throw virtual photons at one another, thus repelling each other.



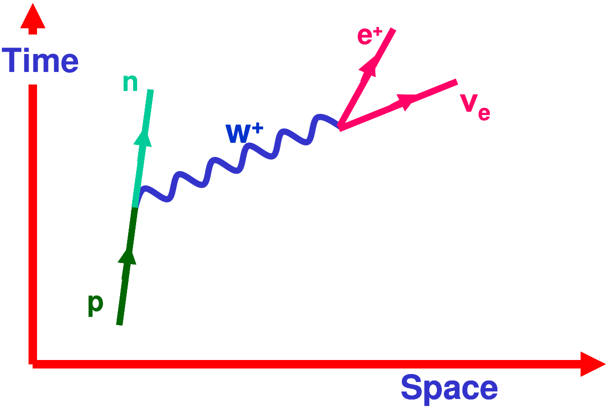
Beta Minus Emission

$$n \rightarrow p + e^- + \overline{\nu}_e$$



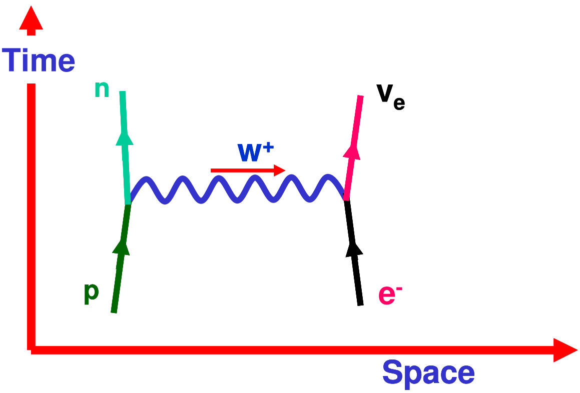
Beta PLUS Emission

$$\boxed{p \rightarrow n + e^{+} + \nu_e}$$



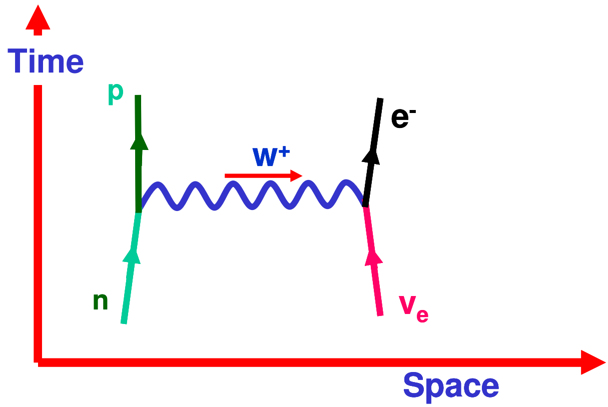
Electron Capture

$$\boxed{p + e^{-} \rightarrow n + \nu_e}$$



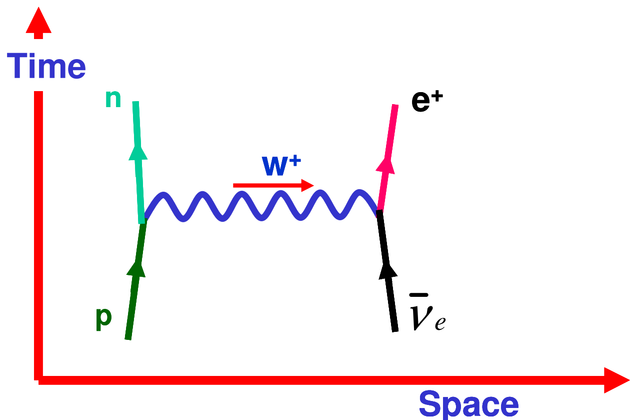
Neutrino - Neutron Collision

$$n + \upsilon_e \rightarrow p + e^-$$



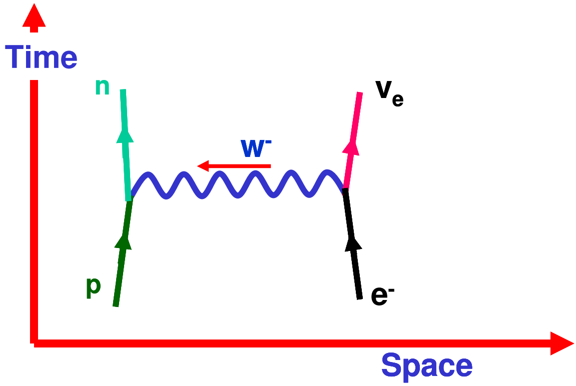
Antineutrino - Proton Collision

$$p + \overline{\nu_e} \rightarrow n + e^+$$

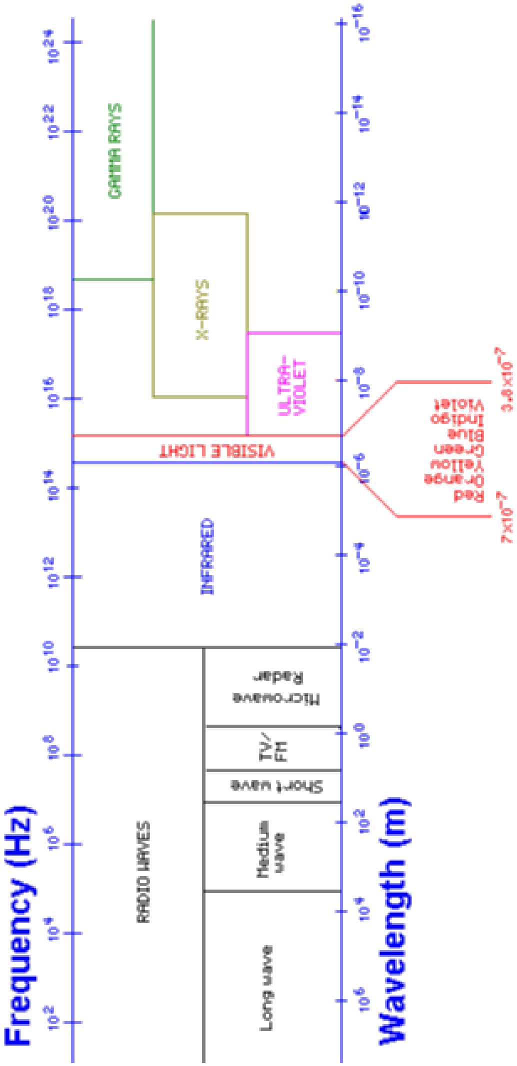


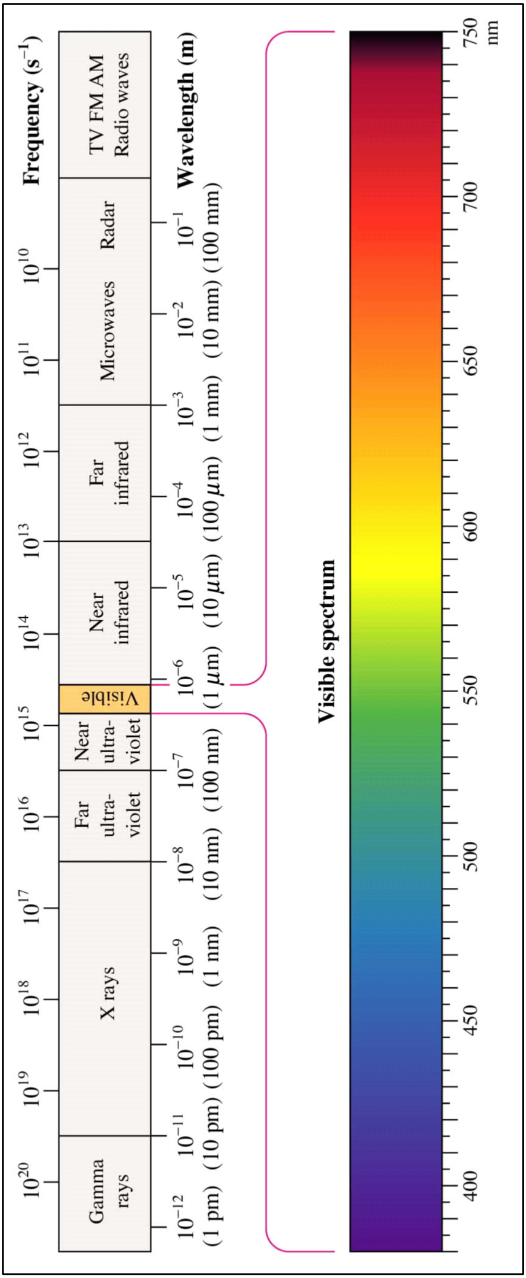
Electron - Proton Collision

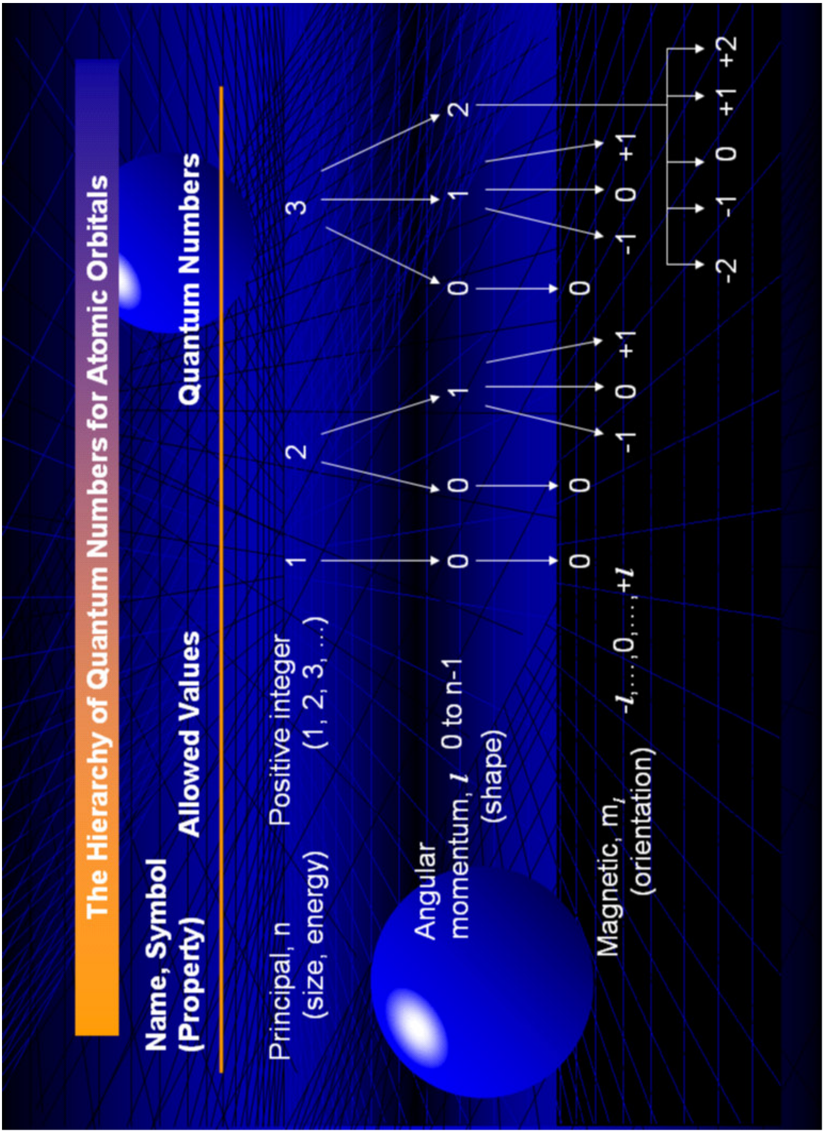
$$p + e^{-} \rightarrow n + \nu_e$$

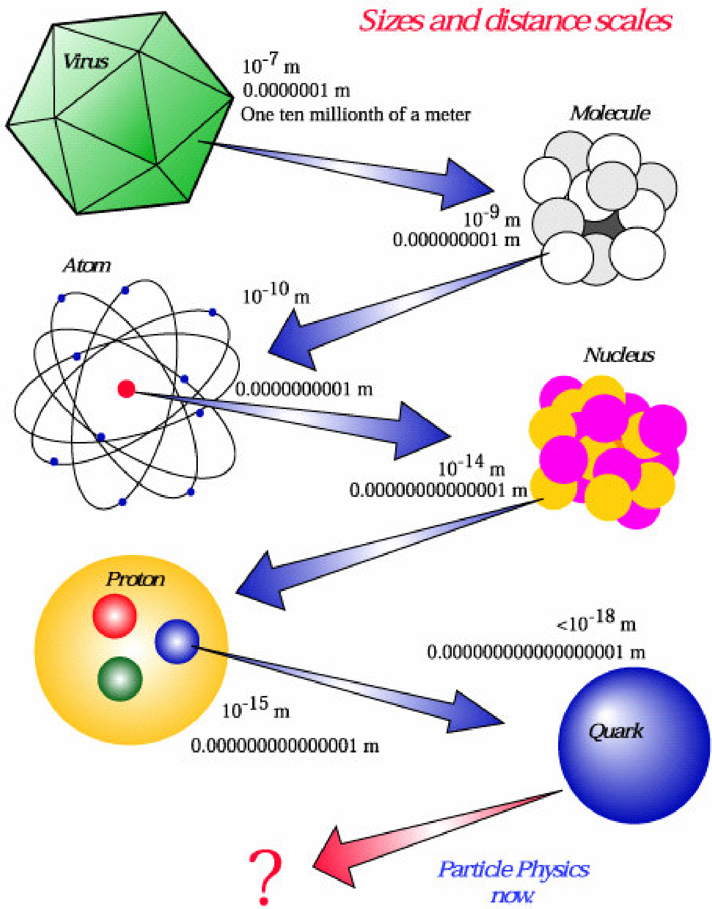


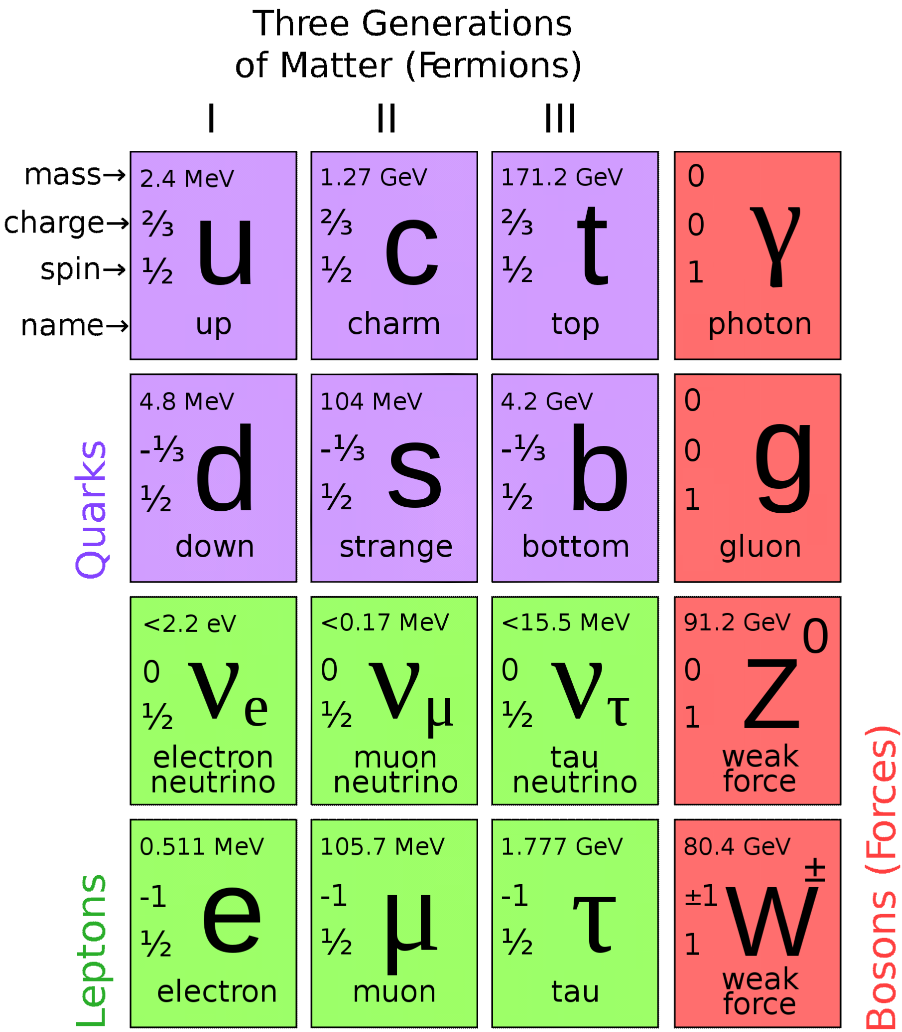
Force	Particles it affects	Exchange particle	Range	Relative strength
Electro-magnetic	anything with charge	virtual photon	Infinite	10^{-2}
Weak	all fundamental particles	W^+, W^-, Z^0	10^{-18} m	10^{-5}
Strong nuclear force	quarks	gluon	10^{-15} m	1
Gravity	anything with mass	graviton	Infinite	10^{-39}


