Keynote Address

READING THE MIND OF GOD[1]

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ABSTRACT

Recently, a revolutionary new theory has shaken the foundations of modern physics, introducing bizarre new concepts such as higher dimensions, parallel universes, and the multiverse into science. Vigorously opposed by the Old Guard in physics, it has since become the leading candidate for a "theory of everything" which will allow us to "read the mind of God," as Einstein hoped. Einstein spent his last 30 years struggling to find a single theory which would unify all physical laws, much like his equation $E = mc^2$ united matter and energy. He failed. But many physicists now believe that they might have it. It is called string theory or M-theory, and postulates that all the particles, atoms, molecules, etc. in the universe are nothing but musical notes on vibrating strings or membranes. If true, it means that physics represents the beautiful harmonies of nature, that chemistry represents the melodies played on these strings, and the universe is a symphony of strings. It would also mean that the "mind of God" is cosmic music resonating through 11 dimensional hyperspace. The theory also melds Buddhist and Christian thinking. Buddhists believe in a timeless universe, a Nirvana with no beginning or end. But Judeo-Christian thinking is based on Genesis, a single moment of Creation. But either the universe had a beginning, or it didn't. There is no middle ground. Until now. In this new theory, universes are constantly being born in an ocean of 11 dimensional hyperspace or Nirvana, like bubbles floating in the air. Hence, we have a beautiful melding of these two theories. In addition, the question now being debated by physicists is: what lies in these other universes? Can we ever reach them? Is there life on these universes? Is there a clone of myself existing in these parallel universes?

KEYWORDS: Physics, higher dimensions, parellel universes, string theory

Thank you very much. After such an exciting and generous introduction, I can't wait to hear the speaker myself! I have a confession to make. It is true that New York magazine did vote me as one of the 100 smartest people; however, in all fairness, I should point out that Madonna also made that same list. So, how authoritative could that be?

Today, I want to talk about a new theory, a fantastic theory, a theory that is almost beyond belief. A theory that has challenged the old guard in physics that scoffed at notions of higher dimensions, notions of parallel worlds, or unseen universes. They are not scoffing anymore. So we are talking about the future of science. Let me now quote from that great philosopher of the western world, Yogi Berra. Yogi Berra once said, quote, "Prediction is awfully hard to do, especially if it is about the future!" And never forget the words of Abraham Lincoln when he was asked to predict the future of this great country of ours. Abraham Lincoln said, "Gentlemen, sometimes it is better to keep your mouths shut, even if your friends suspect that you are a fool, rather than to open it up and remove all doubt!" Well, today I am going to open the mouths of some of the leading physicists in the world. Nobel Laureates, directors of major scientific laboratories, are now saying, this could be it. This could be the theory that eluded Einstein for the last 30 years of his life when he chased after a theory of everything, a theory that would unite all the fundamental forces of the universe into a single equation, perhaps no more than just one inch long. Now of course, physicists have made mistakes before in predicting the future. We made a famous one when we helped invent the Internet back in the 1960's. One of us predicted that the Internet, our baby, would become a major forum of high culture, high art and high society. Well, today we know that 5% of the Internet is pornography. But that is because teenage boys log on to the Internet. Just wait until the grandmas and grandpas log on to the Internet . . . then maybe 50% of the Internet could be pornography!

So, today, I will talk about a new revolutionary theory, a theory almost beyond belief. But there is one thing that I must say before I begin, and that is, in all the years that I have been a physicist working on this theory, I have learned one thing: to be humble. The universe is a lot stranger, a lot more wondrous and beautiful, a lot more harmonious and unified than we physicists can imagine.

Well, let me tell you a little about myself. When I was a child growing up, I was faced with a contradiction in my worldview. My parents, my ancestors, are Buddhist, and in Buddhism there is no great deity. There is only Nirvana. Timeless Nirvana. And the purpose of life is to attain the highest levels of harmony and peace, to attain that state of timeless Nirvana through meditation. But my parents sent me off to Sunday school and so I learned about the Bible. I learned about gardens and apples. I learned about burning bushes and arks. And in the Bible there is a moment when God declares, "Let there be light!" And there was light. So I had these two mutually contradictory views in my mind. "Is there a God? Or isn't there? Was the universe born in an instant? Or wasn't it?" There is no middle ground. Either the universe had a beginning or it didn't.

Well, ladies and gentlemen, today we physicists believe that we can meld these two seemingly contradictory paradigms. We now believe that there was a Genesis. But Genesis happens all the time. Continual Genesis. Even as I began my remarks, parallel universes have sprung into existence. Continual Genesis, in a multi-verse of universes. Imagine a bubble bath with bubbles popping into existence, bubble universes expanding and contracting, bumping into each other. That is the new paradigm. Continual Genesis. That sounds like a contradiction in terms doesn't it?

When I was a child, I used to visit the Japanese tea garden in San Francisco. How many people in the audience have been to the Japanese tea garden? Almost all of you, I see. I used to spend hours looking at the pond, gazing at the fish. And as a child, I asked myself a question that only a child would ask. "What would it be like to be a fish?" What would it be like to live in a two-dimensional world, beneath the lily pads? Where I could swim forward, backward, left and right, but the concept of "up"—up into hyperspace, up into the third dimension, up into an unseen universe—was considered crackpot, silly. Then I imagined that there was a carp physicist swimming in that pond. The carp physicist would say, "Bah, humbug. The pond is all there is. The pond is the universe. We cannot see beyond the lily pads, because nothing lies beyond the lily pads. Our eyes face to the side. We can only swim forward, backward, left and right. There is no world of up." Then I imagined as a child, reaching down, grabbing the fish, and lifting the carp physicist into the third dimension. What a fantastic journey it would be! The scientist would

see strange beings moving without fins, obeying a new law of physics. Beings breathing without water, obeying a new law of biology in this fantastic world of "up." Then I imagined putting the fish back into the pond. What a story he would tell: That beings could disappear and re-appear instantly. That the third dimension touched every place in the pond. Anywhere you were in the pond, you touched the third dimension. Well, ladies and gentlemen, today we physicists believe, though we cannot yet prove (and I will get into the proof of this in the afternoon talk) that we are the fish. We spend all our life moving in three dimensions, moving forward, backward, left, right, up and down, and we laugh, we snicker when anyone talks about unseen worlds, unseen universes that touch every point in our universe. Well, we physicists aren't laughing anymore. Yet this is now the dominant theory within theoretical physics. My books on this subject, written for Ph.D. physicists, are now required reading at many of the major physics laboratories around the world.

