Quantum gravity takes singularity out of black holes

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Travel to another universe? May be possible - physicists got rid of singularity in black holes! An article featuring Jorge Pullin, Louisiana State University Center for Computation & Technology faculty member who is a Professor and Horace Hearne Chair of Theoretical Physics at LSU Department of Physics & Astronomy, was published in New Scientist, a London-based international science and technology magazine.

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NEW SCIENTIST
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Falling into a black hole may not be as final as it seems. Apply a quantum theory of gravity to these bizarre objects and the all-crushing singularity at their core disappears.

In its place is something that looks a lot like an entry point to another universe. Most immediately, that could help resolve the nagging information loss paradox that dogs black holes.

Though no human is likely to fall into a black hole anytime soon, imagining what would happen if they did is a great way to probe some of the biggest mysteries in the universe. Most recently this has led to something known as the black hole firewall paradox – but black holes have long been a source of cosmic puzzles.

According to Albert Einstein's theory of general relativity, if a black hole swallows you, your chance of survival are nil. You'll first be torn apart by the black hole's tidal forces, a process whimsically named spaghettification.

Eventually, you'll reach the singularity, where the gravitational field is infinitely strong. At that point, you'll be crushed to an infinite density. Unfortunately, general relativity provides no basis for working out what happens next. "When you reach the singularity in general relativity, physics just stops, the equations break down," says Abhay Ashtekar of Pennsylvania State University.

The same problem crops up when trying to explain the big bang, which is thought to have started with a singularity. So in 2006, Ashtekar and colleagues applied loop quantum gravity to the birth of the universe. LQG combines general relativity with quantum mechanics and defines space-time as a web of indivisible chunks of about 10^{-35} metres in size. The team found that as they rewound time in an LQG universe, they reached the big bang, but no singularity – instead they crossed a "quantum bridge" into another older universe. This is the basis for the "big bounce" theory of our universe's origins.

Information paradox

Now Jorge Pullin at Louisiana State University and Rodolfo Gambini at the University of the Republic in Montevideo, Uruguay, have applied LQG on a much smaller scale – to an individual black hole – in the hope of removing that singularity too. To simplify things, the pair applied the equations of LQG to a model of a spherically symmetrical, non-rotating "Schwarzschild" black hole.

In this new model, the gravitational field still increases as you near the black hole's core. But unlike previous models, this doesn't end in a singularity. Instead gravity eventually reduces, as if you've come out the other end of the black hole and landed either in another region of our universe, or another universe altogether. Despite only holding for a simple model of a black hole, the researchers – and Ashtekar – believe the theory may banish singularities from real black holes too.

That would mean that black holes can serve as portals to other universes. While other theories, not to mention some works of science fiction, have suggested this, the trouble was that nothing could pass through the portal because of the singularity. The removal of the singularity is unlikely to be of immediate practical use, but it could help with at least one of the paradoxes surrounding black holes, the information loss problem.

A black hole soaks up information along with the matter it swallows, but black holes are also supposed to evaporate over time. That would cause the information to disappear forever, defying quantum theory. But if a black hole has no singularity, then the information needn't be lost – it may just tunnel its way through to another universe. "Information doesn't disappear, it leaks out," says Pullin.

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LSU
Center for Computation & Technology
2003 Digital Media Center • Telephone: +1 225/578-5890 • Fax: +1 225/578-8957