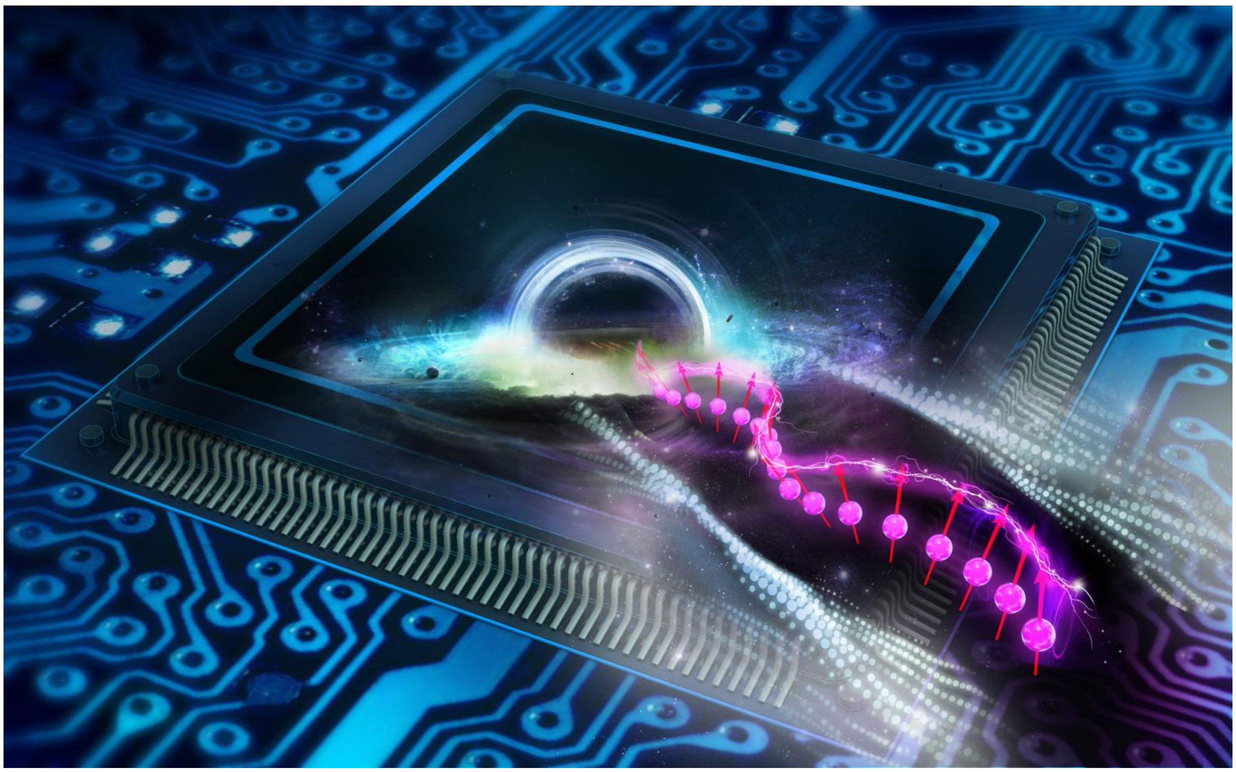
Black holes on an electronic chip

January 26 2017



Credit: Utrecht University

A team of theoretical physicists has proposed a way to simulate black holes on an electronic chip. Additionally, the technology used to create these lab-made black holes may be useful for quantum technologies. The researchers from the University of Chile, Cedenna, TU Eindhoven, Utrecht University, and FOM will publish their results in *Physical Review Letters* on 1 February 2017.

Black holes are astronomical objects so dense that nothing – not even light – can escape their gravitational pull once it passes a point of no return called the event horizon. The researchers have discovered how to make such points of no return for spin waves, fluctuations that propagate in magnetic materials, by using the behaviour of these waves when they interact with electric currents.

Spin waves

Magnetic materials have north and south poles. If perturbed, the north and south pole move from one position in the material to another in a wavelike manner. Such a wave is called a spin wave. When an electric current runs through the material, the electrons drag these waves along. When passing such a current through a wire that is thick on one end and thin on the other, the electrons flow faster on the thin end, just like water flows faster through a narrow hose. The flow of electrons on the thin end of the wire can be so fast that the spin waves that are dragged along cannot flow in the opposite direction anymore. The point at which this happens along the wire is a point of no return for the spin waves, analogous to a black hole event horizon.

Hawking radiation

Near astronomical black holes, gravitation is so strong that it causes an event horizon for any type of particle. Even photons cannot escape from a black hole once they pass its horizon. In 1974, Stephen Hawking discovered that black holes are not completely black, but emit radiation. Roughly speaking, subtle quantum mechanical effects cause pairs of particles and antiparticles to continuously appear and disappear. If this happens near the horizon of a black hole, one of the particles in the pair is sometimes swallowed by the black hole, leaving the other particle to escape and radiate away. This so-called Hawking radiation is almost impossible to observe in outer space. However, the possibility of simulating the black hole on an electronic chip makes it possible to study this effect in a much simpler way by looking at Hawking radiation of spin waves.

Quantum entanglement, quantum computers, and future research

The particles in the pairs that cause Hawking radiation are quantum mechanically entangled, meaning that their properties are so closely intertwined that they cannot be described by classical physics. Entanglement is one of the key ingredients of quantum technologies such as quantum computers. One of the directions that the researchers are now investigating is how to make devices that use this entanglement and can serve as building blocks for applications based on the quantum entanglement of spin waves.

More information: A. Roldan-Molina, A.S. Nunez, and R.A. Duine. Magnonic Black Holes, *Phys. Rev. Lett*. (2017). arxiv.org/abs/1610.02313

Provided by Utrecht University Faculty of Science

Citation: Black holes on an electronic chip (2017, January 26) retrieved 10 April 2024 from https://phys.org/news/2017-01-black-holes-electronic-chip.html

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