So you see, I stumbled onto pieces of this theory as a child, and I wanted to be part of this great revolution. I read about Einstein. I read about all this new physics. So one day, I went to my mother and I said, "Mom, for my science fair project, can I have permission to build an atom smasher in the garage?" A 2.3 million electron volt betatron particle accelerator, to be exact. My mom just looked at me blankly and said, "Sure. Why not? And don't forget to take out the garbage." So I took out the garbage, went to Westinghouse, and assembled 400 pounds of transformer steel, 22 miles of copper wire, and I built a 2.3 million electron volt betatron particle accelerator in the garage. It created a 10,000 gauss magnetic field. That is 20,000 times the Earth's magnetic field. If you were to walk by my machine, it could pull the fillings out of your teeth. That is how powerful the magnet was. Finally, it was ready. It consumed 6 kilowatts of power, the entire output of my house. Then, I plugged it in. I closed my eyes. I plugged my ears, and there was this huge noise and a gigantic electrical spark that came out of the capacitor bank. I could smell electrical smoke throughout the house. And I could hear this popping sound, pop, pop, pop, as I blew out every single circuit breaker in the house. And the whole house was plunged into darkness. My poor mom. Every time she would come home from work, the lights would flicker and then die. Everything would be plunged into darkness. Then she would say, "Why couldn't I have a son who learns how to play basketball? Maybe if I buy him a football? And for God's sake, why can't he find a nice

Japanese girl? What is wrong with him?" Well, I didn't think anything was wrong with me. But it got me a grand prize at the national science fair and I went off to Harvard to become a physicist.

So, this is my journey, a journey that took me from a tea garden to working on one of the most fantastic theories in science. You have probably seen PBS specials on this. You have probably seen front-page New York Times articles or heard NPR programs. What is this new fantastic theory that everyone is talking about, a theory which "may allow us to read the mind of God?" That was Einstein's dream, "to read God's thoughts."

We are talking about universes beyond Einstein. Einstein gave us the fourth dimension, and now we physicists are working to fulfill his grand dream, a dream that is now taking us beyond the Big Bang, to the 10th and even 11th dimensions. Well, of course, we feeble humans have always thought about other worlds. Where is the edge of our universe? What lies beyond the edge? This is a new picture, one that may allow us, the far distant future, to create "baby universes" in the laboratory. Our universe, apparently, is a bubble, a bubble that has been expanding for 13.7 billion years and today we will approach the question what lies beyond our bubble universe.

Let's begin with the beginning. 13.7 billion years ago, there was this colossal explosion that took place. We even know the date of the Big Bang to within one percent accuracy. But how do we know there was this titanic explosion? Because every time we gaze in to the night sky, the splendor of the greatest show in town, we see galaxies moving away from us at fantastic velocities. We see that yellow galaxies become slightly reddish as they move away from now. Now, when you move away from yellow light, light is stretched like an accordion, it turns reddish. If you move toward yellow light, light is compressed, and it turns blue-green.

I was reading the newspaper the other day, and in New Jersey there was a high school physics teacher who got a speeding ticket for running a red light. According to the article, he went to the court and said, "Your honor, I was moving toward a yellow light. Light is compressed in the forward direction, so therefore it appeared to be green because of the Doppler Shift. So I don't deserve a traffic ticket." The high school physics teacher, according to the

article, went to the blackboard and correctly gave all the equations for the Doppler Shift. "Yes, when moving toward yellow light, light becomes greenish." Well, the judge, according to the article, was amazed. The judge said, "I guess there is a law beyond the laws of the State of New Jersey, and this the law of physics." Then, according to the article, there was a little boy in the back. He raised his hand and said, "Your honor, I am just a high school kid, but I happen to be in his high school physics class. He taught us last week that this only happens near the speed of light!" So from the red shift, we now know that the universe is expanding. But, the article did not say what happened to that poor little boy. But I tell my students, if I am ever in traffic court, and I see them in the back, they better keep their mouths shut if they know what is good for them and if they don't want to flunk out of my course!

So we have this expanding universe. Our universe is a soap bubble of some sort. We still debate the size and shape of the soap bubble, but it is a soap bubble that is expanding and we even know the date when it started to expand. How do we know the date? We run the videotape backwards. We can calculate how fast everything is expanding in the universe, and then we simply run the videotape backwards. That's how we determine that the universe was born 13.7 billion years ago. We now have satellites in orbit, like the WMAP satellite, that have given us "baby pictures" of the infant universe. This is astounding. We now have baby pictures of the Big Bang given to us by the WMAP satellite. The WMAP satellite has changed our entire view. The press called this photograph "the face of God." This is not the face of God; this is a baby picture of the Big Bang. Our satellites have now photographed the residual embers, the echo of Genesis. It is all around us, and it's called the "3 degree microwave background radiation." These little fluctuations are the fluctuations of the original explosion. Our galaxy was once upon a time one of these little fluctuations here in this photograph.

So we now have this gorgeous photograph taken by satellite. However, the satellite picture has also proven that every physics book and chemistry book on earth is wrong. This is very upsetting. If you go to any library, every chemistry or physics book says the universe is made out of atoms. You all remember that from high school. (If you didn't, then you couldn't pass high school. We all said, "Yes, teacher, the universe is made out of atoms.") But we now know that is wrong. We now know that most of the universe is

invisible. 73% of the universe is made of "dark energy," the energy of nothing, the energy of empty space. Who would of thought of that? In fact, it was Nicola Tesla, 70 or so years ago, who wrote about invisible energy, the energy of nothing. And now our latest satellite, the WMAP satellite, has confirmed it. 73% of the universe is made out of dark energy, and 23% is made out of "dark matter," or invisible matter. Last year it was announced on the Internet that we have now captured on film the first invisible galaxy. A galaxy that is totally invisible, made out of dark matter. So I rushed home because I wanted to download this photograph, the first one ever taken of a dark galaxy. I downloaded it, and of course the screen was totally blank, because it is invisible. I forgot about that. However, the artist drew a little oval where the galaxy should be, and there is nothing inside. This is astounding. Who would have thought that we could actually photograph invisible galaxies made entirely out of dark matter? The stars we see in the heavens are made of hydrogen and helium, which make up 4% of the universe, but the heavy elements, which make up the atoms of our bodies, only make up 0.03% of the universe. So we have this mystery: what is dark matter and dark energy?