Frequency (Hz)
Wavelength (m)
GAMMA RAYS
X-RAYS
ULTRA-VIOLET
VISIBLE LIGHT
INFRARED
RADIO WAVES
Microwave
Radar
TV/FM
Short wave
Medium wave
Long wave
Red
Orange
Yellow
Green
Blue
Indigo
Violet
7x10^-7


Frequency (s⁻¹)
10^20
10^19
10^18
10^17
10^16
10^15
10^14
10^13
10^12
10^11
10^10
Gamma rays
X rays
Far ultra-violet
Near ultra-violet
Visible
Near infrared
Far infrared
Microwaves
Radar
TV FM AM Radio waves
Wavelength (m)
10^-12 (1 pm)
10^-11 (10 pm)
10^-10 (100 pm)
10^-9 (1 nm)
10^-8 (10 nm)
10^-7 (100 nm)
10^-6 (1 μm)
10^-5 (10 μm)
10^-4 (100 μm)
10^-3 (1 mm)
10^-2 (10 mm)
10^-1 (100 mm)
Visible spectrum
400
450
500
550
600
650
700
750
nm

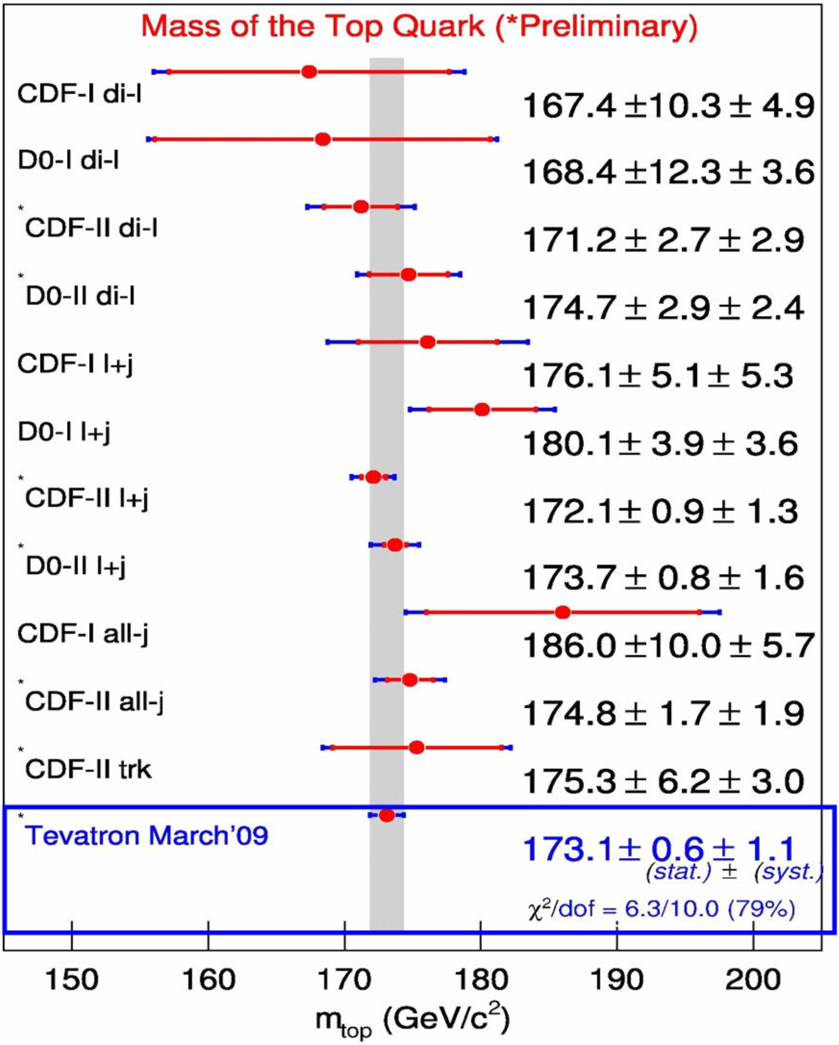

The Hierarchy of Quantum Numbers for Atomic Orbitals
Name, Symbol (Property)
Allowed Values
Quantum Numbers
Principal, n (size, energy)
Positive integer (1, 2, 3, ...)
1
2
3
Angular momentum, l (shape)
0 to n-1
0
0 1
0 1 2
Magnetic, m_l (orientation)
-l,...,0,...,+l
0
0
-1 0 +1
0
-1 0 +1
-2 -1 0 +1 +2


Sizes and distance scales
Virus
10^{-7} m
0.0000001 m
One ten millionth of a meter
Molecule
10^{-9} m
0.000000001 m
Atom
10^{-10} m
0.0000000001 m
Nucleus
10^{-14} m
0.00000000000001 m
Proton
10^{-15} m
0.000000000000001 m
$<10^{-18}$ m
0.000000000000000001 m
Quark
?
Particle Physics
now.


Three Generations
of Matter (Fermions)
I
II
III
mass→
charge→
spin→
name→
2.4 MeV
⅔
½
u
up
1.27 GeV
⅔
½
c
charm
171.2 GeV
⅔
½
t
top
0
0
1
γ
photon
4.8 MeV
-⅓
½
d
down
104 MeV
-⅓
½
s
strange
4.2 GeV
-⅓
½
b
bottom
0
0
1
g
gluon
<2.2 eV
0
½
νe
electron neutrino
<0.17 MeV
0
½
νμ
muon neutrino
<15.5 MeV
0
½
ντ
tau neutrino
91.2 GeV
0
1
Z0
weak force
0.511 MeV
-1
½
e
electron
105.7 MeV
-1
½
μ
muon
1.777 GeV
-1
½
τ
tau
80.4 GeV
±1
1
W±
weak force
Quarks
Leptons
Bosons (Forces)

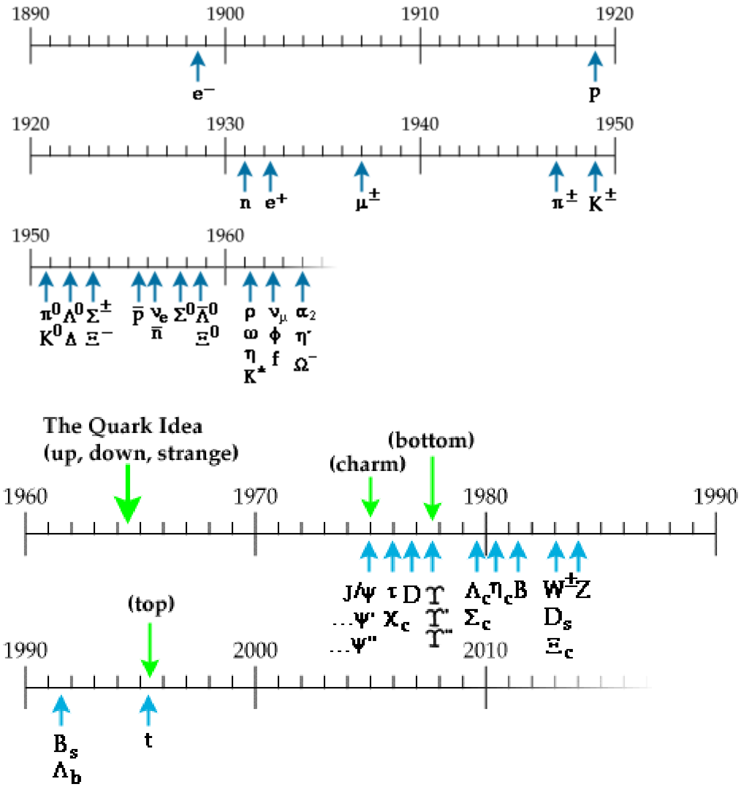
	$J = 1/2$		$J = 3/2$	
$q_1q_2q_3$	$\star n_3 n_2 2$	$\star n_2 n_3 2$	$\star\star\star 4$	
ddd			Δ^-	111
udd		n	Δ^0	211
uud		p	Δ^+	221
uuu			Δ^{++}	222
sdd		Σ^-	$\Sigma^{\star -}$	311
sud	Λ	Σ^0	$\Sigma^{\star 0}$	321
suu		Σ^+	$\Sigma^{\star +}$	322
ssd		Ξ^-	$\Xi^{\star -}$	331
ssu		Ξ^0	$\Xi^{\star 0}$	332
sss			Ω^-	333
cdd		Σ_c^0	$\Sigma_c^{\star 0}$	411
cud	Λ_c^+	Σ_c^+	$\Sigma_c^{\star +}$	421
cuu		Σ_c^{++}	$\Sigma_c^{\star ++}$	422
csd	Ξ_c^0	$\Xi_c^{\prime 0}$	$\Xi_c^{\star 0}$	431
csu	Ξ_c^+	$\Xi_c^{\prime +}$	$\Xi_c^{\star +}$	432
css		Ω_c^0	$\Omega_c^{\star 0}$	433

	$J = 1/2$		$J = 3/2$	
$q_1q_2q_3$	$\star n_3 n_2 2$	$\star n_2 n_3 2$	$\star\star\star 4$	
ccd		Ξ_{cc}^+	$\Xi_{cc}^{\star +}$	441
ccu		Ξ_{cc}^{++}	$\Xi_{cc}^{\star ++}$	442
ccs		Ω_{cc}^+	$\Omega_{cc}^{\star +}$	443
ccc			$\Omega_{ccc}^{\star ++}$	444
bdd		Σ_b^-	$\Sigma_b^{\star -}$	511
bud	Λ_b^0	Σ_b^0	$\Sigma_b^{\star 0}$	521
buu		Σ_b^+	$\Sigma_b^{\star +}$	522
bsd	Ξ_b^-	$\Xi_b^{\prime -}$	$\Xi_b^{\star -}$	531
bsu	Ξ_b^0	$\Xi_b^{\prime 0}$	$\Xi_b^{\star 0}$	532
bss		Ω_b^-	$\Omega_b^{\star -}$	533
bcd	Ξ_{bc}^0	$\Xi_{bc}^{\prime 0}$	$\Xi_{bc}^{\star 0}$	541
bcu	Ξ_{bc}^+	$\Xi_{bc}^{\prime +}$	$\Xi_{bc}^{\star +}$	542
bcs	Ω_{bc}^0	$\Omega_{bc}^{\prime 0}$	$\Omega_{bc}^{\star 0}$	543
bcc		Ω_{bcc}^+	$\Omega_{bcc}^{\star +}$	544
bbd		Ξ_{bb}^-	$\Xi_{bb}^{\star -}$	551
bbu		Ξ_{bb}^0	$\Xi_{bb}^{\star 0}$	552
bbs		Ω_{bb}^-	$\Omega_{bb}^{\star -}$	553
bbc		Ω_{bbc}^0	$\Omega_{bbc}^{\star 0}$	554
bbb			$\Omega_{bbb}^{\star -}$	555

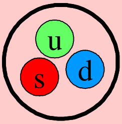


Mass of the Top Quark (*Preliminary)
CDF-I di-l
167.4 ±10.3 ± 4.9
D0-I di-l
168.4 ±12.3 ± 3.6
*CDF-II di-l
171.2 ± 2.7 ± 2.9
*D0-II di-l
174.7 ± 2.9 ± 2.4
CDF-I l+j
176.1 ± 5.1 ± 5.3
D0-I l+j
180.1 ± 3.9 ± 3.6
*CDF-II l+j
172.1 ± 0.9 ± 1.3
*D0-II l+j
173.7 ± 0.8 ± 1.6
CDF-I all-j
186.0 ±10.0 ± 5.7
*CDF-II all-j
174.8 ± 1.7 ± 1.9
*CDF-II trk
175.3 ± 6.2 ± 3.0
*Tevatron March'09
173.1 ± 0.6 ± 1.1
(stat.) ± (syst.)
χ^2/dof = 6.3/10.0 (79%)
150
160
170
180
190
200
m_{top} (GeV/c^2)

Time line of particle discoveries

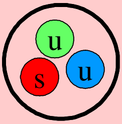


Quark	up	down	strange
Charge, Q	+2/3	-1/3	-1/3
Mass	~5 [MeV/c^2]	~10 [MeV/c^2]	~200 [MeV/c^2]
	u u u	d d d	s s s



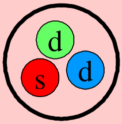
Lambda (Λ)

Q = 0
M=1116 MeV/c^2
Lifetime~2.6×10^{-10}[s]



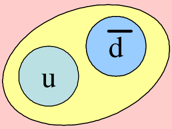
Sigma (Σ^+)

Q = +1
M=1189 MeV/c^2
Lifetime~0.8×10^{-10}[s]



Sigma (Σ^-)

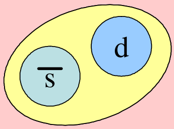
Q = -1
M=1197 MeV/c^2
Lifetime~1.5×10^{-10}[s]



What's the charge of this particle?

Q=+1, and it's called a π^+

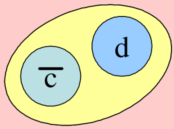
M~140 [MeV/c^2]
Lifetime~2.6×10^{-8} [s]



What's the charge of this particle?

