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# Scientists Expect to "See" Miniature Black Holes

An article soon to be published in the conference proceedings of Snowmass 2001, The Future of Particle Physics," fuels excitement that scientists will be able to see the traces of miniature black holes created in an accelerator.

The possibility has been explored by Steven B. Giddings, professor of physics at the University of California, Santa Barbara, and his co-author, Scott Thomas, who is an assistant professor of physics at Stanford University.

"If certain theories of nature are correct, then black holes would be produced in high-energy collisions of particles in particle accelerators," said Giddings. These theories go by the generic name of "TeV-scale gravity."

"TeV-scale gravity is expected to be tested in the next generation of particle accelerators, with the Large Hadron Collider near Geneva, Switzerland being the first of these," he added.

Giddings explained that the only scenarios we know that allow black holes to be produced at energies around a TeV are those with extra dimensions of space-time.

There may, however, be other scenarios not yet discovered.

And if black holes are produced in accelerators, their properties will depend on properties of the extra dimensions.

So scientists will be able to study the extra dimensions. In fact, the creation of bigger and bigger black holes may allow exploration of the geography of the extra dimensions.

Why create even small black holes? Wouldn't they gobble up everything in sight?

Giddings answered that one of British physicist Stephen Hawking's greatest discoveries is that black holes evaporate. Small ones evaporate exceedingly quickly, in around 10 to the minus 17 seconds. "They simply don't have time to absorb an appreciable amount of matter before they explode," he said. When they explode they are expected to send out a tiny amount of radiation, which scientists will be able to detect.

Hawking has also showed that black holes behave as if they have a temperature -- which decreases as the black holes get bigger. The little ones are quite hot, and therefore radiate their energy away very quickly.

Giddings expects miniature black holes to increase understanding about the relationship between quantum mechanics and gravity. Black hole evaporation is a quantum-mechanical phenomenon.

Since big black holes, like those in the center of galaxies, evaporate so slowly, scientists do not expect to be able to see this phenomenon there.

However, for small black holes, this, and other quantum-mechanical effects, are very important, indeed crucial, in determining their behavior and evolution. So, once scientists can study small black holes, they can start learning about the relationship between quantum mechanics and gravity.

Studying miniature black holes will reveal a wealth of information about the very fabric of the universe, explained Giddings.

"Black holes are perhaps the most profound and mysterious objects we've imagined.

Being able to create and study them should teach us a lot.

In particular, it can teach us about how quantum mechanics can be reconciled with gravity; it could allow us to explore extra dimensions of space and time; and it may tell us something about an ultimate unified theory of physics.

It may also signal the breakdown of the very concepts of space and time at short distances."

Giddings explained that black hole production may occur at the Large Hadron Collider in Switzerland, or that scientists will have to go to higher energies by building a bigger accelerator. Meanwhile, he said that "if nature allows us to create black holes in accelerators, then that also means that they should be created when cosmic rays strike the atmosphere," adding increased interest to the study of miniature black holes.

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