However, I have to make a confession on behalf of the physics community. About 30 years ago, there was a woman astronomer, Vera Ruben, who was actually the first to indirectly detect the presence of dark matter. But this discovery was so incredible that she was ignored for decades. Vera Ruben may eventually win the Nobel Prize, but she was laughed at for decades. And that is a dark secret of our field: if you are a woman, the tendency is for many male physicists to snicker behind your back. The most famous example of this is the story of Jocelyn Bell. About 40 years ago, she was a woman graduate student in astronomy. One day, she looked up in the sky with her telescope and saw a star blinking at her. Scientists had never seen that before. Now, stars can twinkle because of small atmospheric disturbances. But a blinking star had never ever been seen before. She very carefully logged all of the details of this blinking star on cold nights, day after day, week after week, and then she made the biggest mistake of her life. She told her thesis advisor. But when it was time to write the paper, whose name came first? Jocelyn Bell's name? No. The big shot thesis advisor's name came first. When it was time to give talks around the world, who gave the talks? Jocelyn Bell, who did all the work and logged all of the details? No. It was her advisor. And when it was time to win the Nobel Prize in physics for the discovery of

the pulsar, who won the Nobel Prize? He did. What is the lesson? The lesson is: if you ever discover what dark matter is, tell me first! I am a very generous man. Maybe I will give you a subway token or two. I mean, I have a heart, you know? Just be sure you tell me first.

So we have this mystery. We are clueless about the origin of dark matter and dark energy. The leading theory is that dark energy and dark matter are nothing but a higher vibration or octave of the string. We will get into that in a second.

Now let's say a few words about Einstein. When I was a child, I remember one day all the teachers in my class were whispering that a great scientist had just died, the greatest scientist of our era. I didn't know who he was; I was just an eight-year-old child. But they said that he had changed everything. That very night, the newspapers flashed a picture of his desk, and the caption read, "This is Einstein's desk, and on it, is the unfinished manuscript of the greatest unfinished work by the greatest scientist of our era." Now I was just a kid. I said to myself, "What's in that book? What could be so important that the greatest scientist of our time could not finish it? What is in that unfinished manuscript of Albert Einstein?" Well, I wanted to know. Years later, I found out that it was the unified field theory, the theory of everything, the theory that would allow us to summarize creation, the formation of the galaxies, the formation of the Earth, people, maybe even love, a theory of everything. I thought to myself, "This is neat. This is greater than any murder mystery. This is greater than any adventure story." I had to know what was in that book so I could help finish it. Well, today I can read that book. And today, we think we can finally finish it.

But first, let me give you a simple introduction to Einstein's theory. Let's say I have a bowling ball and I place it on a trampoline net, and then I shoot a marble around it. You all know that the marble circles around the bowling ball. Well there are two ways you can look at this. You could either say that the bowling ball exerts a mysterious "force" or pull on the marble. Now, we laugh, because we know that the bowling ball exerts no force on the marble. The second, correct way of looking at this is to observe that trampoline net is deformed or warped by the bowling ball, and the warped fabric in turn pushes the marble. The bowling ball distorts the trampoline net, and the trampoline net pushes on the marble. So in other words, gravity does not pull. In this

sense, there is no such thing as gravitational force. In my astronomy course, I tell my students on the very first day that gravity keeps you on the floor, that gravity pulls you to the floor. I tell the students, "gravity sucks!" But in the last lecture I say, "I lied to you! There is no such thing as gravitational pull. Space pushes." If you learn one thing from my talk, learn this: Gravity does not pull, space pushes. So why are you sitting in your chair today? Most of you would say, "Well, gravity is pulling me to the floor." But look, the bowling ball does not pull the marble. It's the trampoline that pushes. So, why are you sitting in your chair today? It's because the Earth has warped the four-dimensional space/time continuum around your head and space above you is pushing you down into your chair. That is Einstein's theory summarized into one sentence. "Gravity does not pull—space pushes." This revolutionary new picture has been verified experimentally when we measure the movement of light throughout the universe.

Well, when we examine the data from the WMAP satellite, the theory which seems to fit all the data is called "inflation." Inflation says that there was a turbo charged expansion at the beginning of time. However, inflation has upset a lot of people. When I talk to astronomers, many are upset. Astronomers are used to thinking in terms a single explosion which gave rise to our universe. One explosion, and that's it, end of the story. It was a single Big Bang, that's all there was. But inflation fits the data. In fact, my colleague, Alan Guth, may eventually win the Nobel Prize for this theory. And inflation says more. Inflation says there was something before the Big Bang. There was something before Genesis. Universes can have Big Bangs all the time. Even as we speak, universes may be budding off other universes. So we now have a unification of Buddhism with Judeo-Christian ideas of Genesis: continual Genesis. This is the new picture. This is the picture that is overthrowing all our conceptions of astronomy. Every astronomer is astounded that inflation seems to fit the data, which means that perhaps universes are budding off of other universes, in a continual creation of parallel universes. So we now have a picture of what happened before the Big Bang: chaotic and eternal inflation, like a bubble bath. Each bubble represents an entire universe. Universes pop into existence, they split, they bud, and they sprout other universes in an ocean of Nirvana. But to actually explain this inflation process, we have to go to an even greater theory, a theory that can explain inflation and the multiverse, and perhaps that is String Theory. This

is the new picture, universes beyond universes, universes in a continual Genesis of Nirvana. And what is this Nirvana?

