# Imitation black hole seen on earth

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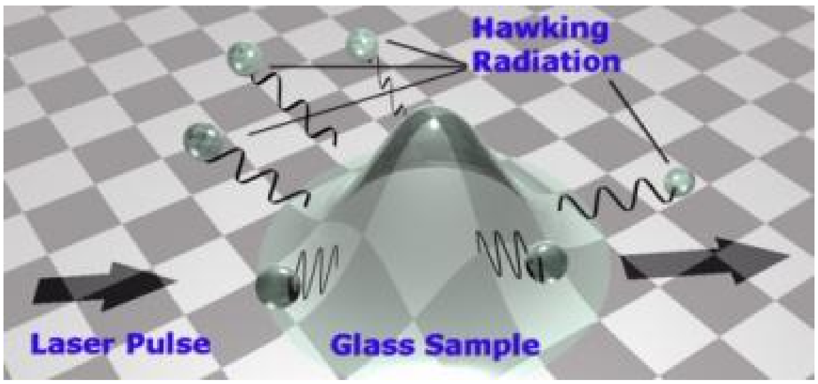


Hawking radiation (little sideways moving balls) is created when a powerful and brief pulse of light (black arrows) is sent through a sample of pure glass. The pulse instantaneously changes the optical conditions in the glass to such a degree that the light seems to come to a halt, represented by the green-shaded warped tiling. Credit: ISNS/ Daniele Faccio

Astrophysics deals mostly with things that are so distant -- thousands or billions of light years away -- that we can't ever hope to see them up close. But clever scientists can do the next best thing to making a light-year journey; they can recreate some of the celestial occurrences in a lab. In effect, they can bring parts of the sky down here to earth.

That's what physicists in Italy have done. Using nothing more than lasers, a sample of pure glass, and sensitive detectors they have created a miniature environment that mimics the conditions of a black hole.

## Black Holes And Pure Glass

Black holes, whose existence is now universally accepted by astronomers, are thought to be the remnant of celestial objects such as stars or galaxies that have collapsed under the strength of their own gravity. Encapsulating a volume of space much smaller than the original object, a black hole bends space and time so drastically that nothing can escape, not even light, once it passes inside a hypothetical boundary known as the "event horizon."

PhysOrg.com Report: Physicists may have observed Hawking radiation for the first time

Something analogous to the gravitational warping of space can be achieved in terms of light waves. A collaboration of physicists from several Italian institutions sent laser light into a crystal of very clear glass. Normally the light passes right through. However, if the intensity of the light passes a certain level, then the atoms that make up the glass material are wrenched slightly out of position. This in turn alters the material's index of refraction, the parameter that tells you the angle light can be deflected when it passes from that material into air.

The change in the refraction index occurs in lockstep with the laser pulse as it passes through the glass. The resulting moving disturbance is referred to as RIP, the refractive index perturbation. The RIP happens not because of the energy of the laser pulse, and not even because of the size of the change in the refractive index (which is less than 1 percent), but because of the quickness of the change, occurring over mere picoseconds (trillionths of a second).

## Escaping A Black Hole

Proposed in 1974by British physicist Stephen Hawking, the radiation that bears his name -- Hawking radiation -- overturned the concept that black holes are inescapable. Until then black holes were thought to be a one-way-only phenomenon, in which light, comets, spacecraft -- any conceivable object -- might enter a black hole but would never come out. Hawking allowed that the intruding object would indeed never re-emerge. In fact, it would be torn apart by the powerful gravity tides inside the hole.

But the very violence of a black hole might, Hawking said, allow for some energy to escape from the black hole. He counted on the fact that the vacuum of space, including even the space inside a black hole, is teeming with virtual particles, courtesy of the concept of quantum weirdness. The fuzzy nature of quantum reality allows particle-antiparticle pairs to come into existence out of the vacuum. These pairs normally disappear quickly back into the nothingness, never to be seen.

However, Hawking foresaw that in the vicinity of the event horizon the density of energy was so great that occasionally the surplus energy could convert the evanescent pair of particles into real particles. This is also the way particles are created out of the vacuum at the collision point at huge particle accelerators. If the pair had been born right at the event horizon, the point of no return, then one of the particles might escape from the black hole while its mate would remain trapped behind.

In this way the black hole could actually emit a form of radiation in the form of those unpaired, just-created-out-of-the-vacuum particles. This stream of particles is now called Hawking radiation, and it plays a prominent part in the study of how the universe behaves over long time periods. But black holes are elusive. They can't be seen directly and their existence is inferred only through their effect on surrounding space. No actual Hawking radiation has been seen.

## Stopping Light In The Lab

What the Italian physicists have made with their laser disturbance moving through glass is a tiny zone where (at least amid the disturbance itself) light cannot move forward, which is just the situation at the event horizon of a black hole.

From the perspective of the RIP -- consider, for the moment, the disturbance zipping through the glass to be a sort of physical thing all by itself -- the contention between the light and the local perturbation in the glass causes the light to come to a standstill. This is just what happens at the event horizon of a black hole.

In one case the progress of light is frustrated by the immense warping of space by gravity, in the other the progress of light is frustrated by the warping of the optical environment in the glass.

What happens in the glass is what happens in the black hole: the vacuum will sprout virtual particle pairs, in this case pairs of parcels of light, or photons. However, in the high-energy environment of the artificial event-horizon, some of the virtual photons will be converted into real photons.

And indeed the INFN scientists see light coming out of their glass sample. But is this truly Hawking radiation made in the wrenching pulse within the laser disturbance, in analogy to light emitted from black holes, or could it be coming from somewhere else?

The leader of the Italian team of researchers, Daniele Faccio, who works at Insubria University in Como, Italy (where the research was done), said that all other known origins of the light can be ruled out. The careful tuning of the laser pulse precludes the light having been absorbed by the atoms in the crystal sample, he said. The use of an oriented laser pulse also rules out the idea that the Hawking radiation observed to the side of the glass could be light scattered from the laser beam.

The idea of creating Hawking radiation with an artificial event horizon inside a solid material was proposed two years ago by a team of U.K. scientists from The University of St. Andrews, writing in Science Magazine. One of the authors of that paper, Ulf Leonhardt, said that the new Italian results are extremely important.

"Their experiment is the very first observation of Hawking radiation -- I salute them," Leonhardt said.

Leonhardt's group is attempting to create an artificial event horizon inside an optical fiber rather than in a bulk piece of glass. He believes this general line of research is important since it combines the study of astrophysics, quantum science, and thermodynamics (the science of energy). Leonhardt said that it might be possible to test theories -- like string theory -- that combine gravity and quantum behavior.

The new Italian experimental results will soon be reported on in the journal *Physical Review Letters*.

According to Faccio, the creation of Hawking radiation in a terrestrial lab will not lead to direct modeling of celestial objects like black holes. But he does suggest that an artificial event horizon in the lab might be useful for other things.

"We can now study and test some very exotic and exciting things," Faccio said. "We can combine black hole and white hole (a black hole in which time goes backward, and into which light may not enter, but only exit) horizons to create a black hole laser, one in which light bounces back and forth between the horizons, each time amplifying light energy just as in a laser."

Source: Inside Science News Service