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Novel thermal phases of topological quantum matter in the lab

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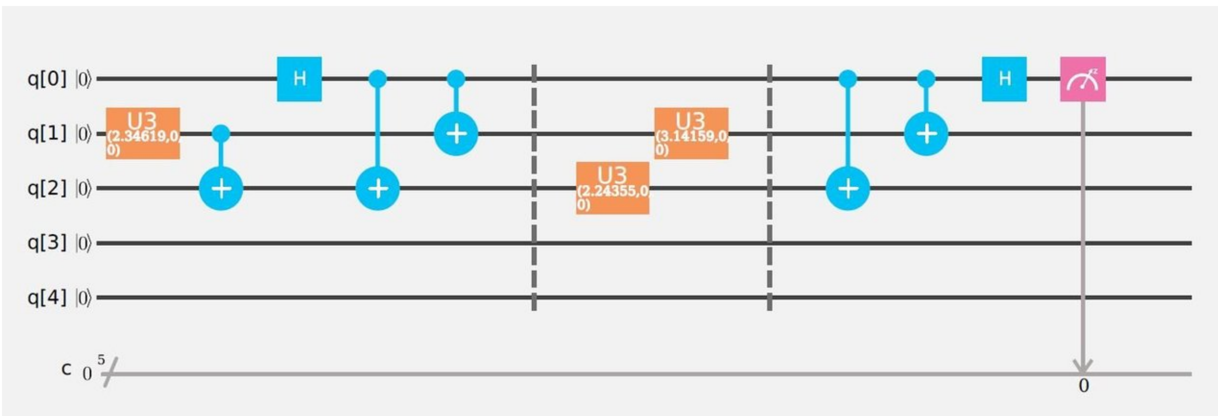

Quantum circuit implemented on the IBM Quantum Experience platform in order to measure the topological Uhlmann phase. Credit: Oscar Oviyuela et al.

For the first time, a group of researchers from Universidad Complutense de Madrid, IBM, ETH Zurich, MIT and Harvard University have observed topological phases of matter of quantum states under the action of temperature or certain types of experimental imperfections. The experiment was conducted using quantum simulator at IBM.

Quantum simulators were first conjectured by the Nobel Prize laureate Richard Feynman in 1982. Ordinary classical computers are inefficient at simulating systems of interacting quantum particles These new simulators are genuinely quantum and can be controlled very precisely.

They replicate other quantum systems that are harder to manipulate and whose physical properties remain very much unknown.

In an article published in the journal *Quantum Information*, the researchers describe using a quantum simulator with superconducting qubits at IBM to replicate materials known as topological insulators at finite temperature, and measure for the first time their topological quantum phases.

Topological phases of matter represent a very exciting and active field of research that is revolutionising the understanding of nature and material science. The study of these novel phases of matter has given rise to new materials such as topological insulators, which behave as regular insulators in the bulk and as metals at the boundaries. These boundary electronic currents have polarised spin.

Since the discovery of topological matter, researchers have looked for innovative ways to maintain their properties at finite temperature. Previous theoretical works of the researchers at Universidad Complutense proposed a new topologial quantum phase, the Uhmann phase, to characterise these phases of matter in thermal systems. The Uhlmann phase allows researchers to generalise the topological phases of matter to systems with temperature.

The results represent the first measurement of topological quantum phases with temperature, and advance the synthesis and control of topological matter using quantum technologies. Among other applications, topological quantum matter could be used as hardware for future quantum computers due to its intrinsic robustness against errors. The experimental results presented in this work show how these topological quantum phases can also be robust against temperature effects.

More information: O. Viyuela et al, Observation of topological Uhlmann phases with superconducting qubits, *npj Quantum Information* (2018). DOI: 10.1038/s41534-017-0056-9

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