

Black Hole on a Tabletop : Unveiling Hawking Radiation

SUPRAKASH CHANDRA ROY

Few objects in the universe grip our imagination as powerfully as black holes. They are regions of space where gravity is so intense that anything that comes close to it is sucked in and disappears. Once it enters the black hole, it cannot come out. Not even light, the fastest-moving particle in the universe. To human minds, the idea of something vanishing completely has long been a source of fascination. In H.G. Wells' *The Invisible Man* (1897), the scientist Griffin discovers a way to alter the body's refractive index to match that of air, rendering himself unseen. Light neither reflects nor absorbs, and the man becomes invisible.

The science of invisibility rests on a deceptively simple principle: optical media such as glass or water bend the way light perceives the space. If a handful of clear glass balls with a refractive index equal to that of water were thrown into water, the balls would seem to disappear because the speed of light in the water and in the balls is the same. This experiment mirrors the imaginative leap Wells made in his classical science fiction story of invisibility.

Black holes, however, are not fiction. They exist. Most black holes are born when massive stars exhaust their fuel. After burning all their fuel, the star's core collapses under its own weight,

squeezing matter into a point of infinite density, which physicists call a singularity, surrounded by an invisible boundary of no return, known as an event horizon.

In the 1970s, Stephen Hawking, a distinguished British theoretical physicist, startled the scientific world with the idea that even a black hole emits a certain kind of radiation, now known as Hawking radiation. In his own words, 'Black Holes Ain't So Black'. The idea of radiation from black holes was the first example of a prediction that depended essentially on both the general theory of relativity and quantum mechanics. To quote Hawking, 'It aroused a lot of opposition initially because it upset the existing viewpoint: "How can a black hole emit anything?" When I first announced the results of my calculations at a conference at the Rutherford-Appleton Laboratory near Oxford, I was greeted with general incredulity. At the end of my talk, the chairman of the session, John G. Taylor from King's College, London, claimed it was all nonsense.' He even wrote a paper to that effect.

Yet, over time, the physics community, including John Taylor, accepted Hawking's insight that black holes must radiate if other ideas about general relativity and quantum mechanics are correct. The existence of radiation

from black holes seems to imply that gravitational collapse is not as final and irreversible as once thought. If an astronaut falls into a black hole, the black hole's mass will increase, and eventually the energy equivalent of that extra mass will be returned to the universe in the form of radiation. Thus, in a sense, the astronaut will be 'recycled'. In Hawking's own words, 'It would be a poor sort of immortality, because any personal concept of time for the astronaut would almost certainly come to an end as he was torn apart inside the black hole!' The only features of the astronaut that would survive would be his mass or energy.

Direct observation of Hawking radiation is currently impossible. In fact, the signal is expected to be so faint that it is not possible to disentangle it from the cosmic background. Hawking radiation has never been observed in astronomy, and the chances of ever observing it in space are astronomically small.

Instead of studying black holes directly, scientists from Germany, Mexico and Israel built a laboratory system where an analogue of Hawking radiation could be observed. This was reported in a recent paper published in the 1st July 2026 issue of the journal *Nature*. Scientists in this paper reported experimental and theoretical evidence of the process that generates Hawking radiation in a fibre-optical analogue of the event horizon.

Prof. Leonhardt, the senior author of the paper, has been engaged for years in a set of experiments that involve creating an artificial 'black hole' that might

demonstrate Hawking radiation. Using optical communication fibres and the ultrafast pulses of light, he realised that it is possible to create a simulation of the event horizon of a black hole. When the first intense pulse of light hits the fibre, it changes the physical properties of the fibre, creating a distortion that amounts to a change in the fibre's index of refraction. A tiny shift in the laser pulse generated the analogue Hawking radiation.

Previously, physicists thought the Hawking radiation seen in black hole analogues emerged through a complex cascade of optical interactions. Instead, the new results point to a single, direct process that naturally explains the origin of radiation.

A tabletop 'black hole' fashioned from optical fibre and laser pulses may prove invaluable in understanding both the physics of light and the astrophysics of black holes. If the mechanism holds across other black hole analogues, it could strengthen the case that the researchers have identified something fundamental about Hawking radiation itself and resolved some of the trickiest problems in theoretical black hole physics. It could help resolve the infamous information paradox: how black holes might simultaneously erase information from an object and yet somehow preserve it. This paradox haunted Hawking until his final paper in 2018. Now, with each laboratory experiment, we inch closer to an understanding that black holes are not just cosmic destroyers, but also subtle storytellers of the universe's deepest laws. ■

* The writer is a former Professor of Physics at Bose Institute, Kolkata, a member of the National Commission of History of Science, INSA and former Editor-in-Chief of the journal *Science and Culture*.