Q= 0, this strange meson is called a K^0

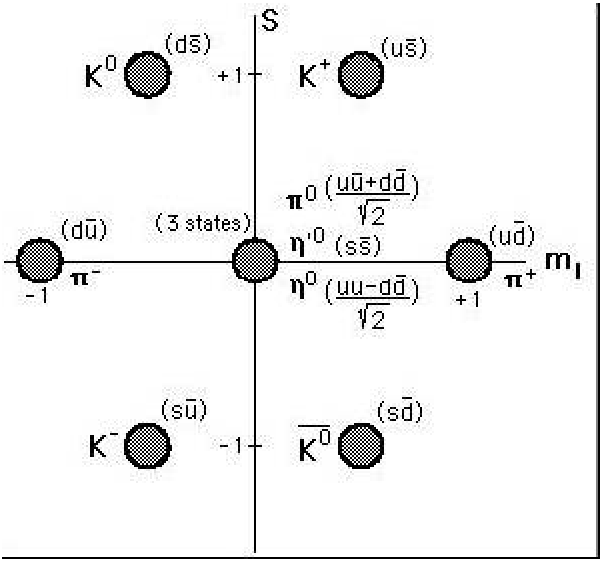
M~500 [MeV/c^2]
Lifetime~0.8×10^{-10} [s]

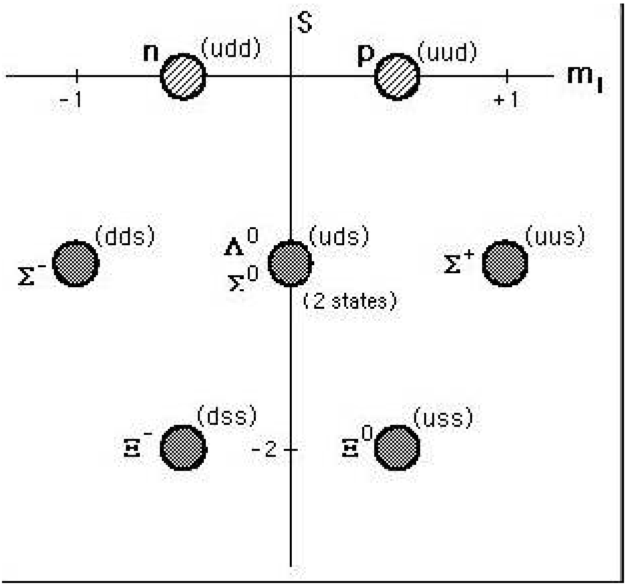


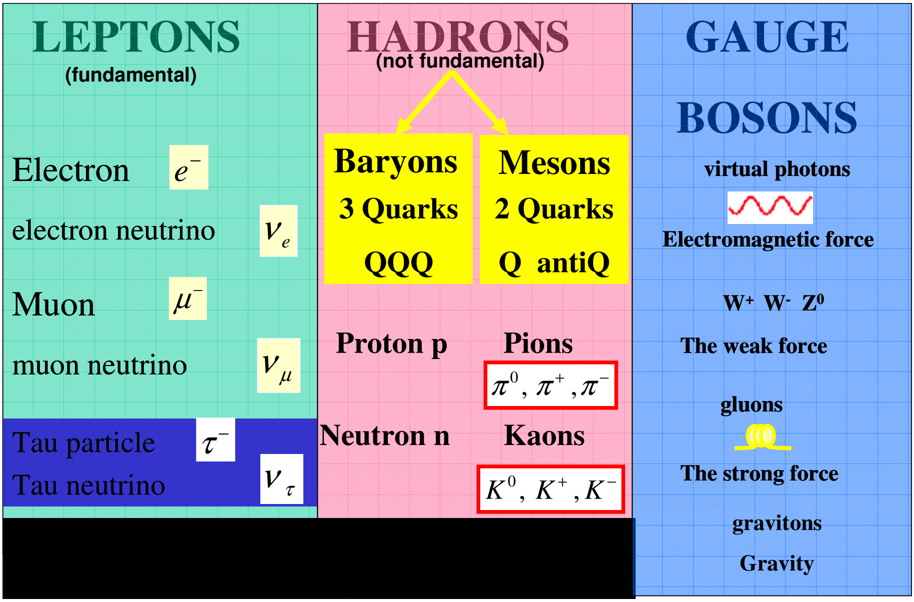
What's the charge of this particle?

Q= -1, and this charm meson is called a D^-

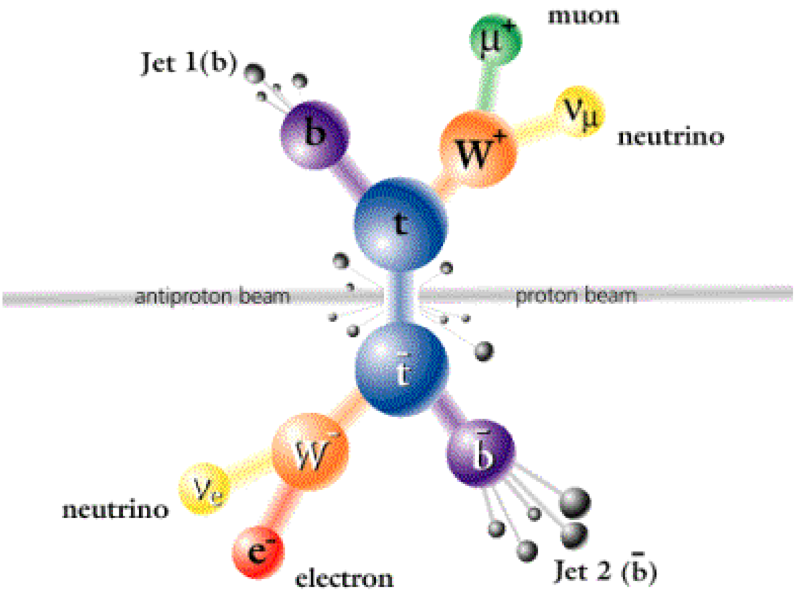
M~1870 [MeV/c^2]
Lifetime~1×10^{-12} [s]


S
K0 (ds̄)
+1
K+ (us̄)
π0 (uū+dd̄)/√2
(3 states)
(dū)
η'0 (ss̄)
(ud̄)
mI
π−
−1
η0 (uu−dd̄)/√2
+1
π+
K− (sū)
−1
K̄0 (sd̄)


S
n (udd)
p (uud)
mI
−1
+1
Σ− (dds)
Λ0 (uds)
Σ0
(2 states)
Σ+ (uus)
Ξ− (dss)
−2
Ξ0 (uss)

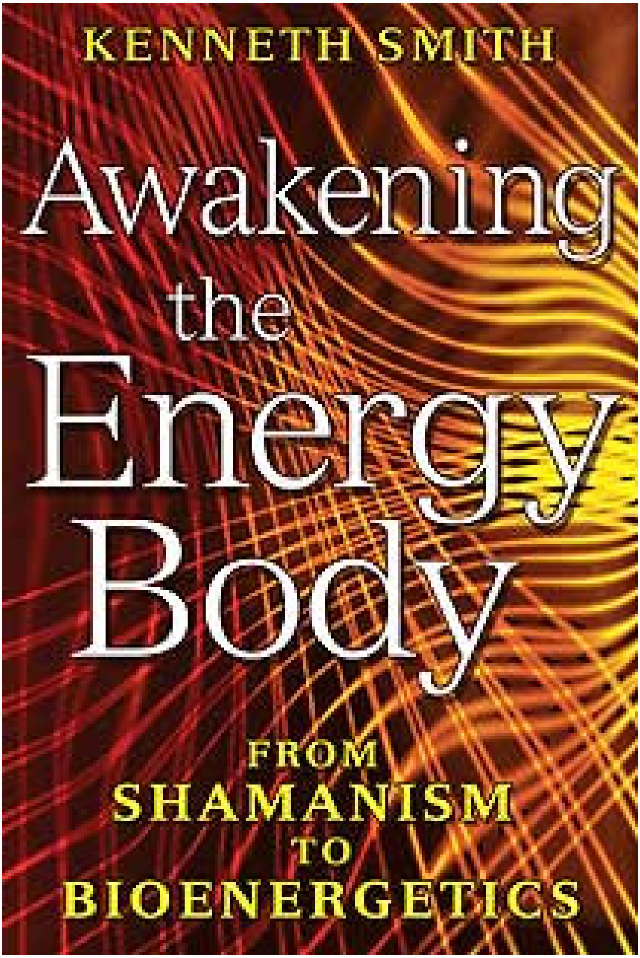

LEPTONS
(fundamental)
Electron e^-
electron neutrino ν_e
Muon μ^-
muon neutrino ν_μ
Tau particle τ^-
Tau neutrino ν_τ
HADRONS
(not fundamental)
Baryons
3 Quarks
QQQ
Mesons
2 Quarks
Q antiQ
Proton p
Neutron n
Pions
π^0, π^+, π^-
Kaons
K^0, K^+, K^-
GAUGE
BOSONS
virtual photons
Electromagnetic force
W+ W- Z0
The weak force
gluons
The strong force
gravitons
Gravity

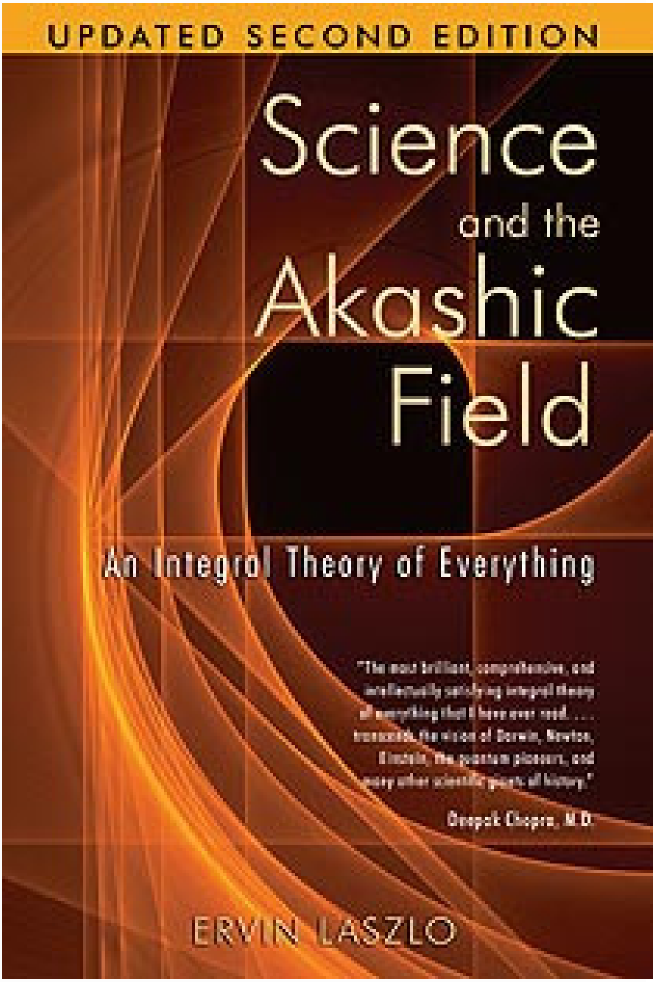
TABLES

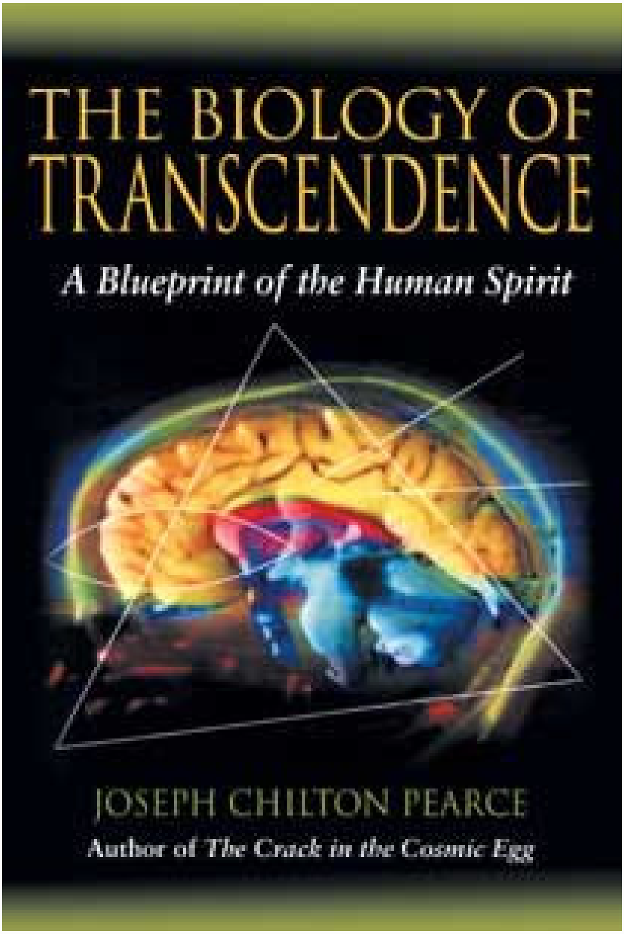


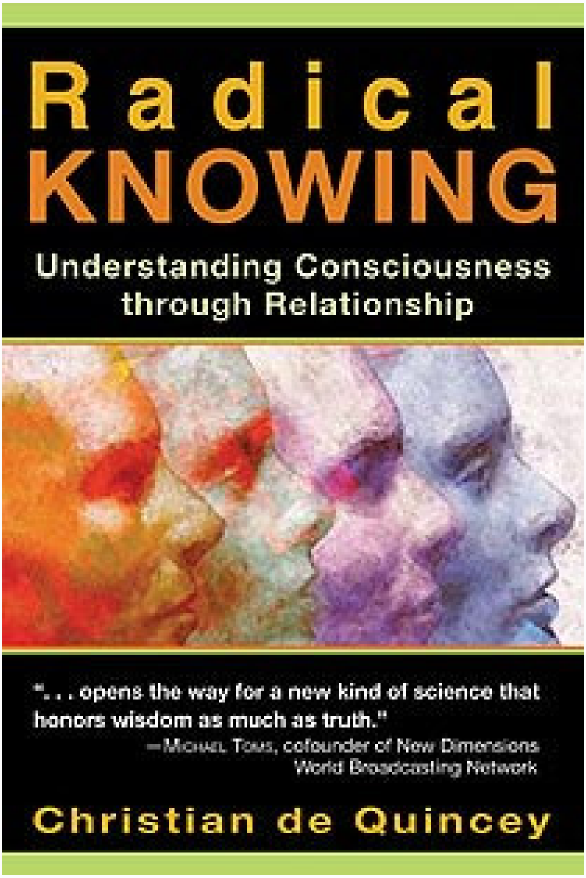
muon
Jet 1(b)
neutrino
antiproton beam
proton beam
neutrino
electron
Jet 2 (b̄)

