Did the universe once have fewer dimensions?

March 16, 2011
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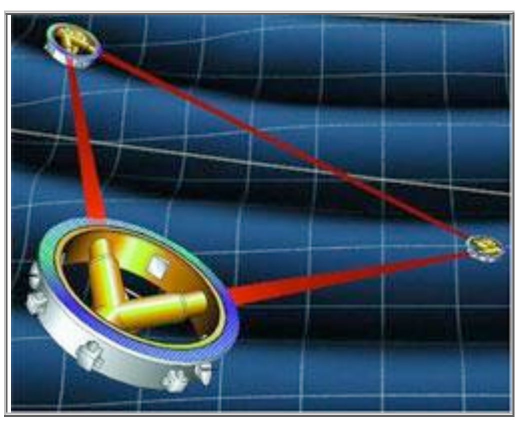
The familiar three dimensions of space—height, width and length—may have been just one or two when the universe was formed, some physicists say.

In the March 11 issue of the research journal *Physical Review Letters*, a scientific team proposes a test of the theory using a planned, space-based observatory for gravitational waves. Gravitational waves are ripples in space and time predicted by Einstein's theory of relativity.



TheLISA gravitational wave detector consists of three satellites that would pick up gravitational waves from distant, large-scale events, such as the Big Bang. (Courtesy NASA)

The proposal is also summarized in an article in *Physical Review Focus*, an online magazine of the American Physical Society, which also publishes *Physical Review Letters*.

Although the theory is speculative, the report says, the researchers think existing data has already shown hints of vanishing dimensions at early times.

According to the report, their proposal holds that the familiar three di-

mensions of space could have been folded into two or just one at extremely high energies and temperatures. Such conditions characterized the universe just after the "Big Bang" that gave it birth. As the universe cooled, in this view, more spatial dimensions would have appeared one by one.

The theory also proposes that our current universe has four spatial dimensions, but that we only experience a three-dimensional "slice" of it, the report goes on. The appearance of the fourth spatial dimension would have given rise to extra energy, triggering a boost to an ongoing expansion of the universe. This might in turn explain an accelerating expansion of the universe that was discovered in 1998 and is usually ascribed to a mysterious "dark energy" pervading space.

The theory also solves some problems in particle physics, said one of its proponents, physicist Dejan Stojkovic of the State University of New York at Buffalo, according to *Physical Review Focus*.

Evidence of vanishing dimensions may already have been detected in cosmic rays, high-energy particles from space that shower the Earth's atmosphere, the report explains. A 2005 reanalysis of cosmic ray data showed that the jets of particles produced by the most energetic cosmic rays were aligned unexpectedly close to a flat plane, which, they argue, could point to dimension reduction.

Other researchers plan to use the Large Hadron Collider, a particle accelerator near Geneva, Switzerland, to test for vanishing dimensions, the publication said. The machine smashes subatomic particles to reveal what their components are. If dimensions vanish at very high energies, the thinking goes, then the particles produced in such collisions would be confined to a two-dimensional plane, like a piece of paper, instead of a three-dimension volume, like a box.

But interpreting the accelerator data may be tricky because different models will have different predictions, Stojkovic said in the report. So he and Jonas Mureika of Loyola Marymount University in Los Angeles looked for a more definitive test. They settled on gravitational waves—ripples in space and time caused by violent events in the cosmos. These waves can't exist in fewer than three spatial dimensions, said Stojkovic. So in the vanishing-dimensions hypothesis, he told *Focus,* "you can't get around the non-existence of gravity waves" at the earliest times.

Gravitational waves reaching Earth are expected to have originated at different times, because they can take a long while to get here. Some would presumably come from the earliest eras of the universe, according to scientists. Proponents of the vanishing-dimensions hypothesis say that the primordial gravitational waves with the highest frequencies—that is, those that oscillate fastest—correspond to the highest energies and the earliest times. So there should be a maximum frequency of the observed waves; higher frequencies couldn't exist because they would come from the fewer-dimension era.

Stojkovic and Mureika have developed an estimate of this frequency cutoff: about 10,000 oscillations per second, depending on certain factors. They say this is within the range accessible to the Laser Interferometer Space Antenna, or LISA, a space-based gravitational wave detector

planned jointly by NASA and the European Space Agency. Stojkovic and Mureika said they are working with experimentalists from several U.S. universities to prepare a test of their proposal, though this would be about a decade away.

This range of frequencies "is extremely interesting to probe by observat-ions, if that is possible at all," Martin Bojowald, a theorist at Pennsylva-nia State University in State College, told *Focus*. He said the paper is "promising, if one tries to draw reliable conclusions in the absence of a detailed underlying theory."