A robust, two-ion quantum logic gate that operates in a microsecond is designed

24 March 2017

The theory group led by Gonzalo Muga of the UPV/EHU's Department of Physical Chemistry has teamed up with the experimental group of the National Institute of Standards and Technology in Boulder, United States, led by David Wineland, the 2012 Nobel Physics Laureate, to design a two-ion, robust, ultrarapid quantum logic gate capable of functioning in less than a microsecond. This study was published in February in the journal *Physical Review A*.

This theoretical research explores what could be achieved beyond current technological limitations to further motivate experimental progress. Together with qubits (the quantum version of the 0/1 bit), logic gates are the basic components of a quantum computer. They need to be fast not only to speed up the calculations, but also to minimize harmful interactions with environmental noise.

In the 1980s, Richard Feynman proposed a "quantum computer" that would outperform ordinary computers by exploiting quantum properties such as the possibility of calculating several paths in parallel. Over 30 years later, it is still difficult to realize technologically, because the useful quantum behaviour of atoms is easily destroyed by noise and unwanted interactions. Yet researchers have made progress with new architectures to control physical systems so that they behave as expected.

One of the most advanced architectures uses trapped ions, which can be isolated and handled with great precision using lasers and electrodes to produce qubits and quantum gates. Two-qubit gates, such as the one examined in the study, may be useful for other applications of quantum technology, such as secure communications. This makes them particularly valuable gates, but designing and manufacturing them is challenging. High accuracy and speed are crucial to performing arbitrary computations in a fault-tolerant way.

According to Gonzalo Muga, this work "is another step forward among the many that have yet to be taken" towards attaining a quantum computer, "capable of making calculations that cannot be tackled by a traditional computer."

More information: M. Palmero et al. Fast phase gates with trapped ions, *Physical Review A* (2017). DOI: 10.1103/PhysRevA.95.022328

Provided by University of the Basque Country