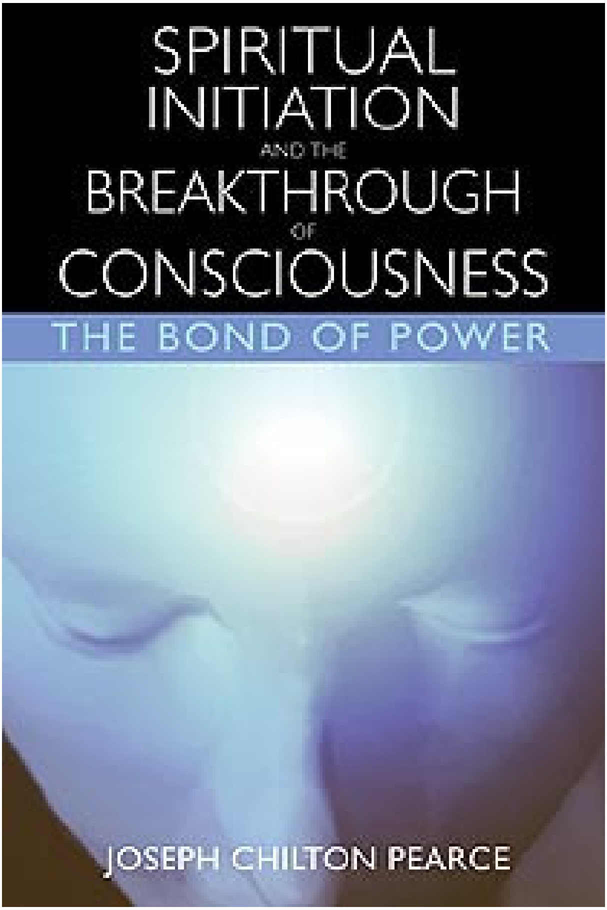
BIBLIOGRAPHY

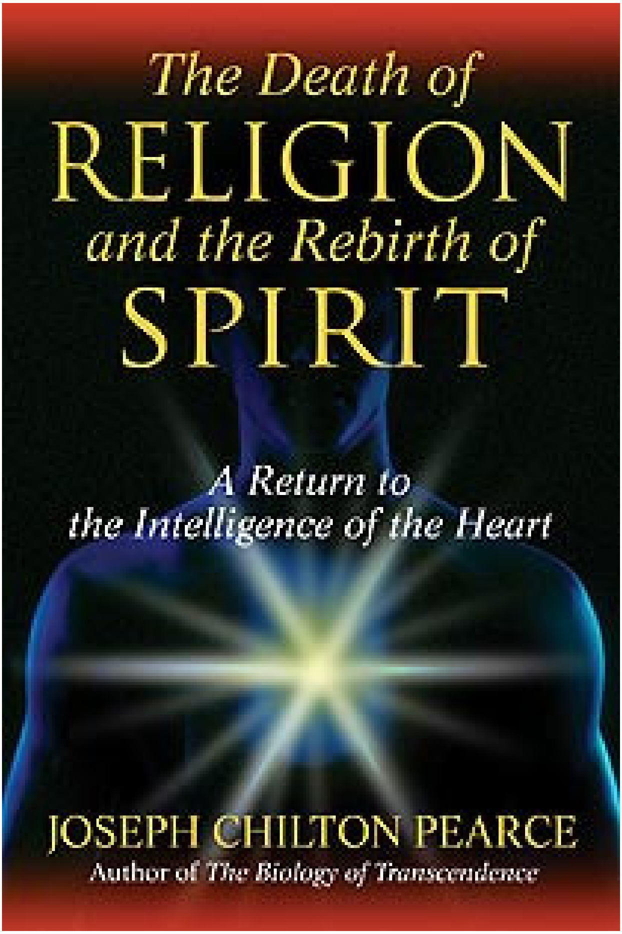

KENNETH SMITH
Awakening the Energy Body
FROM SHAMANISM TO BIOENERGETICS

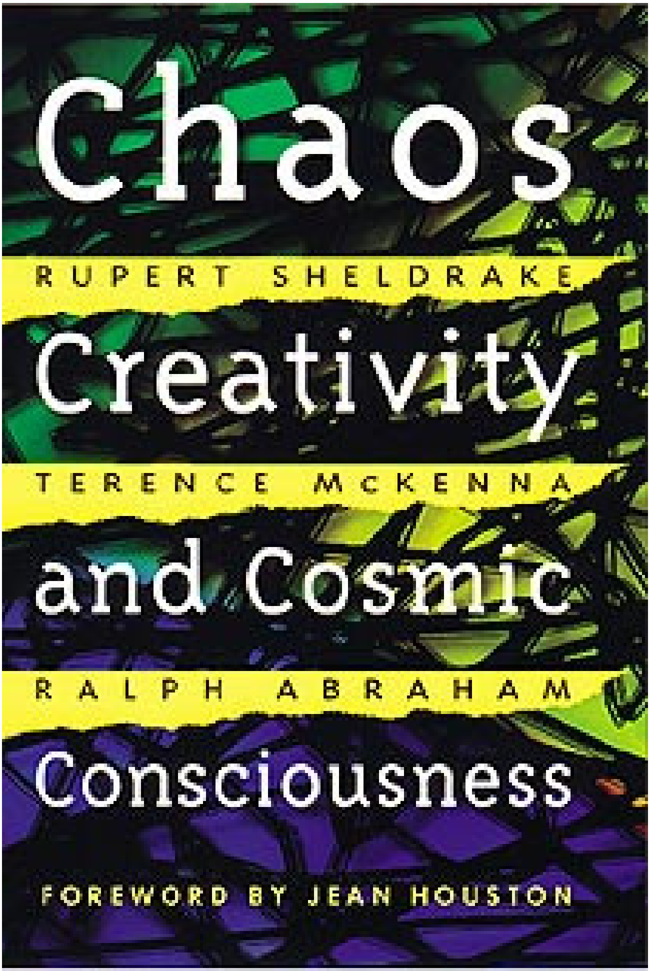

UPDATED SECOND EDITION
Science and the Akashic Field
An Integral Theory of Everything
ERVIN LASZLO

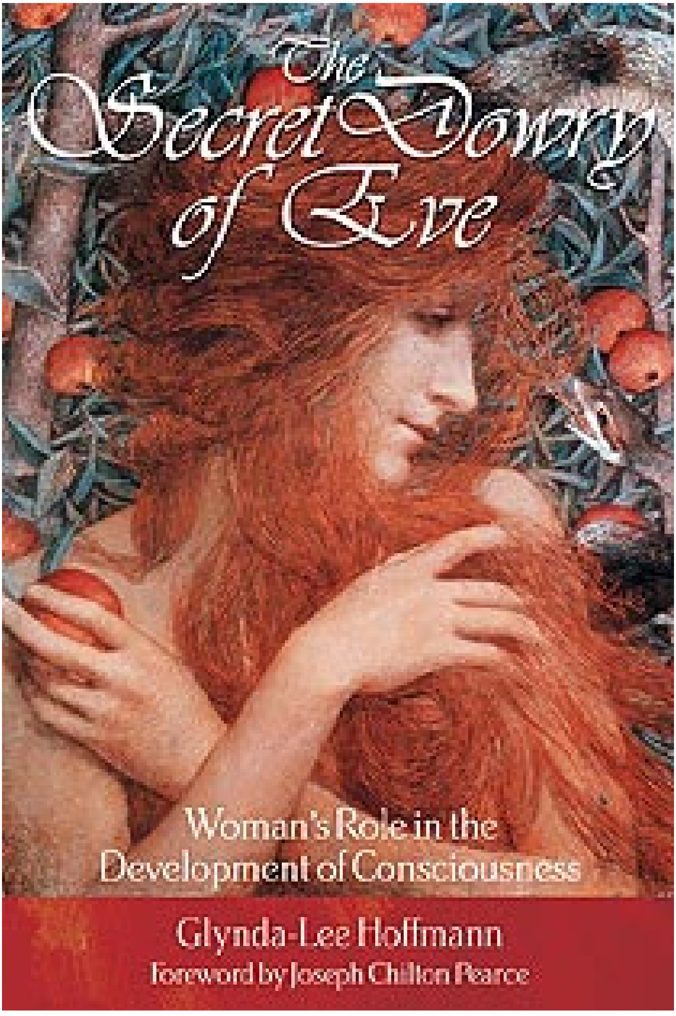

THE BIOLOGY OF TRANSCENDENCE
A Blueprint of the Human Spirit
JOSEPH CHILTON PEARCE
Author of The Crack in the Cosmic Egg


Radical
KNOWING
Understanding Consciousness through Relationship
". . . opens the way for a new kind of science that honors wisdom as much as truth."
—MICHAEL TOMS, cofounder of New Dimensions World Broadcasting Network
Christian de Quincey


SPIRITUAL
INITIATION
AND THE
BREAKTHROUGH
OF
CONSCIOUSNESS
THE BOND OF POWER
JOSEPH CHILTON PEARCE


The Death of
RELIGION
and the Rebirth of
SPIRIT
A Return to
the Intelligence of the Heart
JOSEPH CHILTON PEARCE
Author of The Biology of Transcendence


Chaos
RUPERT SHELDRAKE
Creativity
TERENCE McKENNA
and Cosmic
RALPH ABRAHAM
Consciousness
FOREWORD BY JEAN HOUSTON


The Secret Dowry of Eve
Woman's Role in the Development of Consciousness
Glynda-Lee Hoffmann
Foreword by Joseph Chilton Pearce

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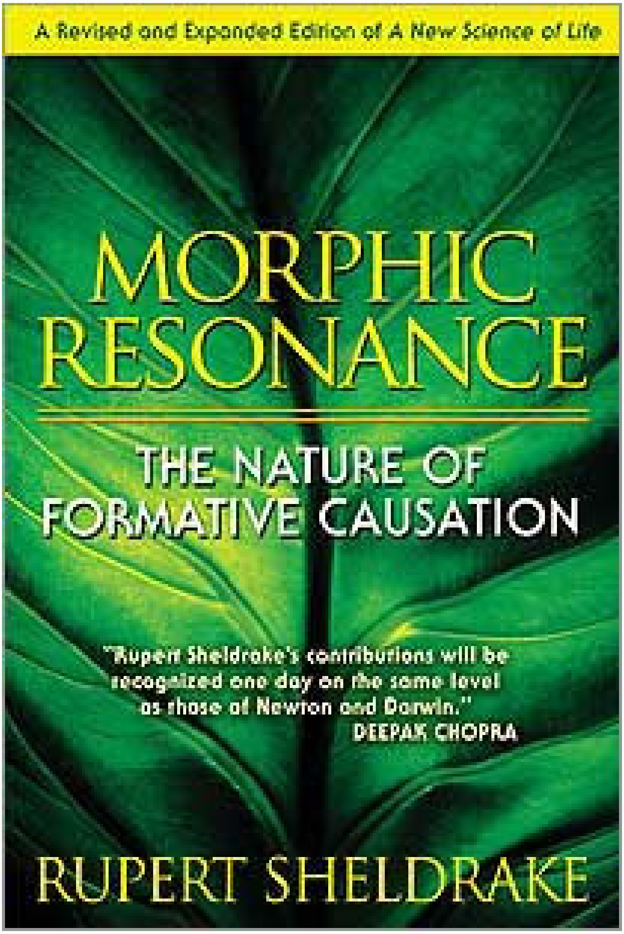
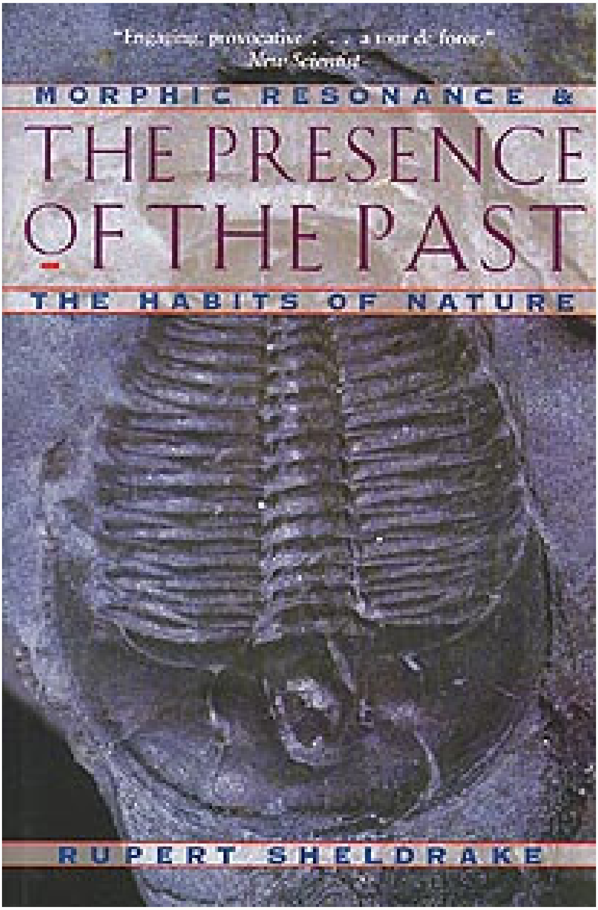
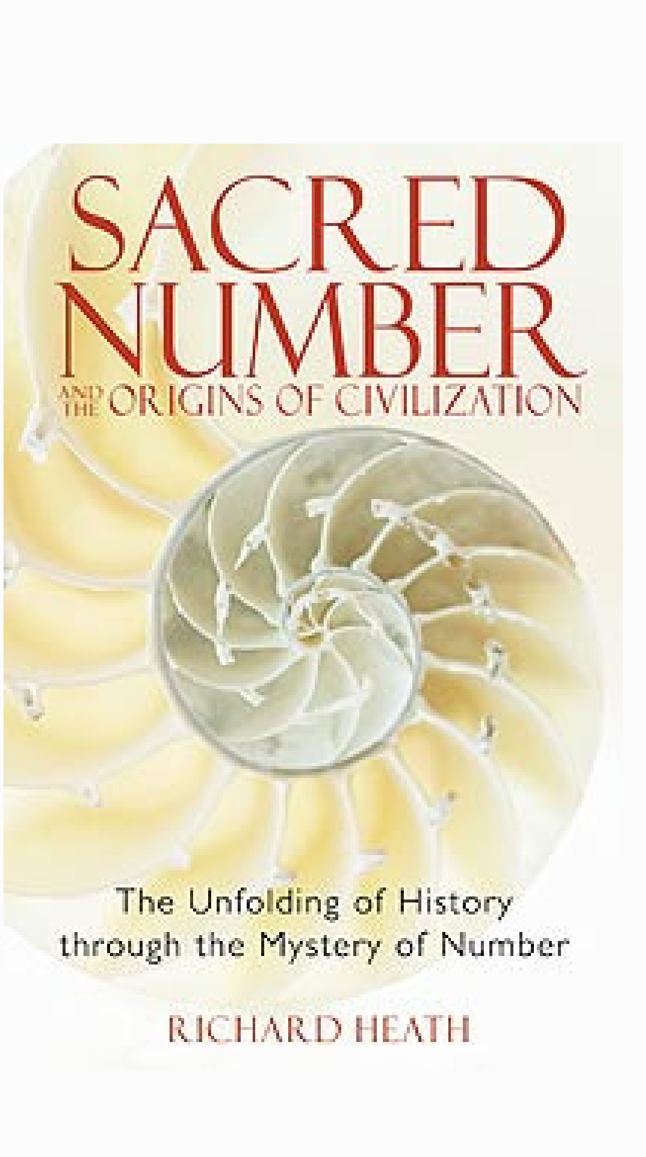



