

Particle accelerator may reveal shape of alternate dimensions

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When the world's most powerful particle accelerator starts up later this year, exotic new particles may offer a glimpse of the existence and shapes of extra dimensions.

Researchers from the University of Wisconsin-Madison and the University of California-Berkeley say that the telltale signatures left by a new class of particles could distinguish between possible shapes of the extra spatial dimensions predicted by string theory.

String theory, which describes the fundamental particles of the universe as tiny vibrating strings of energy, suggests the existence of six or seven unseen spatial dimensions in addition to the time and three space dimensions that we normally see.

Much as the shape of a musical instrument determines its sound, the shape of these dimensions determines the properties and behavior of our four-dimensional universe, says Gary Shiu, lead author of a paper appearing in the Jan. 25 issue of *Physical Review Letters*.

"The shape of the dimensions is crucial because, in string theory, the way the string vibrates determines the pattern of particle masses and the forces that we feel," says the UW-Madison physics professor.

Zeroing in on that shape should further our understanding and predictions of our four-dimensional world, Shiu says. "There are myriad possibilities for the shapes of the extra dimensions out there. It would be

useful to know a way to distinguish one from another and perhaps use experimental data to narrow down the set of possibilities."

Such experimental evidence could appear in data from a new particle accelerator, the Large Hadron Collider, scheduled to begin operating later this year near Geneva, Switzerland.

In an accelerator, smashing atomic nuclei head-on at nearly the speed of light can briefly create new high-energy and highly unstable particles, which quickly decay into a shower of detectable lower energy ones. Characteristic patterns of decay serve as fingerprints of the fleeting exotic particles and, possibly, the shape of the unseen dimensions.

With colleagues Bret Underwood and Kathryn Zurek at UW-Madison and Devin Walker at UC-Berkeley, Shiu shows in the new study that the signature patterns from particles called Kaluza-Klein (KK) gravitons can distinguish between different proposed extra-dimensional geometries.

How? Shiu compares the effect to a darkened room in which patterns of sound resonating off the walls can reveal the shape of the room. Similarly, KK gravitons are sensitive to the extra-dimensional shape and, through their behavior and decay, may reveal clues to that shape.

The current study shows that, in simulations, even small geometric variations lead to visible differences in KK graviton signatures, Underwood says.

Based on these results, Shiu says, "At least in principle, one may be able to use experimental data to test and constrain the geometry of our universe."

Last year, Shiu and Underwood reported that clues to dimensional geometries might also be visible in patterns of cosmic radiation left over

from the Big Bang. The new work complements the previous approach, they say.

"The more hints we get, the better idea we have about the underlying physics," says Shiu.

Adds Underwood, "If the cosmology and particle physics data agree, it's an indication we're on the right track."

Source: University of Wisconsin-Madison

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