Physicists Demonstrate How Information Can Escape From Black Holes

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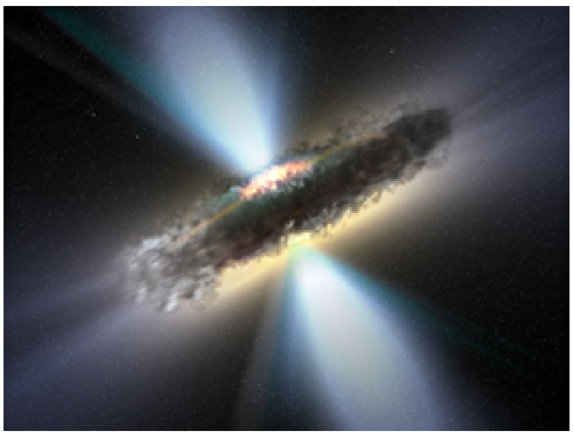

An artist's depiction of the accretion of a thick ring of dust into a supermassive black hole. The accretion produces jets of gamma rays and X-rays. Credit: ESA / V. Beckmann (NASA-GSFC)

Physicists at Penn State have provided a mechanism by which information can be recovered from black holes, those regions of space where gravity is so strong that, according to Einstein's theory of general relativity, not even light can escape. The team's findings pave the way toward ending a decades-long debate sparked by renowned physicist Steven Hawking. The team's work will be published in the 20 May 2008 issue of the journal *Physical Review Letters.*

In the 1970s, Hawking showed that black holes evaporate by quantum processes; however, he asserted that information, such as the identity of matter that is gobbled up by black holes, is permanently lost. At the time, Hawking's assertion threatened to turn quantum mechanics--the most successful physical theory posited by humankind--on its head, since a fundamental tenet of the theory is that information cannot be lost.

Hawking's idea was generally accepted by physicists until the late 1990s, when many began to doubt the assertion. Even Hawking himself renounced the idea in 2004. Yet no one, until now, has been able to provide a plausible mechanism for how information might escape from a black hole.

A team of physicists led by Abhay Ashtekar, Holder of the Eberly Family Chair in Physics and director of the Penn State Institute for Gravitation and the Cosmos, now has discovered such a mechanism. Broadly, their findings expand space-time beyond its assumed size, thus providing room for information to reappear.

To explain the issue, Ashtekar used an analogy from Alice in Wonderland. "When the Cheshire cat disappears, his grin remains," he said. "We used to think it was the same way with black holes. Hawking's analysis suggested that at the end of a black hole's life, even after it has completely evaporated away, a singularity, or a final edge to space-time, is left behind, and this singularity serves as a sink for unrecoverable information."

But Ashtekar and his collaborators, Victor Taveras, a graduate student in the Penn State Department of Physics, and Madhavan Varadarajan, a professor at the Raman Research Institute in India, suggest that singularities do not exist in the real world. "Information only appears to be lost because we have been looking at a restricted part of the true quantum-mechanical space-time," said Ashtekar. "Once you consider quantum gravity, then space-time becomes much larger and there is room for information to reappear in the distant future on the other side of what was first thought to be the end of space-time."

According to Ashtekar, space-time is not a continuum as physicists once believed. Instead, it is made up of individual building blocks, just as a piece of fabric, though it appears to be continuous, is made up of individual threads. "Once we realized that the notion of space-time as a continuum is only an approximation of reality, it became clear to us that singularities are merely artifacts of our insistence that space-time should be described as a continuum."

To conduct their studies, the team used a two-dimensional model of black holes to investigate the quantum nature of real black holes, which exist in four dimensions. That's because two-dimensional systems are simpler to study mathematically. But because of the close similarities between two-dimensional black holes and spherical four-dimensional black holes, the team believes that this approach is a general mechanism that can be applied in four dimensions. The group now is pursuing methods for directly studying four-dimensional black holes.

Source: Penn State

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