MORPHIC RESONANCE &
THE PRESENCE OF THE PAST
THE HABITS OF NATURE
RUPERT SHELDRAKE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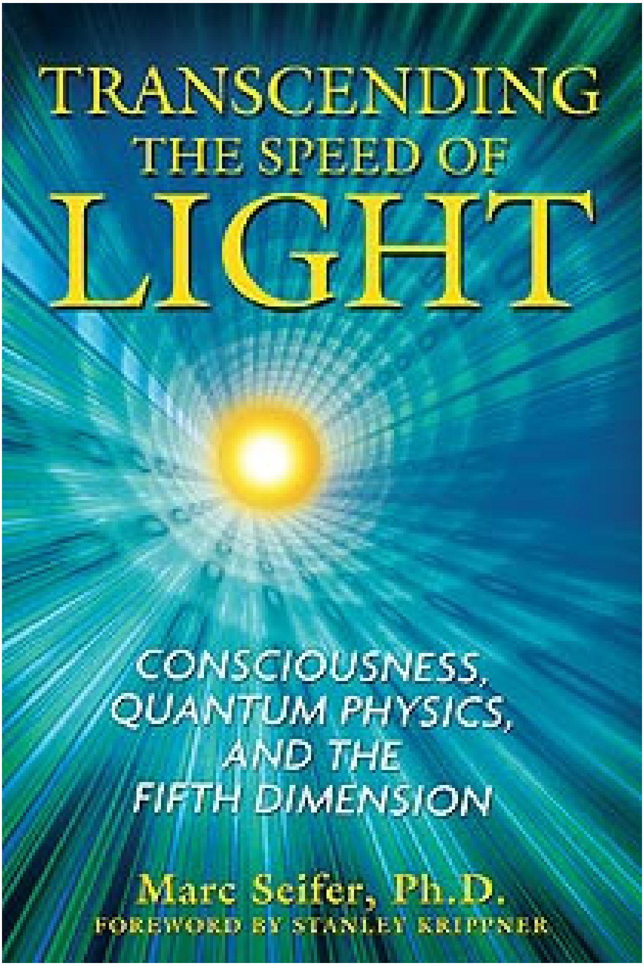
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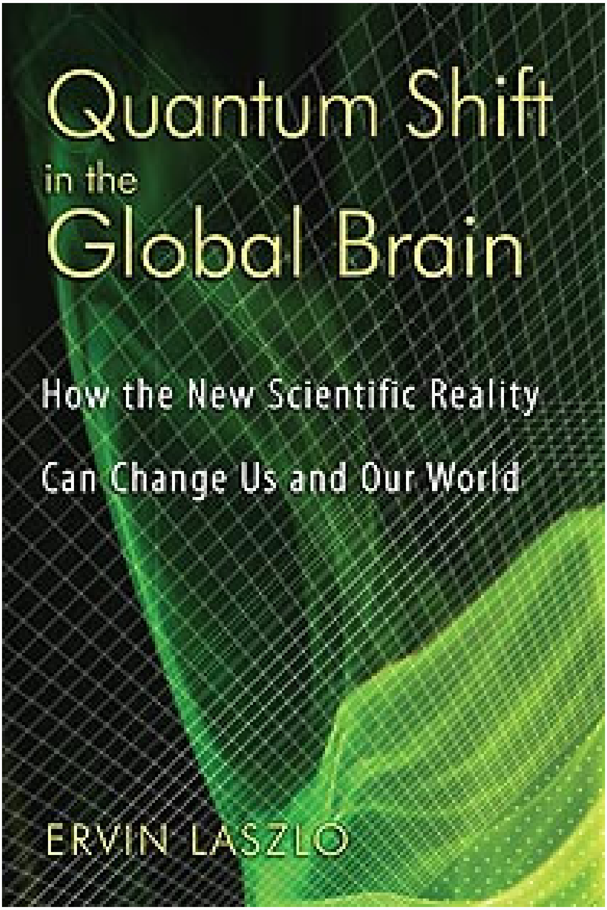
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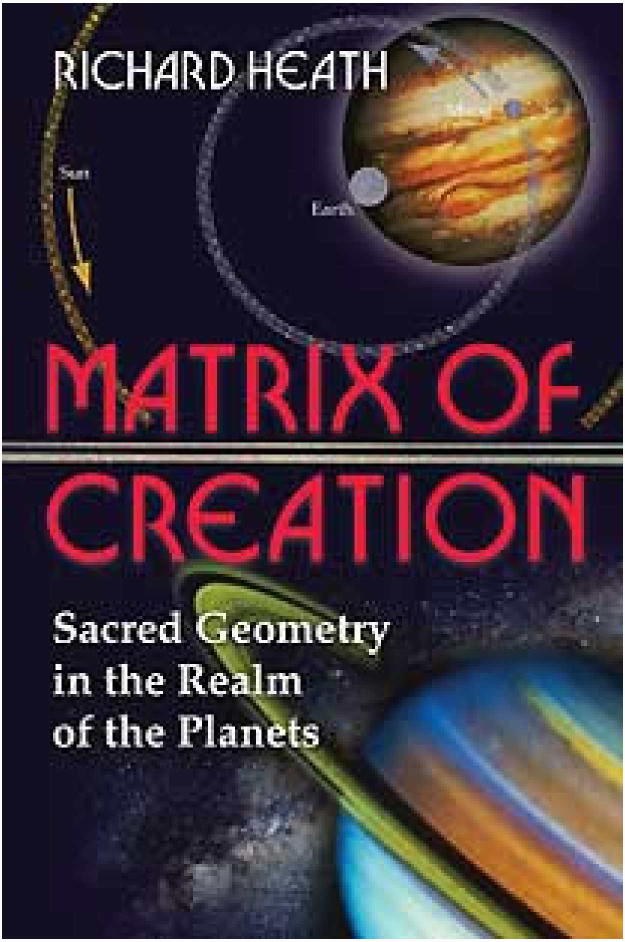
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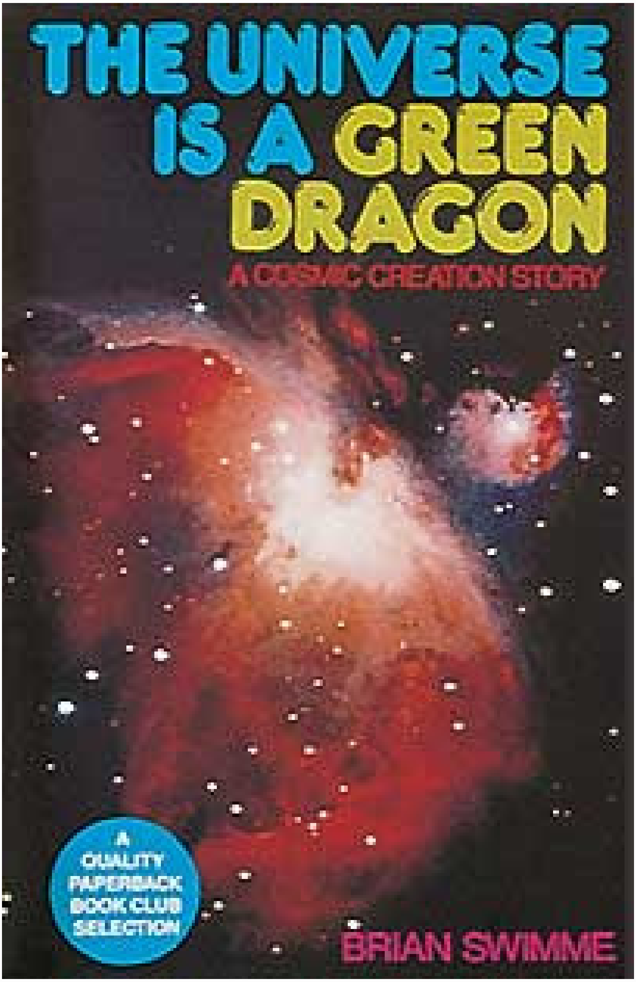
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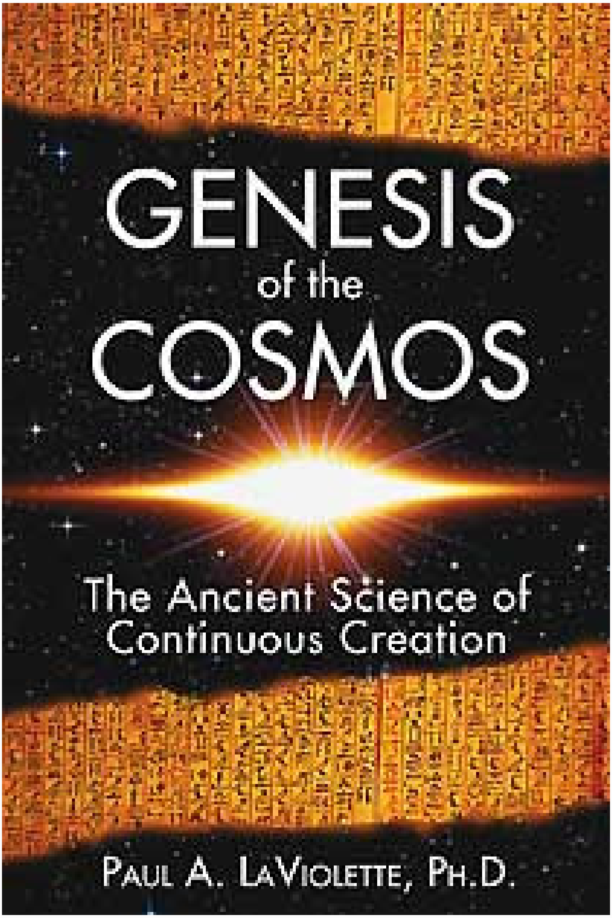
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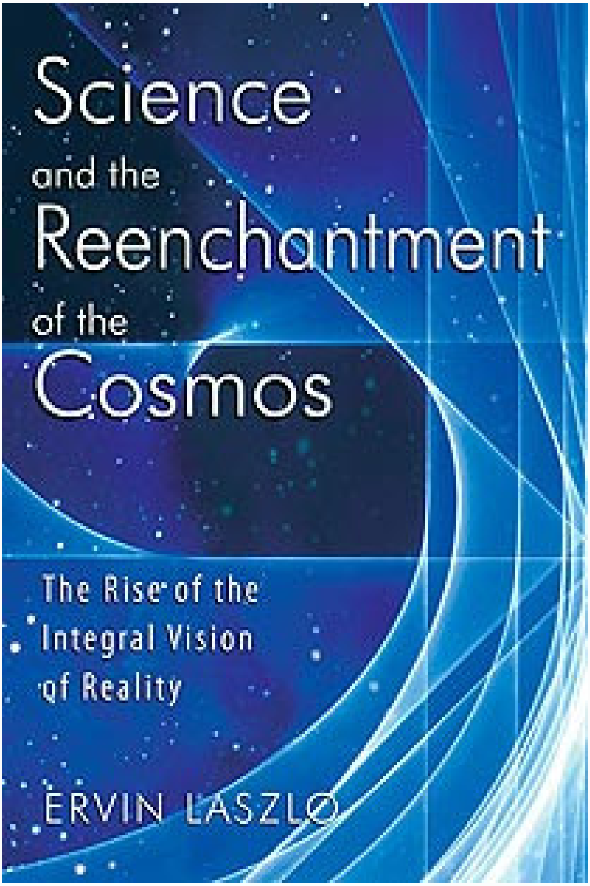
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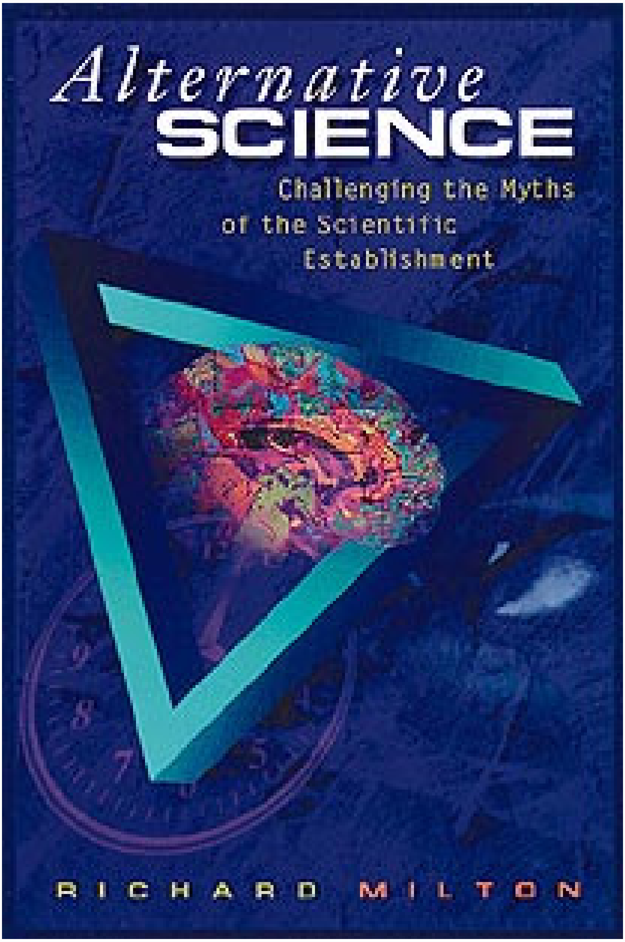
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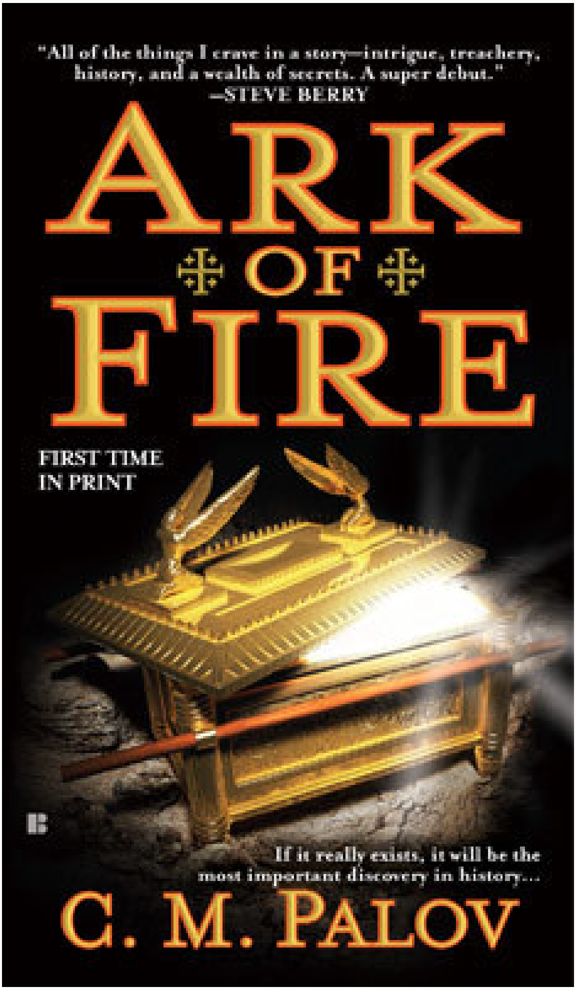
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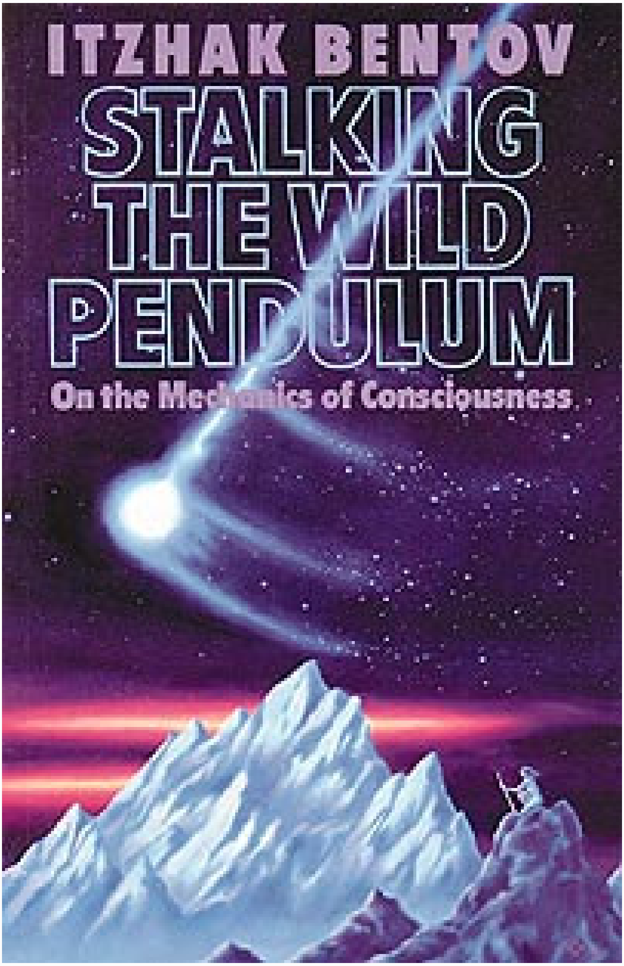
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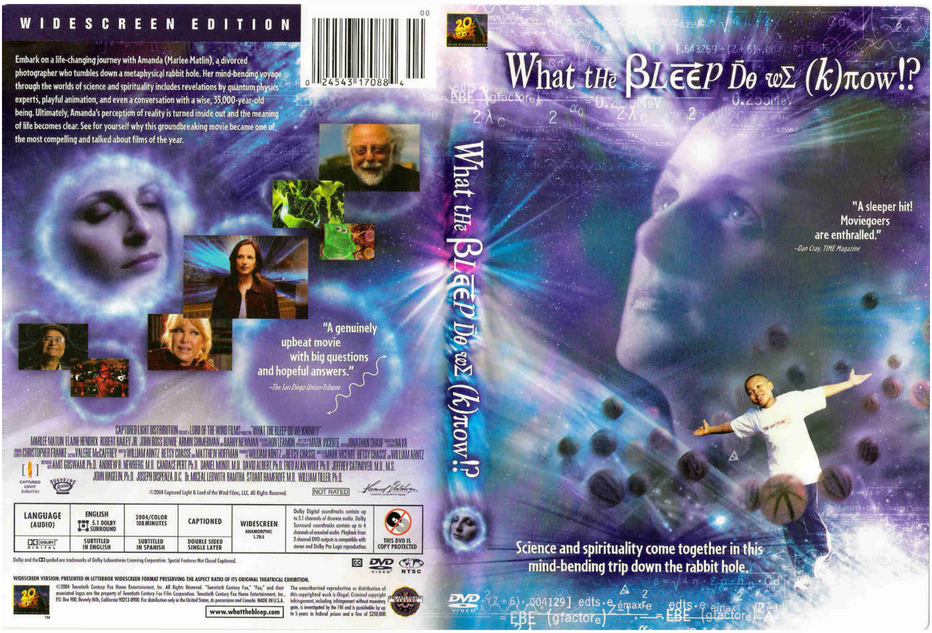
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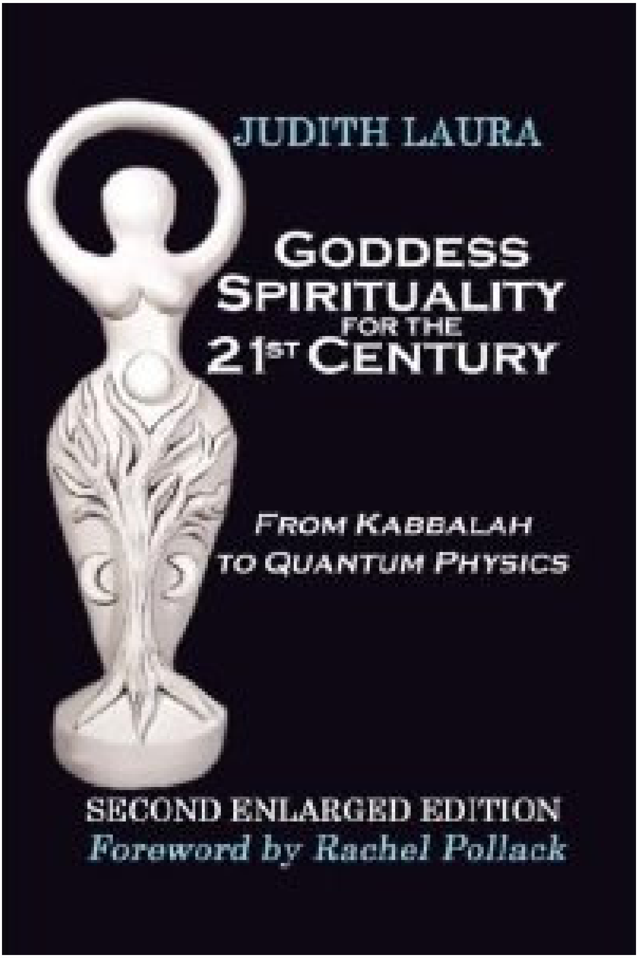
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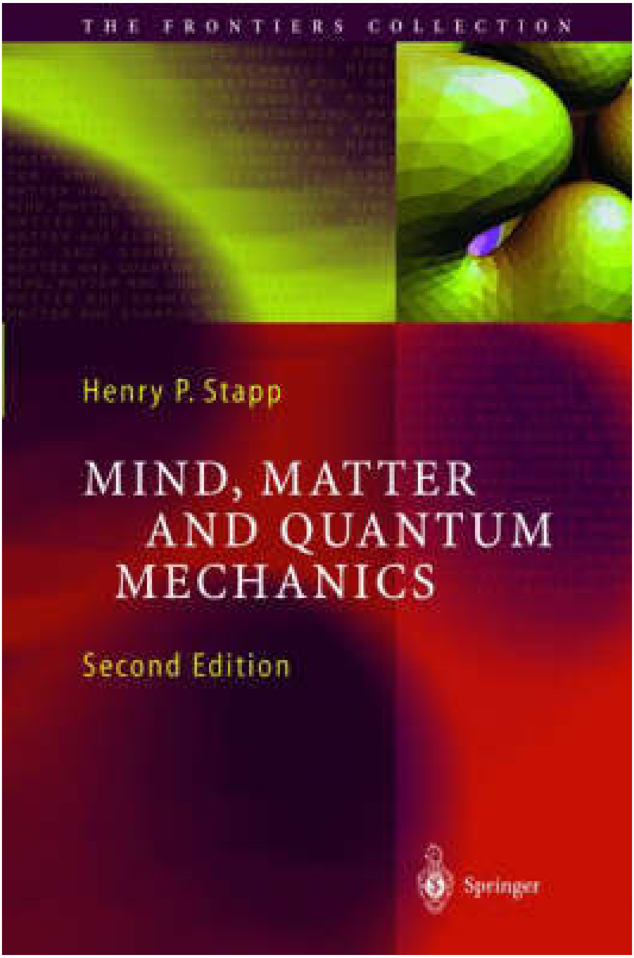

