A pure quantum algorithm that overcomes the no-cloning challenge of quantum information and a third way to describe non-equilibrium fluid flows

Developed by Professor Myong's research team at Gyeongsang National University, Republic of Korea (7 Oct 2024)

The research team led by Professor Rho-Shin Myong, director of the Aerospace Systems Research Center (ASRC) affiliated with Gyeongsang National University and a civilian member of the National Space Committee, has been developing quantum algorithms and innovative methods for describing fluid flows in highly non-equilibrium states since the second half of 2022 with support from the U.S. Air Force Office of Scientific Research (AFOSR), which aims to create basic research outcomes in the fields of space, aviation, and cyber.

Previously, it was considered impossible to apply quantum computers to science and engineering such as aerospace where nonlinearity is important due to the no-cloning theory of quantum information. The no-cloning theory is based on the quantum mechanical principle that enables the quantum gain of quantum computing and means that it is impossible to independently create an identical copy of any quantum state. As a result, quantum computers alone could not explain nonlinear physical phenomena related to fluid dynamics without the help of conventional computers.

The research team (jointly with Professor Doyeol Ahn of the University of Seoul) developed a method to overcome the no-cloning theory within a pure quantum framework by introducing additional quantum qubits while preserving quantum gains through reuse and then verified its validity through a quantum simulator. This algorithm can be applied to almost all scientific and technological fields where nonlinearity is present and is expected to make a groundbreaking contribution to the development of quantum computing.

Professor Myong's research team also proposed a third way to describe non-equilibrium fluid flows. Until now, the description of fluid flows has been achieved through conventional equation-based or particle-based computational simulation methods. The team proposed an innovative method that is based on mathematical equations for the conservation laws, like the existing method, but is based on compact data constructed via deep learning and topology from direct simulation of particle motion for the constitutive relationships. It is expected to contribute to the space and semiconductor fields as it can accurately and efficiently calculate hypersonic and rarefied gas flows.

The research team said, "*Both research outcomes were published in the October issue of Physics of Fluids, a top journal in fluid physics. In particular, the quantum algorithm article was published as a 'desk accept', which means it was accepted by the editors without review by external reviewers, so it can be said to be an exceptionally novel and outstanding work.*"