We physicists have been able to put together a new picture of the universe, which summarizes 2,000 years of physics. Today, our universe is quite old and cold, and the four forces of the universe are horribly broken. The world you see around us is broken; it is chaotic, and it is disjoint. The first of the four forces is gravity, which keeps you on the floor. The second force, the electromagnetic force, lights up our cities. And the weak and strong nuclear forces energize the stars and galaxies. What we want is the "super force" that ruled the universe at the beginning of time. We think that at the instant of creation, the universe was whole, coherent, harmonious, unified. At the instant of creation, there was cosmic perfection. Then the universe exploded giving us the four fundamental forces of today, the nuclear force, the electromagnetic force and gravity.

So let's talk about these forces one at a time. The electromagnetic force is the force of light. It is the force that is wiring up the world. It is the force of the Internet. It is the force of electricity and magnetism, the force of lasers, radio, television, and radar, which gives us prosperity and wealth. It is amazing that the equation for the electromagnetic force is very simple; it is called Maxwell's equation and it's barely half an inch long. This is absolutely astounding. When I was a graduate student in physics, I was shocked that you could summarize all of this in an equation half an inch long. Maxwell's equation says: "The four dimensional divergence of an anti-symmetric second rank tensor equals zero," and that is the equation for light. And in fact, at Berkeley, where I got my Ph.D. you can get a t-shirt which says, "In the beginning God said, 'The four dimensional divergence of an anti-symmetric second rank tensor equals zero,' and there was light, and it was good. And the seventh day He rested." It is an amazing fact that all of this can be summarized by an equation a half an inch long. This equation gives us the modern prosperity that we see all around us.

Over a hundred years ago, Michael Faraday, toiling in his laboratory in Picadilly, London, was building the electrical machines that would one day light up our cities. One day, William Gladstone, Prime Minister of England, visited Michael Faraday as he was working out this wondrous technology. The Prime Minister

looked around the lab, saw all these unfinished machines, kicked them, and said, "Mr. Faraday, of what use will your machines have for the Empire?" Well, Mr. Faraday didn't know what to say. Nothing worked yet. Then Mr. Faraday said, "Mr. Prime Minister, I know not of what use my machines will have for the Empire, but I do know one thing. One day you, Sir, will tax my machines." And that has come to be. 50% of the world's taxes come from the electromagnetic force.

Now we have the nuclear force, the force that I played with when I was in high school, building atom smashers. Whenever we smash atoms apart, what do we get? More particles. And when we smash those particles, what do we get? We get quarks. We smash those particles, and what do we get? More particles, even more particles! And how many particles are there? Hundreds of particles, thousands of particles! When I got my Ph.D. from Berkeley, I had to memorize the names of all these sub atomic particles, called pi mesons, kappa mesons, quarks, strange quarks, top quarks, bottom quarks, Higgs particles, neutrinos, leptons, gluons . . . it goes on and on. Billions of your taxpayers' dollars have gone into giving us thousands of sub atomic particles. In the 1950's, J. Robert Openhiemer, the man who built the atomic bomb, was so frustrated that we were drowning in these sub atomic particles that he made the announcement: the Nobel Prize shall go to the physicist who does NOT discover a new particle this year!

Well, I would hope that in the future, if you get your Ph.D. from the Berkeley Radiation Laboratory, all you would have to do is say, "String." There is a new theory in town, a new theory that is so elegant, so simple, and so harmonious that it has shaken the entire world of physics. PBS does documentaries on it. The New York Times writes front-page articles on it. It just made the front page of the New York Times two days ago, once again.

String Theory, what is it? Well, first of all, we physicists now believe that we can explain why we have all these thousands of sub-atomic particles. If you had a super microscope and could peer into these particles, you would not see a dot at all. You would see a vibrating rubber band. And when you twanged this rubber band, it changes from an electron into a quark. And you twang it again; it changes from a quark into a neutrino. You twang it again it turns from a neutrino into a photon. So why do we have all these sub atomic

particles? They are nothing but musical notes on tiny little rubber band. So what is string theory? String theory is a theory that explains why we have all these sub atomic particles. They are nothing but notes on a string, like A, B-flat, C-sharp. So what is physics? Physics is nothing but the laws of harmony, the chords of these strings. What is chemistry? Chemistry is nothing but the melodies you can play on these strings. What is the universe? The universe is a symphony of strings. And therefore what is the "mind of God?" Einstein spent 30 years of his life chasing after the mind of God. For the first time in recorded history we now have a scientifically credible candidate for the mind of God. It is: "cosmic music resonating through 11 dimensional hyperspace." This is incredible. This is fantastic. This is beyond belief, and it is so simple. In fact it is so simple, even the Doonesbury comic strip had an episode featuring string theory.

But if this theory is so great, you may be saying to yourself, then how come you guys don't get a phone call from Sweden? What's the problem? Well, there is a problem. This theory is only defined in 10 and 11 dimensional hyperspace. The theory does not exist in 3 dimensions. We have tried for many years to formulate a theory in 3 dimensions, and we failed. This theory only works in dimensions that are unseen. And that is why many physicists used to snicker at us. Nobel laureate Richard Feynman used to get in an elevator with John Schwartz, a pioneer in string theory, and Feynman would say, "Well John, and how many dimensions are we in today?" We were the butt of jokes for many years. Well, not anymore. Next year, the largest machine of science gets turned on outside of Geneva, Switzerland, the Large Hadron Collider. Billions of Euros are being spent by the Europeans to build the world's biggest atom smasher, just outside Geneva, Switzerland, to be turned on next year. The hope is that the Large Hadron Collier may give us partial experimental evidence for String Theory, by finding new particles predicted by the theory.