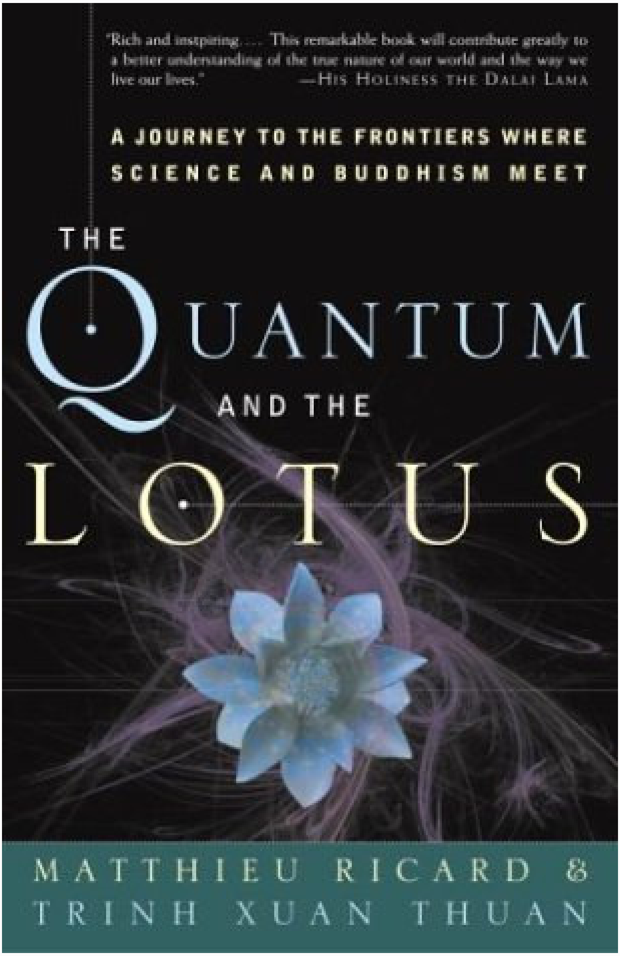
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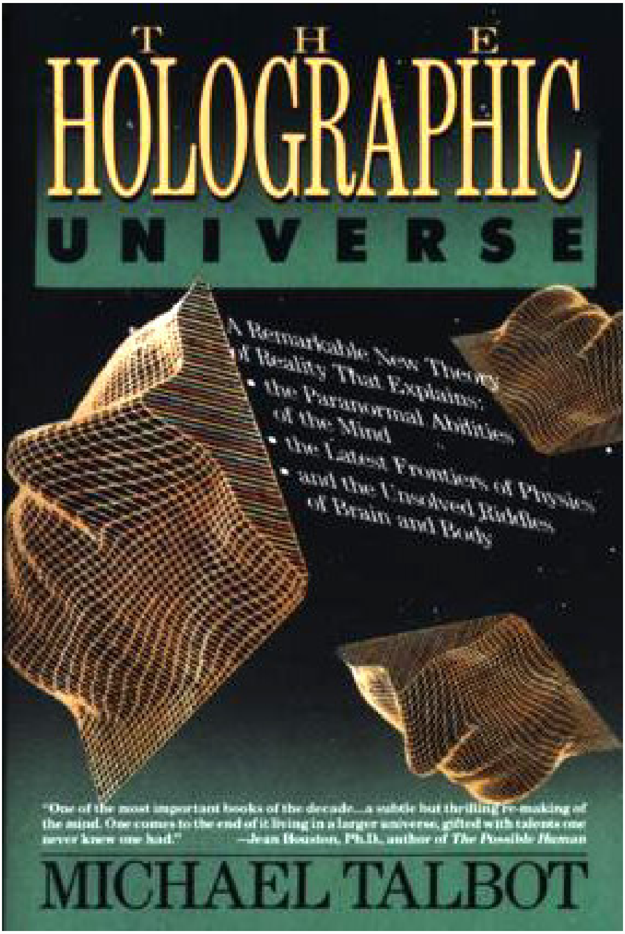

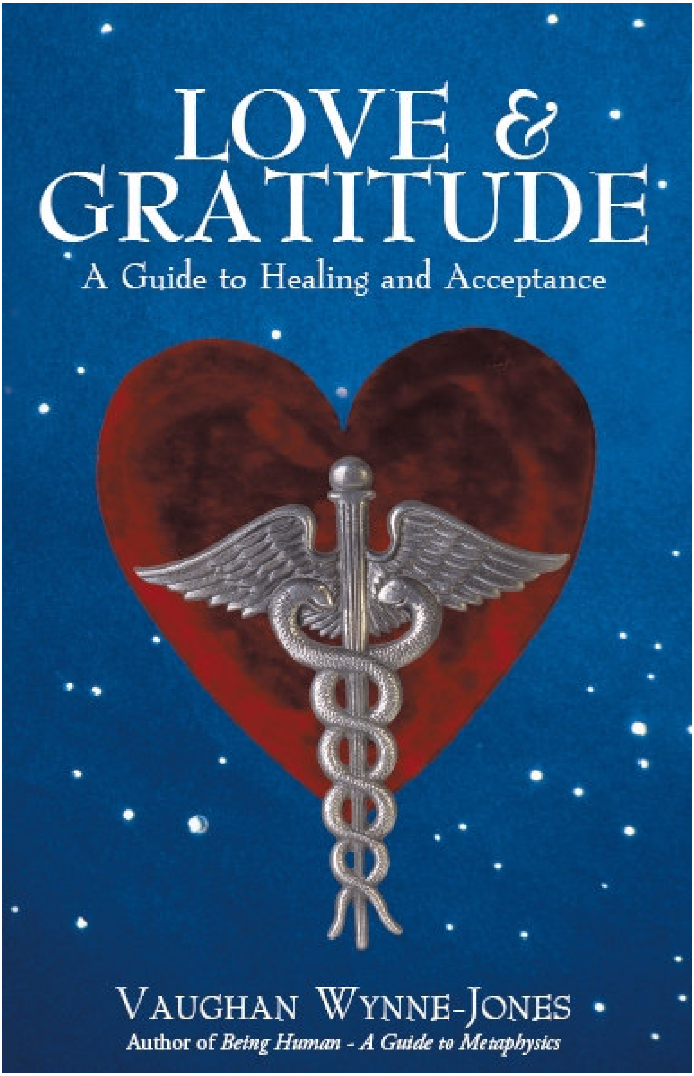
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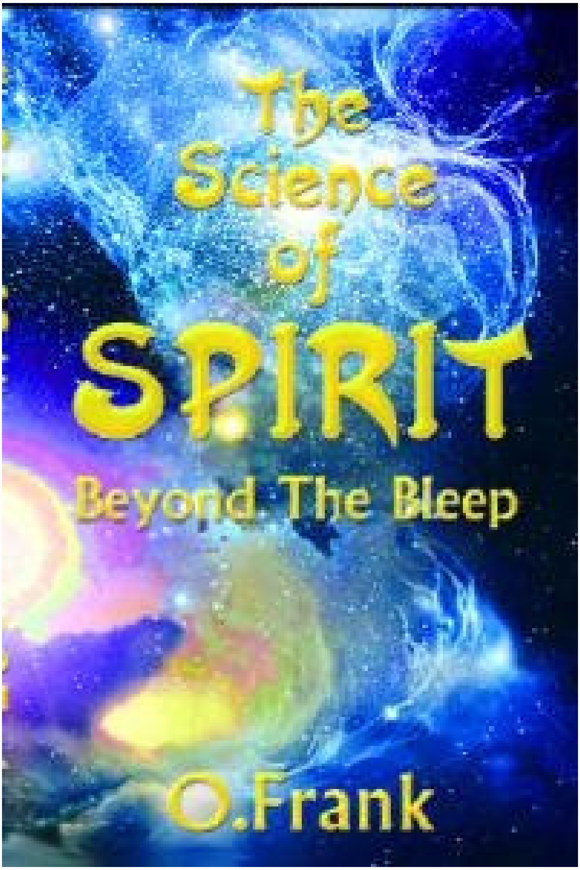
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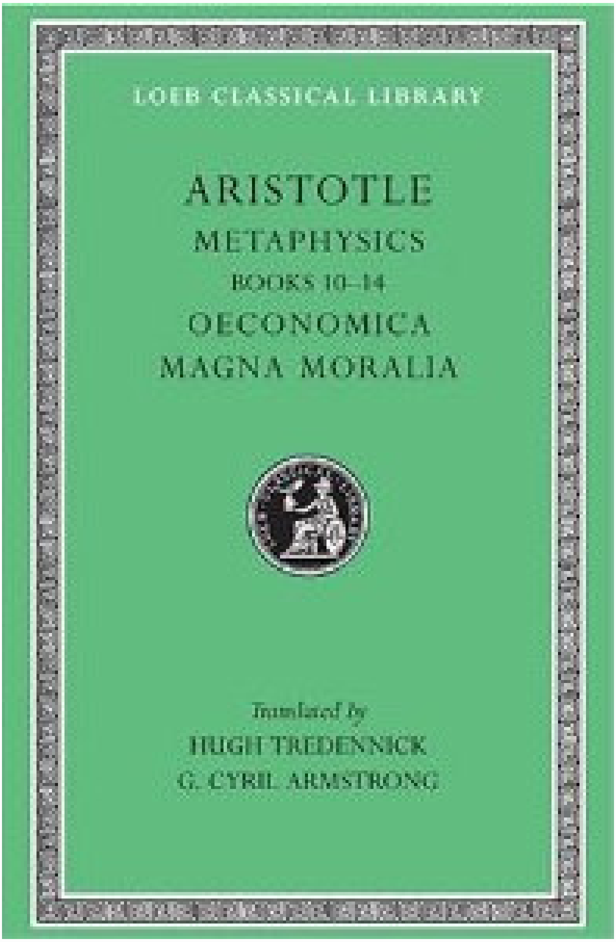
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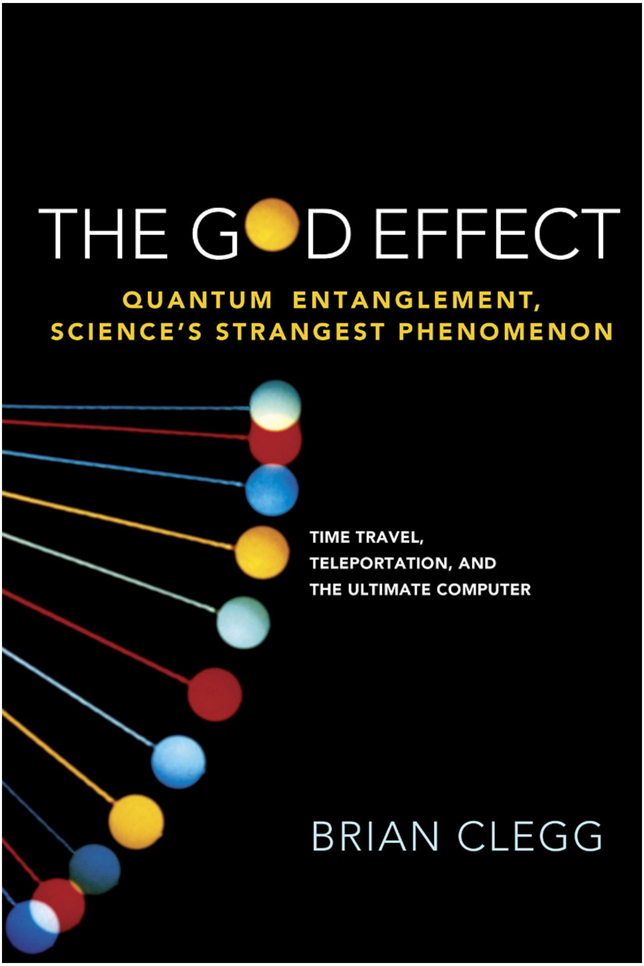

