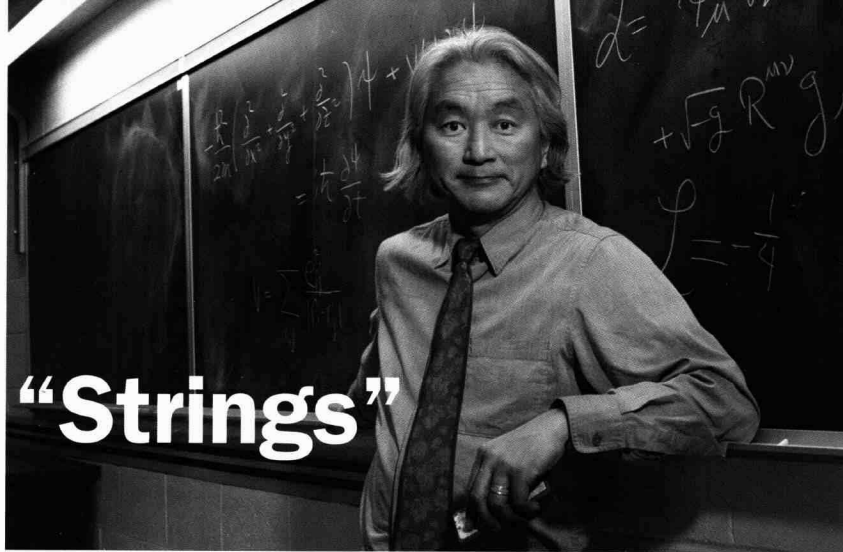


# In Tune With “Strings”



Michio Kaku is Henry Semat Professor of Theoretical Physics at the City University of New York, where he's taught for more than 25 years. His latest of nine books, "Parallel Worlds," was nominated for the Samuel Johnson Prize for Non-Fiction in 2005. A TIAA-CREF participant since 1972, he says, "I sleep soundly knowing that TIAA-CREF is handling my retirement."

Dr. Kaku is co-founder of string field theory, a branch of string theory. We recently talked with him about his work.

**What is a string made of?** The best we can say is that a string is concentrated energy from which everything else is made. A string is so tiny that it can't be seen with any of our instruments. But if we could see it, it would look like a tiny rubber band. If you twang it at a certain frequency it becomes a subatomic particle called a quark. Twang it at another frequency and it becomes an electron, and so on. By twanging enough strings enough times, each with a different vibration pattern, you get all the subatomic particles in the universe.

**What is the relationship between energy and strings?** We believe that time, energy and space are dynamic aspects of a larger multiverse of hyperspace. Energy and matter, as expressed by  $E=mc^2$ , are really the same thing. As for what this energy is, we don't have a word for it yet, unfortunately. However, just as a violin string's different vibrations produce different notes, energy strings' unique vibration patterns correspond to different subatomic particles. If this picture is correct, all of physics

all of life — with one formula. He didn't reach his goal, but we think string theory may provide the unity he sought.

**How does string theory bridge gravity with the other forces?** Every previous attempt to unify gravity with the other forces gave us meaningless calculations while string theory alone produced finite calculation results. We can even use string theory to explain Einstein's theories of gravity, for example, by analyzing just the lowest vibration of a string. And, only string theory lets us explore interesting questions like, "what happened at the instant of the big bang?" or "what happens at the center of a black hole?" Our challenge now is to find experimental evidence that validates string theory.

**String theory lets you investigate what was before the big bang?** Yes. We now believe a *multiverse* of universes has existed since before the big bang. Imagine an ocean of soap bubbles,

rotations in the galaxies, the sum is zero. Likewise, if we add all positive and negative charges, they cancel out exactly to zero. We wondered why: Why do all these physical phenomena always produce a zero sum? The probable answer is that space, time and everything around us comes from *nothingness*. Nothingness has zero charge and zero spin, so it's logical that our universe has zero spin and zero charge.

Since the bubbles must come from somewhere, we think they come from the multiverse ocean of nothingness. If correct, continual fluctuations in the nothingness are generating and subsuming innumerable universes. This shouldn't sound too strange, since Buddhists talk of the timelessness of Nirvana, without beginning or end, and Judeo-Christianity suggests that our beginning derived from the void. String theory, then, beautifully joins Buddhism and Judeo-Christian thinking: Big bangs happen all the time in an ocean of Nirvana.

**Nothingness is actually filled with physical reality?** That's right. We think nothingness is actually chock-full of interactions. We know, for example, that dark energy — the energy of nothingness first predicted by Einstein — makes up 73% of the universe. Humans are made of elements (carbon, nitrogen and oxygen, etc.) that represent only 0.03% of the universe. We're an anomaly — the earth is a very mild, unusual place. But in the realm of Einstein and quantum theory, the universe is generally violently hot or cold. □

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can be summarized as the harmonies of tiny vibrating strings, chemistry as the melodies of interacting strings, and the universe as a symphony of all strings resonating distinctly.

Over his last 30 years of life, Einstein tried to unify gravity and the other basic forces with a theory of everything. He wanted to neatly summarize everything in the universe — matter, energy, the big bang, the Earth's formation and

each representing a universe and us living on the skin of one bubble. This view suggests a continual genesis in which big bang events happen all the time, — since bubbles pop up and expand very rapidly from the multiverse ocean.

**A string vibration requires time and space to already exist. But if strings create everything, what created the antecedent space and time?** We've found that every time we add all