Now you may say to yourself, "Well, how come we don't have a machine like that too? What happened to our machine?" Ten years ago, the United States congress gave us a billion dollars to build a huge hole outside of Texas to house the Superconducting Supercollider. Then congress cancelled on our machine and gave us a second billion dollars to fill up the hole. I can't think of anything more stupid than giving physicists a billion dollars to dig a hole and a second

billion dollars to fill it up. What happened? Well, in the last days of hearings, one congressman, noting how expensive this machine was, asked a physicist, "Will we find God with this machine? If so, I will vote for it." We physicists didn't know what to say. So, the physicist replied, "We will discover the Higgs phoson with this machine." All the jaws hit the floor. 10 billion dollars for another sub-atomic particle! The vote was taken, the machine was cancelled, and we lost our Supercollider. But next year, with lots of fanfare, the Large Hadron Collider outside Geneva will be turned on, funded by the European union.

Now since then, we physicists have tried to run through that hearing in our minds. What should we have said? What should we have said when a congressman asked us, "Will we find God with this machine?" I don't know. But I would have said something different. I would have said something like this: "God, by whatever signs, symbols you ascribe to the deity, this machine will take us as close as humanly possible to his or her greatest creation, Genesis itself. This is a Genesis machine. This is a machine designed to recreate the conditions that created our glorious universe."

Well, String Theory gives us a new picture of our universe, and we hope the Large Hadron Collider may indirectly prove parts of this picture. This new picture says that there are other dimensions out there. Our universe might be nothing but a sheet of paper, but hovering just above us is another sheet of paper, a parallel universe. This picture of higher dimensions has fascinated artists, musicians and philosophers for generations. Think of Salvador Dali's great painting, Christus Hypercubus, or Jesus Christ crucified in the fourth dimension. Many people don't realize that the fourth dimension has fertilized some of the greatest works of art. In this afternoon's program, I will give you a quick introduction to the history of Picasso, Cubism, and Salvador Dali's surrealism, much of it inspired by the fourth dimension.

These are dimensions beyond those we can see or touch. In fact, in 1877, Henry Slade, a mystic, was arrested by the London police. He proclaimed that his magic tricks were made possible by the power of the fourth dimension. Imagine that you are looking down on the pond. Hovering in the third dimension, above the pond, you can perform miracles. You can walk through walls, disappear, re-appear at will. Therefore, who lives in the fourth

dimension? Who has the power to walk through walls and appear and re-appear at will? Henry Slade said, "Ghosts!" Quite simply, you would have the power of a God looking down from the pond. Looking down from hyperspace, looking down at the pond, you are also invisible. H. G. Wells' famous novel, ***The Invisible Man***, has been made into Hollywood movies many times. But they get it wrong each time. How do you become invisible? Read the original, in which H. G. Wells writes that the invisible man becomes invisible because he was blown into the fourth dimension. If you are on a parallel sheet of paper, which is hovering just above our sheet of paper, then you are invisible. Light goes right beneath you. When you look down on the pond, the fish cannot see you either, and that is why the invisible man became invisible. This is also a new picture that can explain dark matter. Today, we can "see" invisible galaxies in outer space. One way to explain this is that there is a galaxy hovering just above us in a parallel universe. It would be invisible, since light passes beneath it. But gravity is caused by the pushing of space, and therefore gravity can hop between universes. This means that we might be able to experimentally detect the presence of these parallel universes and higher dimensions.

At the University of Colorado at Denver, just a few miles from here, the very first experiment was done to test this picture. To be honest, they could not find evidence of a parallel universe. That just means that there is no parallel universe in Denver! But now Purdue University and other universities are joining the hunt. There is a Nobel Prize out there waiting for any enterprising scientist who can detect these parallel universes in their laboratories.

These universes may also collide. Universes can sprout, they can bump into each other. In fact, some physicists believe that a collision between two membrane-universes might have created the Big Bang. This is called the Big Splat theory, and it's being proposed by physicists at Princeton University. How do you experimentally prove this picture? Next year, the largest machine of science every created will be turned on outside of Geneva, Switzerland. We hope it will pick up signals from the 11th or 12th dimension. And in 2011, a new satellite called LISA (Laser Interferometry Space Antenna) goes up in orbit that will hopefully give us gravity wave signals from the pre-Big Bang universe.

Now let me tell you the bad news. The WMAP satellite has also shown that the universe is expanding out of control and it is going to get awfully cold in the future, trillions of years from now. I now quote from the other great philosopher of the Western world, Woody Allen. Woody Allen once said, "Eternity is an awfully long time, especially towards the end." Since it's going to get awfully cold in the future, perhaps we need a lifeboat, a distortion of space and time which will allow us to leave a dying universe. One distortion capable perhaps of ripping the fabric of space and time is a black hole. In outer space, we see fantastic explosions, called gamma ray bursters, which we now believe are baby black holes being born everyday. Our satellites can now detect several of these explosions every day. They are, in fact, the largest explosions in the universe, second only to the Big Bang. They are in fact black holes in formation. Gamma ray boosters are black holes being born every day.

In fact, one of these black holes holds the Milky Way galaxy together. Children ask the question, "Mommy, daddy, the moon goes around the earth, the earth goes around the sun. What does the sun go around?" We can now answer the question. The sun goes around a black hole at the center of the Milky Way galaxy. Tonight, in the great Colorado sky, look in the direction of Sagittarius. That is the center of the Milky Way galaxy. There is a black hole at the very center. By rights, it should illuminate the night sky. This cosmic furnace should outshine the moon. Every night this gigantic furnace burns furiously, but because of dust clouds, we cannot see one of the greatest shows in our vicinity of the universe: the black hole in the center of our Milky Way galaxy. However, some scientists believe, although they cannot prove, that these black holes may also be gateways, perhaps, to leave the universe.

One hundred and fifty years ago there was an Oxford mathematician who wrote a children's book about these wormholes. His book is called ***Alice in Wonderland.*** Does anyone know the name of this Oxford mathematician? Lewis Carroll? No. It was Charles Dodgson. He couldn't write by his own name because he was a distinguished professor of mathematics at Oxford. His true name is Charles Dodgson. He wrote under the pen name Lewis Carroll. Queen Victoria was so enchanted by this book that she wrote Charles Dodgson a letter and said, "Professor, please, please, please give me a copy of your next book." Which he did. It was a treatise on higher mathematics that he sent to Queen Victoria.

