Hitching a Ride Out of a Gluttonous Black Hole

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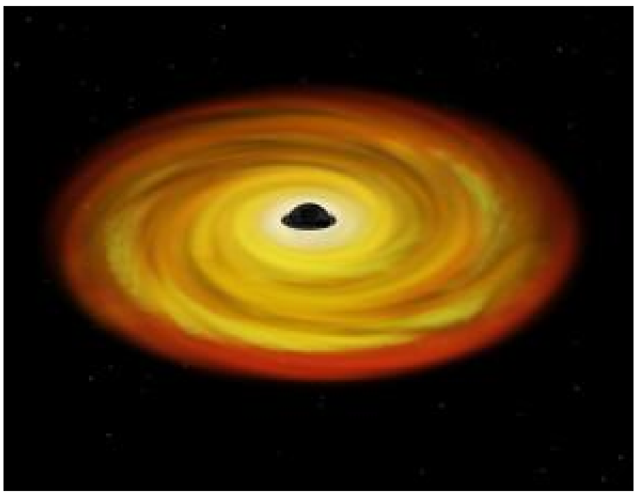

Spinning Black Hole. Illustration: NASA/CXC/M.Weiss

“Ever since Stephen Hawking showed that black holes evaporate,” says Seth Lloyd, an MIT physicist, “people have wondered about the stuff that comes out of them. Is it just garbage, or is it something else?” With his piece published in *Physical Review Letters* on February 14, Lloyd attempts to show that quantum information does escape black holes, and that this information is useful and can have lasting impacts on how we understand our universe.

Lloyd’s assertion is that information escapes as black holes evaporate in what is known as a final state projection model. Final projection is nonlinear, but it is also considered self-consistent. “It’s funky,” Lloyd explains to Physorg.com, “but it is self-consistent. Anything that happens in a final state projection can ‘legally’ happen in a more conventional quantum mechanical manner.”

Final state projection is far from commonly accepted, however. One of the main problems some physicists have with these models is that in order the information has to travel at faster-than-light speeds to escape. While a final state projection model of black hole evaporation preserves unitarity and can even explain entropy as microstates of black hole horizon, getting past the idea of quantum information escaping at such high speeds is difficult. The idea of final state projection and escaping quantum information was put forth in the 1960s, but had been pretty much shunted aside by the 1980s. Despite attempts by a few physicists to substantiate the idea of faster-than-light quantum information escape from black holes, many remain skeptical.

Even Lloyd concedes that quantum bits moving faster than light hard to accept. “I admit that it’s strong medicine, things traveling faster than the speed of light.” But he insists his calculations show that it is possible. In a process similar to teleportation, quantum information inside the black hole entangles itself with Hawking radiation. As the black hole evaporates, the information is mostly preserved in the radiation. In Lloyd’s letter, his calculations show that the escaping quantum information has fidelity $\approx (8/3\ \pi)^2$. This means that if Lloyd is right, an average of half a bit of information is lost, no matter how many bits escape the black hole.

Lloyd’s calculations show that it is possible, in a final state projection scenario, for useful quantum information to escape a black hole. This of itself is a remarkable discovery, considering that it is commonly thought that nothing can escape a black hole, and that fairly useless Hawking radiation is the only product of black hole evaporation. Lloyd’s letter suggests that even the Hawking radiation has a use, as it will carry the entangled bits of quantum information.

But it is the implications regarding a theory of quantum gravity that Lloyd feels is especially significant. “We can understand quantum gravity by looking at how things process quantum information, and one of these things can be an evaporating black hole. This [letter] shows an example of applying methods of quantum information about quantum gravity and then getting something back.”

Not only does Lloyd believe that black holes can help physicists form a theory of quantum gravity, but he also thinks that final state projection shows how black holes can function as quantum computers. “It becomes a matter of putting information into a hole. The hole processes the information and spits it out through Hawking radiation.” Lloyd pauses, then continues: “We don’t know how to program a black hole, but maybe when we learn more about quantum gravity, we will be able to.”

Citation: Seth Lloyd. Almost Certain Escape from Black Holes in Final State Projection Models, *Phys. Rev. Lett.* 96, 061302 (2006)

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