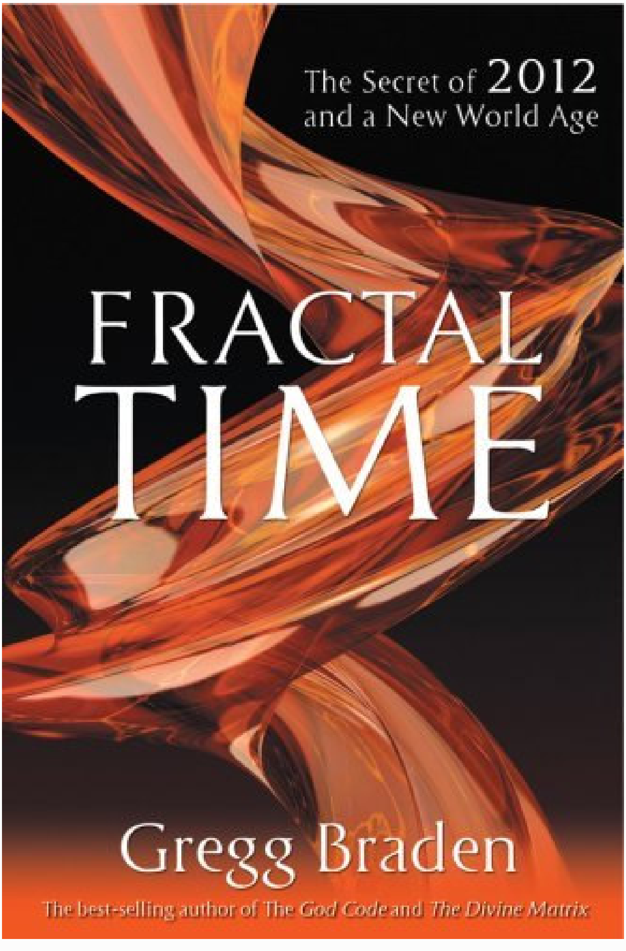
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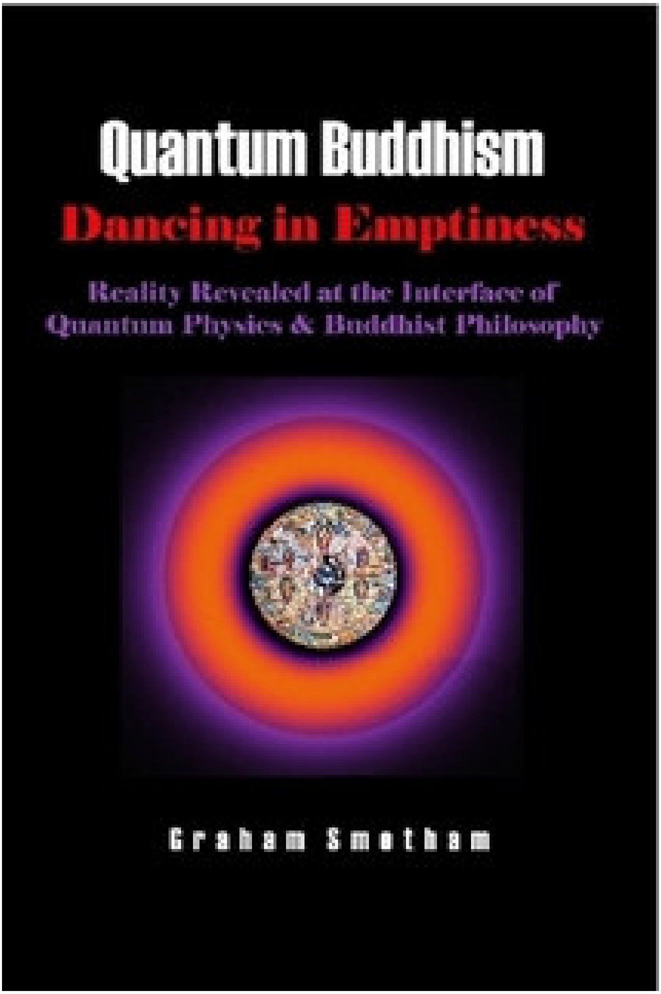
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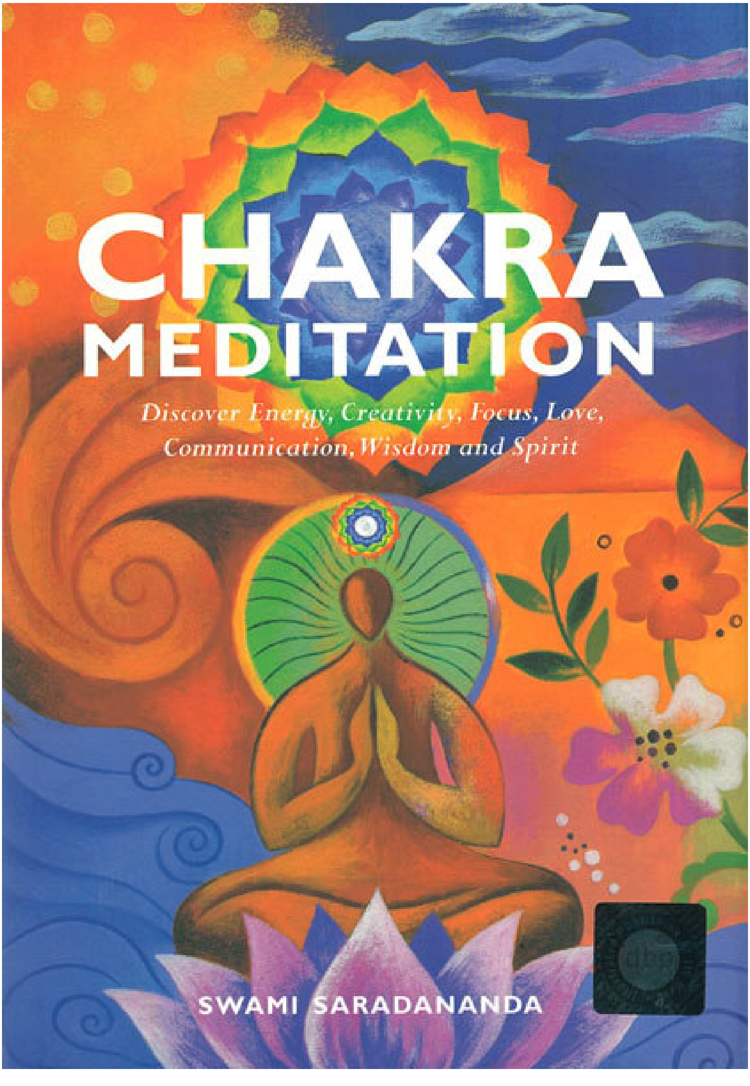
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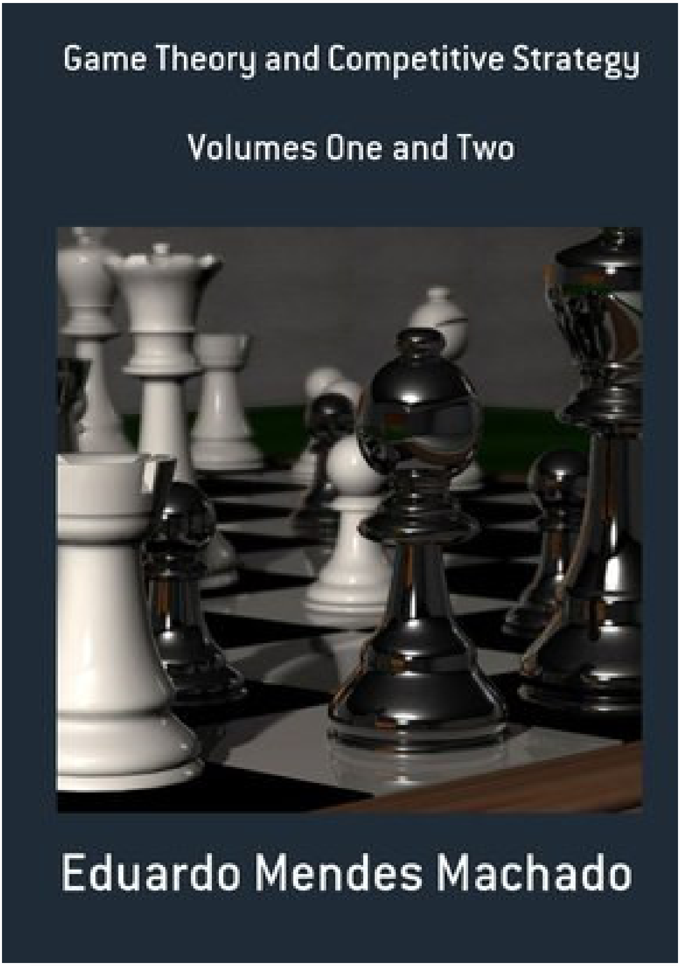