Inside these black holes, the mathematics tells us that there lurks a wormhole, a gateways perhaps to another world. This is still controversial, but these wormholes are apparently short cuts through space and time. If you were to put your hands through each side of these wormholes, your hands would not even meet. Buddhists ask the question, "What is the sound of one hand clapping?" Physicists ask the question, "What is the sound of two hands clapping in hyperspace?" The answer is: Two hands cannot meet in the presence of a wormhole. Each hand wind up in a different universe!

Perhaps these wormholes can be used as time machines. Any short cut through space can also give us a short cut through time. And that gives us a question which we physicists are still mulling this over. What happens when you go backwards in time and your teenage mother falls in love with you? How can you be born if your teenage mother just fell in love with you? Or, what happens if you go back in time and kill your parents before you are born? Now, if you think you are so smart, let me give you a paradox that is the mother of all paradoxes.

We physicists are studying the following science fiction story. The story begins in the year 1945. It was a dark and stormy night. A drifter comes in from the storm carrying a precious baby girl that he drops off at an orphanage. The nuns pick up this basket the next day. They don't know what else to call this baby girl, so the nuns call her Jane. And Jane grows up wondering, "Who is my mother? My father? My brother? My sister? All I know is they found me on the doorstep." Well, when Jane becomes 17, she falls in love. A handsome drifter comes into her life and it is love at first sight. But it was not meant to be. They quarrel and her boyfriend stomps off into the darkness.

Now, this is a very sad story. Jane is left pregnant and abandoned. She is rushed to the hospital 9 months later and she delivers a beautiful baby girl. But that very night, somebody breaks open the window and steals her precious baby girl. And it is even worse than this. Jane is bleeding very badly because of the birth. She is going to die. The doctors, to save her life, have to perform an emergency operation. They find, much to their shock, that she is a "hermaphrodite." She is not normal. Now, I am not going to define that word because this is a family program. There is a dictionary outside, so you can look up that word.

So the doctors have to change Jane into "Jim." So Jim wakes up the next day very depressed; she was left as a foundling at a hospital, abandoned by her boyfriend, and then someone kidnapped her baby girl, and now she is not even Jane anymore. Well, Jim later becomes a barroom drunk and gets into fistfights anytime someone says, "Jim, you drunk, where did you come from? Who is your mother? Who is your father? Who are you?" Sadly, Jim is once again stone drunk at the bottom of a bar, but this time a friendly bartender comes up to him and says, "Wake up, wake up Jim. You see I am not really a bartender. I am really a time traveler. Come into my machine and let us together find out who is this Jane/Jim?"

So they go back in time, way back in time. So poor Jim is left somewhere back in time, very disoriented. Suddenly he meets this beautiful 17-year-old girl. And it is love at first sight. But you know, it was not meant to be. They quarrel a lot and Jim stomps off into the darkness. But then Jim finds out that his girlfriend is pregnant. Jim says, "Ah, this happened to me when I was Jane. I want to make sure that our baby girl has the best education possible." That night, he goes to the hospital breaks open the window and steals his own precious baby girl. Then they go back to the time machine. Back, back, way back into the past, until it is 1945.

It is a dark and stormy night. Jim comes in from the darkness carrying a precious baby girl that he drops off at an orphanage. Well the nuns pick her up the next day. They don't know what else to call her, so they call her Jane. Jane grows up wondering, "Who is my mother? My father, my brother, my sister, my aunt, my uncle? I was raised up as a foundling at the doorstep of the convent." Well, Jim later says to himself, "You know, I have got to get my act together. I don't want to be a drunk for the rest of my life. I want to be a time traveler too." So he joins a time traveler corps and has many heroic exploits in the annals of time.

So now Jim is now an old man. He is about to retire from the time traveler's corps. But he asks permission for one final mission. And that is to put on a wig, to go backwards in time, and impersonate a bartender to meet a certain barroom drunk who gets into fistfights anytime someone asks him, "Who are you Jim? Where did you come from anyway?" Now for 10 points, can anyone tell me who is Jims/Janes mother? Father? Daughter? Granddaughter? Great

granddaughter? Jane, you see, is a family tree unto herself. Can you imagine a family get together? What happens if they have a food fight, when someone yells, "Jane, you did that to me!" No, "Jim, you did that to yourself!" We physicists are studying this paradox. We still don't know how to understand this paradox.

So, let me just wind up. You see, to really manipulate the fabric of space and time, you have to be quite advanced. We physicists try to rank advanced civilizations by the amount of energy they consume. On this scale, we are a Type 0 civilization. We physicists can dream of being Type I, where you can control the energy of an entire planet, where you can control hurricanes, volcanoes, the oceans, and even the weather. A Type II civilization controls the power of an entire star. A Type III civilization controls the power of a galaxy. By the time you are a Type III civilization, you will have the power to literally play with the fabric of space and time.

Now a Type I civilization is about one hundred years more advanced than our civilization. A Type I civilization has mastered their entire planet. All planetary energy is at their disposal. A Type I civilization has colonized some of the asteroids, but not much more. This is where we are headed in about one hundred years. A Type II civilization is stellar. For example, the Federation of Planets in Star Trek is a typical Type II civilization. They harness the power of the sun. They can build a sphere around the sun and use the energy output of the entire star. These Type II civilizations are immortal. Nothing can destroy them, even the death of their own mother star. They have star ships to go to nearby stars if their own sun goes supernova. Then we have Type III. Type III civilizations are truly galactic. They can harness the power of space and time. A typical Type III civilization would be a galactic civilization, a civilization that has harnessed the power of many, many star systems, as in Star Wars. A civilization that uses robots and has been able to merge mind and matter is a Type III civilization; a civilization which sends robots around the galaxy to search for other intelligent life forms. Now when a Type III civilization searches for intelligent life, they would put these robots on moons; these moons would then scan the solar system and wait for signs of life. They would create a factory to create millions of robot copies of themselves and shoot out and scan for even more star systems. That is the most efficient way for a Type III civilization to explore the universe, rather than sending Captain Kirk.

Sending their own people to search for intelligent life is very inefficient. The most efficient way is to send self-replicating robots to scan an entire galaxy.

