Scientists detect new 'quantum echo' in superconducting materials

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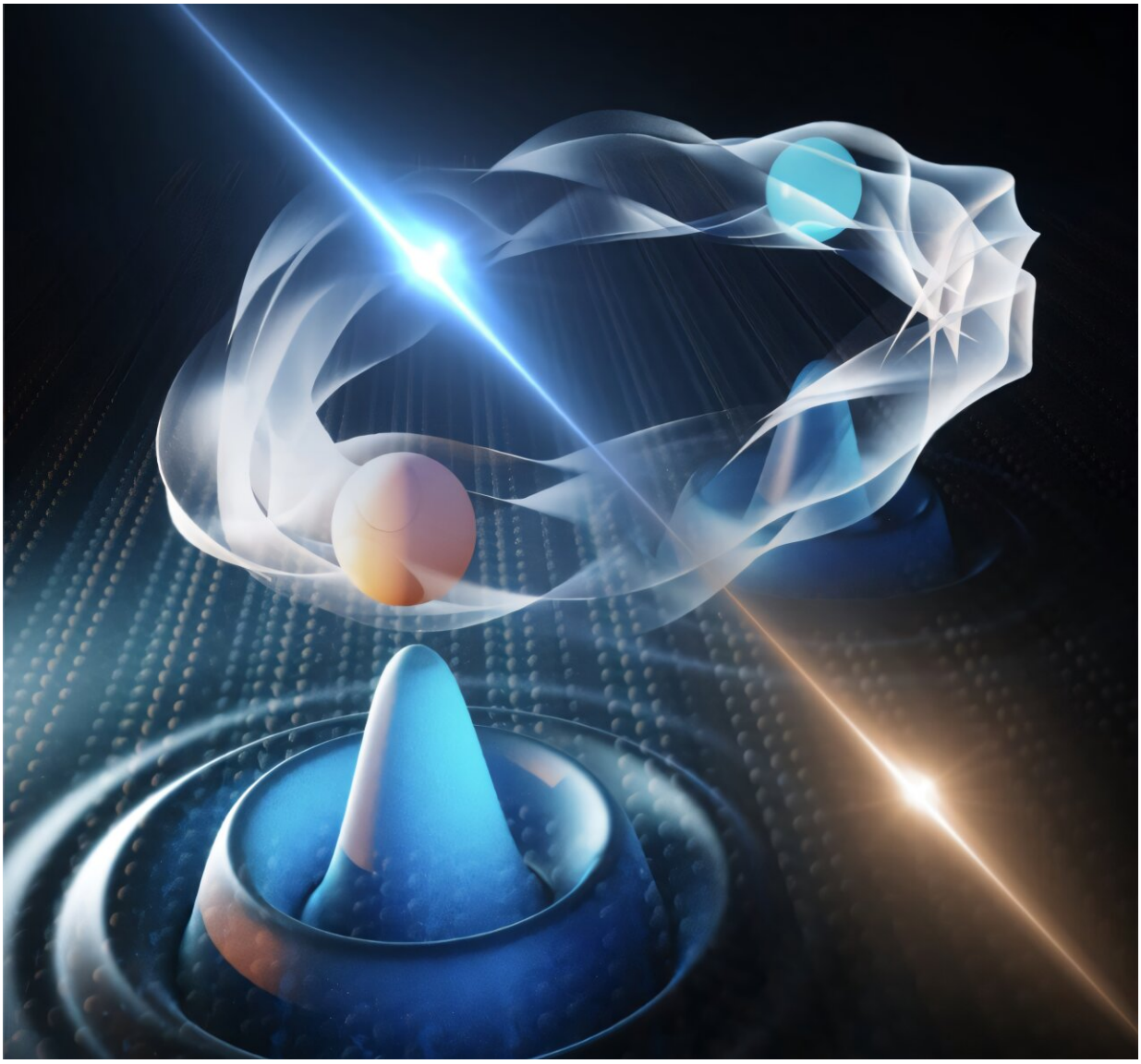

Credit: U. S. Department of Energy Ames National Laboratory

Scientists at the U. S. Department of Energy Ames National Laboratory and Iowa State University have discovered an unexpected "quantum echo" in a superconducting material. This discovery provides insight into quantum behaviors that could be used for next-generation quantum sensing and computing technologies.

Superconductors are materials that carry electricity without resistance. Within these superconductors are collective vibrations known as "Higgs modes." A Higgs mode is a quantum phenomenon that occurs when its electron potential fluctuates in a similar way to a Higgs boson. They appear when a material is undergoing a superconducting phase transition.

Observing these vibrations has been a long-time challenge for scientists because they exist for a very short time. They also have complex interactions with quasiparticles, which are electron-like excitations that emerge from the breakdown of superconductivity.

However, using advanced terahertz (THz) spectroscopy techniques, the research team discovered a novel type of quantum echo, called the "Higgs echo," in superconducting niobium materials used in quantum computing circuits.

"Unlike conventional echoes observed in atoms or semiconductors, the Higgs echo arises from a complex interaction between the Higgs modes and quasiparticles, leading to unusual signals with distinct characteristics," explained Jigang Wang, a scientist at Ames Lab and lead of the research team.

According to Wang, the Higgs echo can remember and reveal hidden quantum pathways within the material. By using precisely timed pulses of THz radiation, his team was able to observe these echoes. Using these

THz radiation pulses, they can also use the echoes to encode, store, and retrieve quantum information embedded within this superconducting material.

This research is further discussed in the paper "Discovery of an unconventional quantum echo by interference of Higgs coherence," published in *Science Advances*.

This research demonstrates the ability to control and observe quantum coherence in superconductors and paves the way for potential new methods of quantum information storage and processing.

"Understanding and controlling these unique quantum echoes brings us a step closer to practical quantum computing and advanced quantum sensing technologies," said Wang.

More information: Chuankun Huang et al, Discovery of an unconventional quantum echo by interference of Higgs coherence, *Science Advances* (2025). DOI: 10.1126/sciadv.ads8740

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