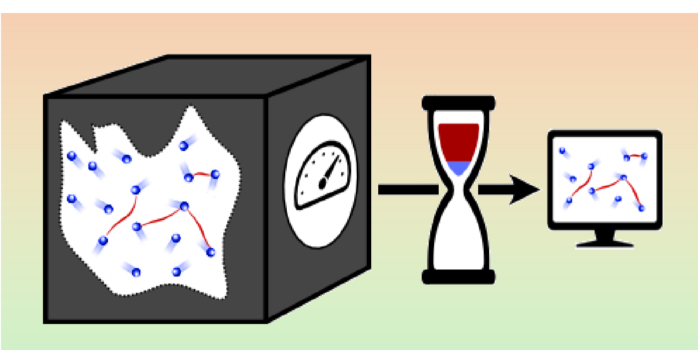
Quantum Learning Made Efficient

An algorithm allows the states of certain quantum systems to be determined from data more quickly than was previously possible.

By **Ryan Wilkinson**

Learning the state of a quantum system from measurements of that system's properties is a fundamental task in quantum computing and quantum simulation. One key system that is of practical relevance to materials science and quantum chemistry is a group of interacting fermions, such as electrons. It is extremely difficult to figure out the state of such a system from data, but an efficient learning algorithm has now been devised by Antonio Mele at the Free University of Berlin and Yaroslav Herasymenko at the Dutch National Research Institute for Mathematics and Computer Science (CWI) [1].

An unknown state of interacting fermions can be prepared by applying two types of quantum operations: ones that involve fermion–fermion interactions and ones that do not. The state's complexity is a property that is determined by the number of interacting operations that were used. By assuming a standard conjecture from cryptography, Mele and Herasymenko proved that their algorithm achieves the highest-possible learning efficiency for a given state complexity. They found that the algorithm is experimentally feasible if the state is prepared using any number of noninteracting operations and up to a certain number of interacting ones.



Credit: Y. Herasymenko/CWI

The researchers also developed a strategy to test if an unknown state is in, or near, the set of states for which the algorithm is feasible. They say that the algorithm has applications in analyzing and benchmarking quantum devices and that their work offers valuable insights into the nature of interacting-fermion systems.

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REFERENCES

1. A. A. Mele and Y. Herasymenko, "Efficient learning of quantum states prepared with few fermionic non-Gaussian gates," PRX Quantum 6, 010319 (2025).