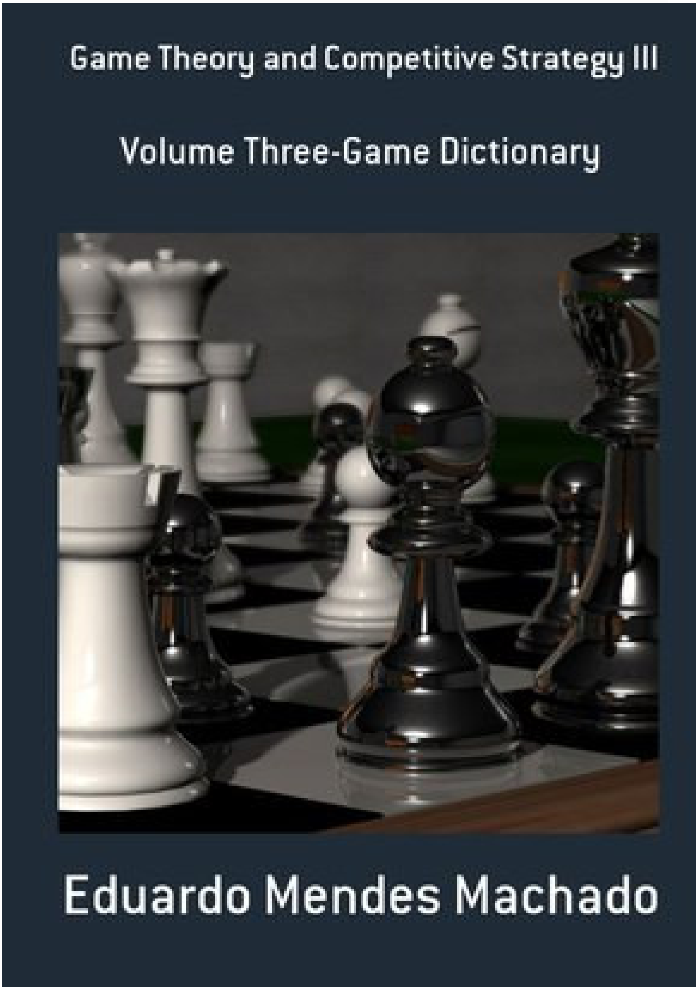
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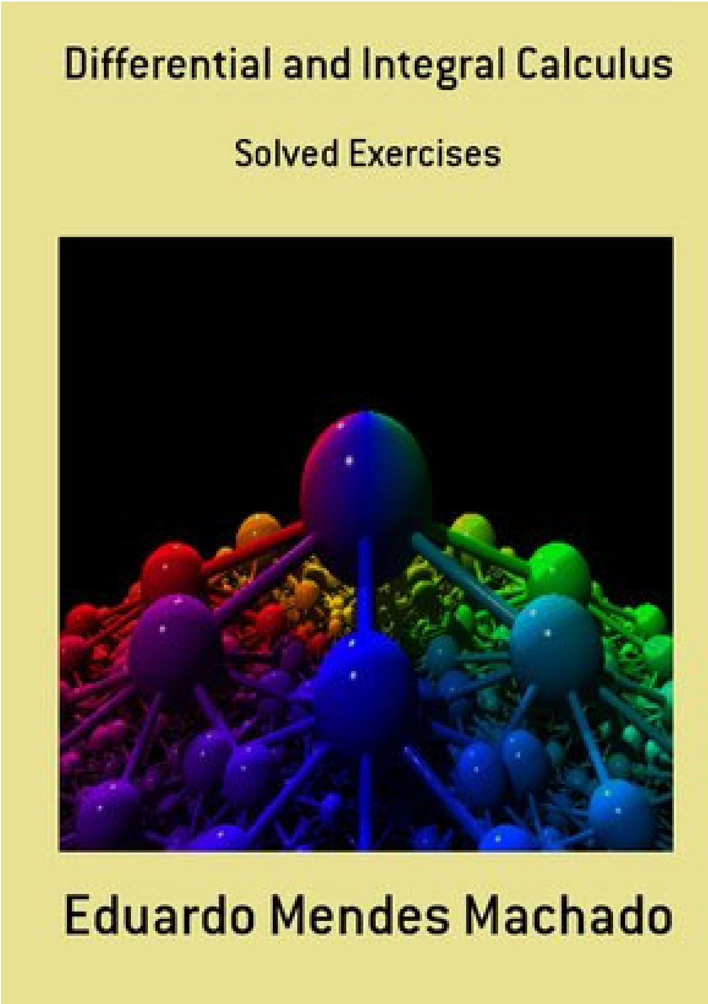
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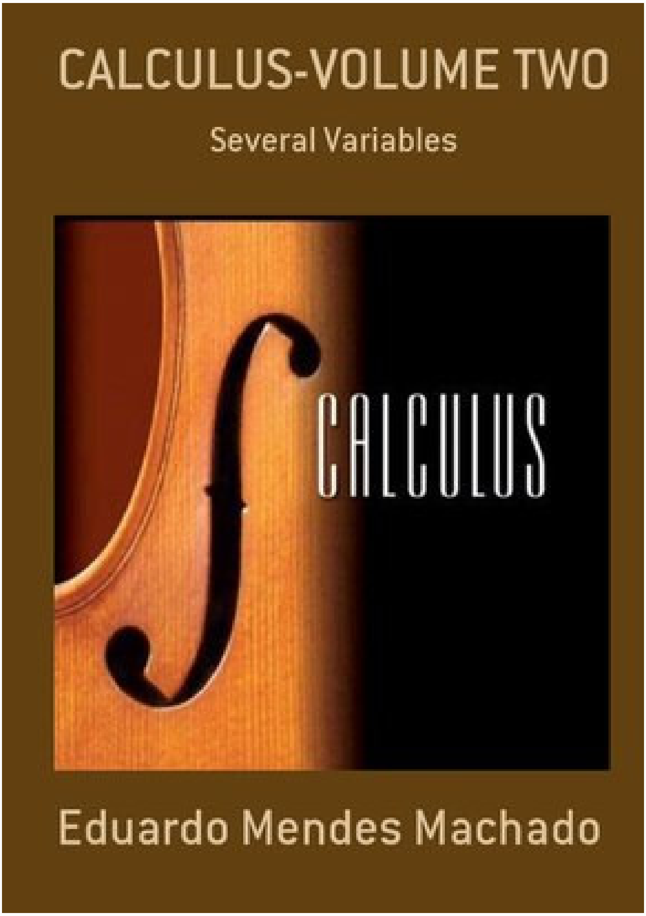
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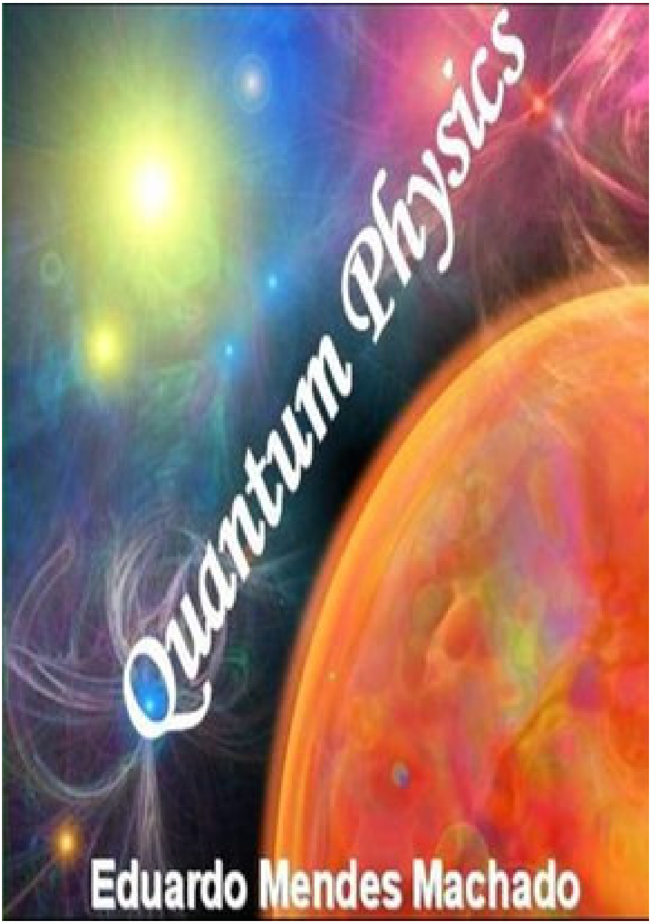

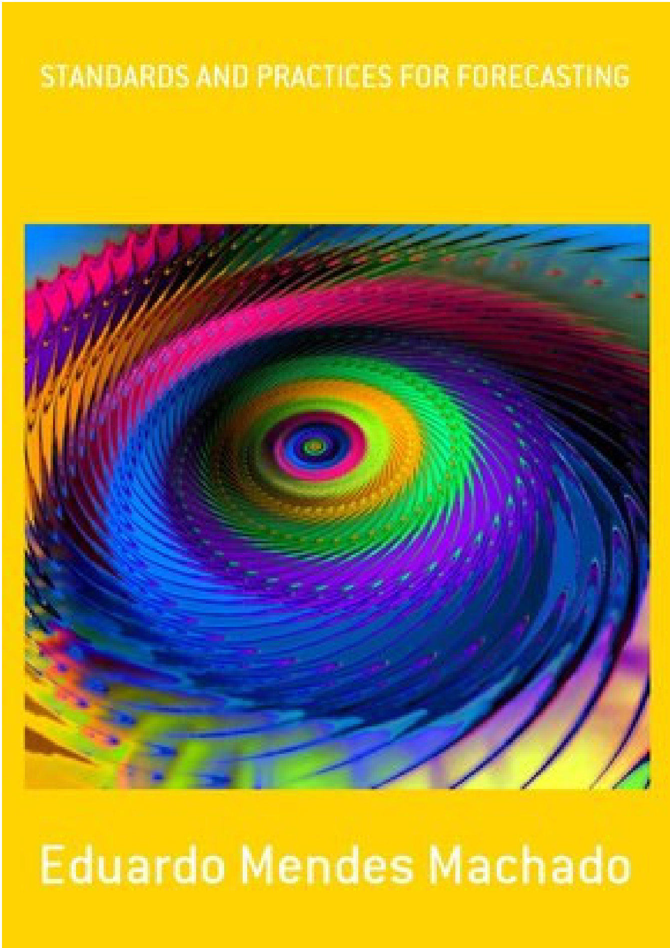
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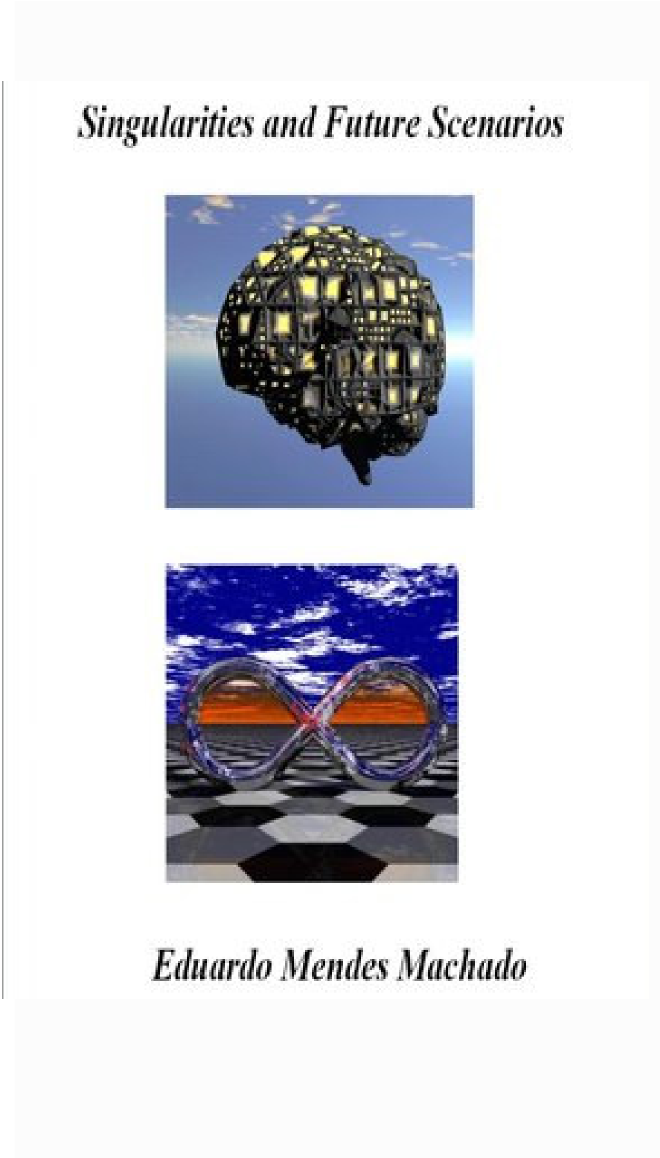

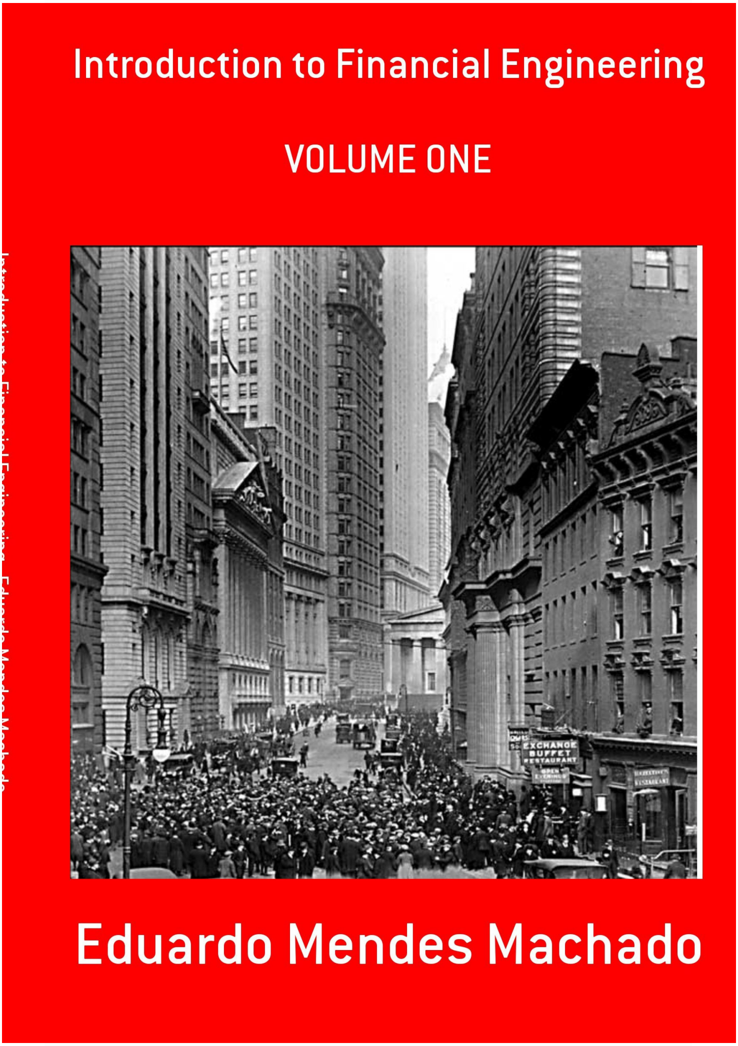
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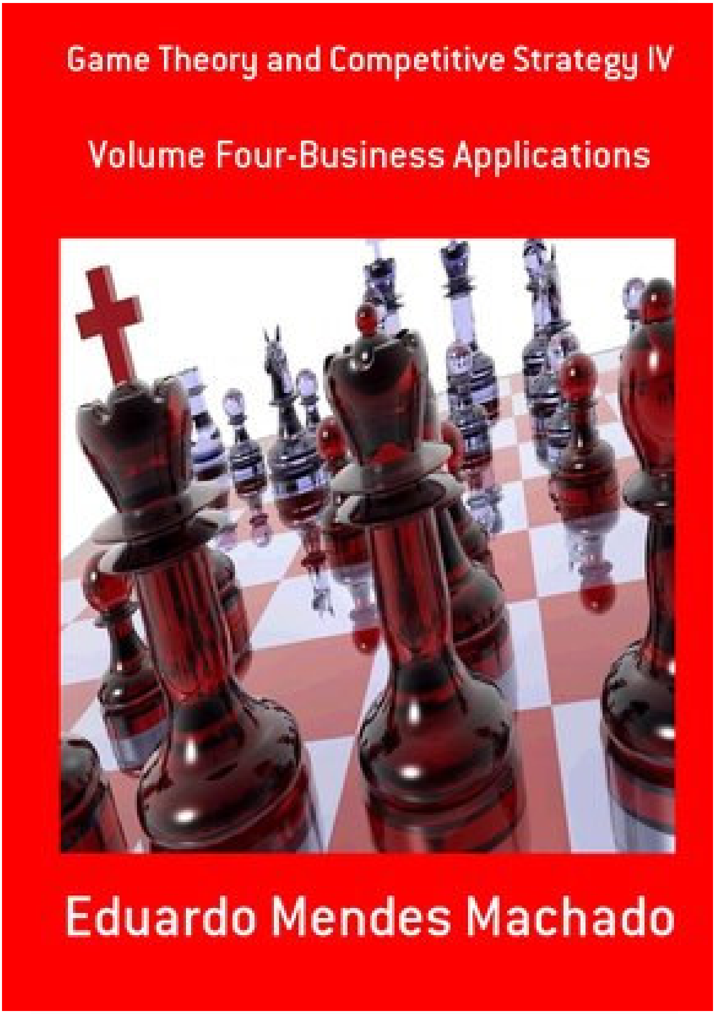

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