Now where have we seen that before? Where have we seen a Type III civilization that sends probes and lands on a moon that makes other copies of itself and waits for a Type 0 civilization to become Type I? There is a Hollywood movie that many of you have seen that gives us perhaps the most realistic encounter with extra-terrestrial civilization. What is that movie? It's ***2001***. At the very beginning of the movie, Stanley Kubrick explained all this. He originally began the movie by interviewing scientists, who said, "Yes, we don't want to send spaceships with people. We want to send robots. They are going to land on the moon where it is nice and stable and wait for a Type 0 civilization to become Type I." Well, so how come you didn't see that in the movie? At the last minute he cut the first ten minutes of his own movie, and ***2001*** became super mystical.

But ***2001*** is the most scientifically accurate representation of an encounter with extra-terrestrial intelligence, which means that probably on our own moon there could be evidence of a previous visitation. Then the question is: if we have the energy of a Type III civilization, then how can such an advanced civilization create a hole in space? One way is to concentrate fantastic energy at a single point, via a battery of laser beams and particle accelerators, which can harness the power of an entire galaxy. At the center of enormous concentration of energy, you can create a "false vacuum," which in turn leads to a wormhole which connects us to a baby universe.

Now, I once gave this presentation at the London planetarium and a little boy comes up to me. I explained that there are Type I civilizations, which have mastered planetary power, Type II civilizations which have mastered stellar power, and Type III civilizations, which have mastered galactic power. And the little boy comes up to me and grabs my pants and says, "Professor, professor, you are wrong. There is Type IV." So I looked down at this little boy, and I said to him, "Shut up kid. What do you know? I am the big shot professor. You are a 10-year-old boy. There are only planets, stars and galaxies. There is no Type IV." But he kept yanking on my pants and he said, "Professor, there is Type IV. The power of the continuum." And I said to myself, "Oh, my God, maybe he's right." I suddenly realized that the power of the

continuum might be the power of dark energy. Do we have any Star Trek fans out here? You fans know the Borg is a Type III civilization but who can tell me the name of the only Type IV civilization on network television? The Q! That's right. We have one true Star Trek fan here in the audience. Now if you did not understand what just transpired in the last five minutes, get with the program. It is on channel 11 every week.

So let me wind up now. String theory is the leading, and in fact only, candidate for a theory of everything which might allow us to read the mind of God. Eternal questions—such as what happened before the beginning of time? Is there an end to space? Can time run backwards? Are there other universes or higher dimensions?—may eventually be solved by this theory. And starting next year, the Large Hadron Collider may provide the first experimental evidence which probes the periphery of the theory. And satellites in outer space, such as LISA, may eventually give us baby pictures of the instant of creation itself. Perhaps we will see evidence of the universe emerging from the womb. And perhaps we will see evidence connecting our baby universe via an umbilicord to another parent universe.

This is truly an exciting time to be a physicist, when we begin to ponder and perhaps answer the greatest questions in all of science.

So let me end on one note and then we are going to show the video, which is an excerpt of a BBC program on parallel universes. We physicists, when we look in outer space, realize that our own earth also radiates radio and television. In fact, surrounding the earth there is a sphere 50 light years in radius, expanding at the speed of light, the speed of radio, containing the finest of our cultural archives, the noblest achievements of the human creative spirit, programs like "I Love Lucy," "Leave it to Beaver," and now joined by the immortal classics, "Beavis and Butt-head, Part II" and "Dumb and Dumber, Part II" and any star within 50 light years of the earth will pick up our cultural missions. And they will be convinced there is no intelligent life on the earth!

Thank you very much!

If you want to visualize these higher dimensions, if you want to know how Picasso, Salvador Dali, Marcel Duchamp, Lewis Carroll, and many others tried

to visualize and capture these higher dimensions or, who lives in these other dimensions, we can talk about that later. But in the meantime, if you have any questions, let's just throw this wide open for the audience.

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REFERENCES & NOTES

1. This paper is based on Prof. Michio Kaku's Keynote Address presented at the Sixteenth Annual ISSSEEM Conference, *The Cutting Edge of Subtle Energies & Energy Medicine* (June 21-27, 2006).

QUESTIONS & ANSWERS

Attendee 1: Wonderful presentation. It seems to me that you missed something very important, and I am sure that we have all been thinking the same thing, more than likely. You didn't mention quantum mechanics.

Kaku: *String Theory is a Quantum Mechanical theory. In its very inception in 1968, it was born as a Quantum Mechanical theory. In fact, the most advanced quantum mechanical theory known to physics is String Theory. String Theory does what no other theory can do. There are two great theories of the universe. The first is the theory of Einstein, relativity, which gives us the Big Bang, black holes, curvature of space and time, and the possibility of maybe even time machines. That is relativity. The second great theory is the Quantum Theory. At present there is only one theory that can unify the theory of the very big, relativity, with the theory of the very small, the quantum theory. String theory is the only game in town. Now some people come up to me and say, "Professor, maybe I don't like string theory, maybe I don't like ten dimensional hyperspace or eleven dimensions. Give me another theory." I tell them that there is none. Either you play this game or you try to invent a new theory of your own. String theory has even intrigued and enchanted musicians and artists. I got a phone call from Madonna's people a few years ago. Kabbalists are very much interested in String theory because there are two magic numbers in string theory, 10 and 26, and they are also the magic numbers of the Kabbalah. Now, I know nothing about the Kabbalah other than that. So String theory is a quantum theory, and in fact it is the only quantum theory that can unify relativity with Quantum Mechanics.*

Attendee 2: In the search for extra-terrestrial intelligence, will the physicists be beaten out by the mystics?

