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# Einstein equations indicate possibility of black hole formation at the LHC

April 6 2010, By Miranda Marquit

A person stands in front of the huge ATLAS detector, one of six detectors that are part of the Large Hadron Collider near Geneva. Credit: Maximilien Brice, CERN

(PhysOrg.com) -- One of the concerns that has been voiced about the Large Hadron Collider (LHC), is that it could result in the formation of black holes that could destroy the world. While most scientists dismiss claims that anything produced in the LHC would destroy the planet, there are some that think that black formation could be seen with LHC collisions of sufficiently high energy. This idea has gotten a further boost from recent efforts by Matthew Choptuik at the University of British Columbia in Vancouver, and Frans Pretorius, at Princeton University in New Jersey.

“What we did was a calculation,” Choptuik tells *PhysOrg.com*. “We solved some of the Einstein field equations describing head on soliton collisions at certain energies." Choptuik and Pretorius present their work, and their conclusions, in Physical Review Letters: "Ultrarelativistic Particle Collisions."

"Our calculation produced results that most were expecting, but no one had done the calculation before. People were just sort of assuming that it would work out," Choptuik says. "Now that these simulations have been done, some scientists will have a better idea of what to look for in terms of trying to see if black holes are formed in LHC collisions."

Choptuik points out that there has been an effort for more than 50 years to marry particle physics with the idea of gravity. "At the level of classical physics we think we understand gravity pretty well," he explains. "However, at the quantum mechanical level, gravity is not at all well understood. Scientists have been looking for a way to understand quantum gravity in the same way as we understand how the smallest particles work on a quantum level. While solving these equations doesn't answer all the questions, it does substantiate what we have already assumed."

One of the keys to the principles behind these field calculations is string theory. String theory suggests that there are several dimensions beyond the three spatial dimensions (plus time) that we see in classical physics. "If extra dimensions do exist, they could be as large as 10s to 100s of a micrometer. And if those extra dimensions are big enough, then there is a chance that the particle collisions at the LHC might be able to form black holes," Choptuik says.

Of course, these black holes would be quite tiny, and difficult to detect. On top of that, they would evaporate almost instantly, making it even more difficult to detect whether they had even existed. "In collision like this, you would have to look at the debris," Choptuik explains. "You'd look at the decay pattern in space. In a normal collision, you would get jets of debris. If a black hole was created and evaporated, the pattern would look more spherical than jet-like."

However, the fact that the solution of these Einstein field equations suggests that black hole formation could be possible at the LHC is a far cry from actually detecting it. "Some are already taking this very seriously," Choptuik says. "However, I don't think that we are likely to actually see any black holes at the LHC, even if it is possible."

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**More information:** Matthew Choptuik and Frans Pretorius, "Ultrarelativistic Particle Collisions," *Physical Review Letters* (2010). Available online: link.aps.org/doi/10.1103/PhysRevLett.104.111101

Citation: Einstein equations indicate possibility of black hole formation at the LHC (2010, April 6) retrieved 17 April 2024 from https://phys.org/news/2010-04-einstein-equations-possibility-black-hole.html