Kaku: *Conceivably. We physicists tend to be myopic. We tend to look at only things that we can see in a laboratory, inside a box. That rules out large areas of the universe that you cannot capture in a box. As I mentioned, some physicists believe that our moon is the most logical place to look for hardware left behind by a passing extra-terrestrial civilization. But it will take us another hundred years before we have an operating moon base like in* ***2001****. So in some sense, we physicists are the last people you want to talk to because we like to look at things inside of a box. We like to do experiments. We like to have reproducibility. And that's why the Big Bang was once so difficult to study. Before, the Big Bang was beyond experiment, since it happened just once long ago, but now we have photographs of the embers of the Big Bang. Before, people even had doubts of whether the Big Bang really took place. Now we can photograph it. Now we are trying to capture evidence of other dimensions inside the laboratory. And that is why the experiment at the University of Colorado at Denver was the first to begin the process of looking for the presence of these other universes.*

Attendee 2: So are mystics and clairvoyants going to discover extra-terrestrial intelligence?

Kaku: *This afternoon, I will talk about attempts by mystics, clairvoyants, artists, and musicians to capture other kinds of consciousness, other kinds of intelligences, and other kinds of dimensions. This is a long history, and we will delve into the history, starting about 120 years ago. It was a long quest to master these unseen universes.*

Attendee 3: I wonder if you could explore a little the comparative predictions and implications of String theory and some of its contenders, for example, Loop Quantum Gravity. Consider how we could choose between them if evidence grows for both string theory and a few others.

Kaku: *There is another theory called Loop Quantum Gravity where space/time consists of little rings. The problem is that when these things touch each other, the theory is probably divergent. Also, the theory has no electrons in it. There are no protons and no quarks. It is a theory of pure gravity so it is not a theory of anything. It is a theory of empty space. String theory, by contrast, is a theory of everything, including protons, neutrons, quarks, and people. Everything is contained in this theory. Loop gravity is a theory of nothing, i.e. a theory of pure empty space. I am not saying it is wrong. I am saying that it has no electrons or protons, so there are no lasers, there are no atoms, no people in the theory. It is a theory of nothing at the present time.*

Attendee 3: As Lee Smolin points out, string theory is stuck with absolute notions of space/time whereas at least Loop Quantum Gravity relativises space/time.

Kaku: *That is not true. String theory is a relativistic theory, as is Loop Gravity. They are both relativistic. In fact, some total of Einstein's theory is nothing but the first octave of the string. If Einstein had never been born, you could actually reproduce the entire Einstein theory. It is nothing but the first musical note of string theory. Loop gravity is also a relativistic theory.*

Attendee 4: During the 90's, I lived with a man who developed the special effects for 2001 and Star Wars. He lives here in Boulder. He had large glasses with thick lenses in the earlier years. To start his work, he would take off his glasses and look at things very close rather than looking at things far away, to develop his skills there. My question is, rather than looking out toward the galaxies and the broader potential civilizations, 2, 3, 4 and beyond, is there a possibility of looking internally? Because it is said that the human body is a compression, you can look at the interior and say we are a compression of the greater cosmos. In terms of human healing, a global thought experiment, would it be wise to look to the interior, to take off our glasses and our telescopes and look inside to find that music of the spheres, that harmony, the continuum that allows us to explore these same worlds?

Kaku: *I think you raise an excellent point. So far, astronomy has give us experimental evidence for a wide range of phenomena. You can see expanding universes, black holes, etc. These are things that can be photographed with our instruments. When we start to go to the very small, inside, things are much more difficult to photograph. However, string theory has a complete set of predictions about the internal world. This afternoon, because I didn't have a chance to talk about everything here, we will talk about inner space. In the morning session we stressed outer space because we can photograph these things. We are not talking science fiction anymore; we have photographs of these things. In the afternoon we will talk about consciousness, we will talk about the inner world, and we will talk about how artists, musicians, philosophers have struggled with these concepts and how they have actually fertilized many of the tricks and diagrams that we use in string theory. Many of these come directly from mystics. We don't like to admit that, but it's true. And if you look back at the history, the same diagrams that mystics were writing down 100 years ago are now found in physics journals. So we will talk about the inner space in the afternoon talk.*

Attendee 4: Thank-you for a marvelous lecture. I would like to hear your speculations, both your scientific and mystical musings about the nature of dark energy and dark matter, since it comprises so much of existence.

Kaku: *There are two ways in which we physicists try to approach this question: where is 96% of the universe? 96% of the universe is invisible, as we now know. Nikola Tesla*

was the first one to call attention to the energy of nothing. Einstein had a theory of nothing (the cosmological constant) but he didn't quite believe in it either. And now the WMAP satellite has given us mountains of data which confirms the fact. There are two ways in which we can view it. First, it is nothing but the next set of vibrations or octave of the string. The string has many octaves. If you look at the next octave and higher vibrations, you find that many of them are invisible, and therefore you immediately have a very simple way of dealing with this invisible matter. Some vibrations are visible, some vibrations are not visible, and you can see that in the string. Second, there is another way, which is actually much more controversial, done by a friend of mine. This other way is to assume that this dark matter is the presence of things living in another universe. Consider the invisible man. The invisible man hovers above our universe. Why is the invisible man invisible? Because light travels beneath him. But gravity can ooze between sheets of paper, because space pushes. That is Einstein's great observation. Space can push. Space pushes between these parallel sheets of paper. Therefore you would not see the presence of a galaxy, but you would feel its gravity. Why? Because light goes right underneath it, just the way H. G. Wells said in his famous novel ***The Invisible Man****. The invisible man is invisible because he hovers above us, in a parallel universe. Light travels beneath him. He can see us, but we can't see him. So the second theory, which is being looked at very seriously, is that this dark matter is ordinary matter living in another dimension. We "see" dark matter indirectly. We have maps of it. The Hubble space telescope has given us maps of dark matter. But we don't know what it is. Like I said before, if you ever find out what it is, you know who to call first. There is a shelf full of Nobel Prizes out there waiting for anyone to figure out where this invisible matter comes from. In fact, in this room there is dark matter, because we think that the earth moves in a wind of dark matter. We physicists are looking at lab experiments to detect the motion of the earth in the wind of dark matter. So this is a very hot field. This field is only about five years old. The WMAP satellite was launched in 2003 and has given us solid evidence now. It means that all our text books are wrong. The universe is not really made out of atoms. You can go back to your high school chemistry teacher and tell him he was wrong. This afternoon session will have another video and slide presentation about visualizing these invisible universes.*

Thank you very much. You have been a great audience!

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