Quantum computation

Dec 14, 2011

"First-generation quantum computers may be available in the near future," reported Iulia Buluta, Sahel Ashhab and Franco Nori based at RIKEN in Japan and the University of Michigan,US. This conclusion follows more than a decade of research worldwide into creating computing bits from quantum systems, which can exist in many states that can interfere – indicating "coherence". Quantum computers could allow new types of algorithms that overcome the limitations of current binary programming.

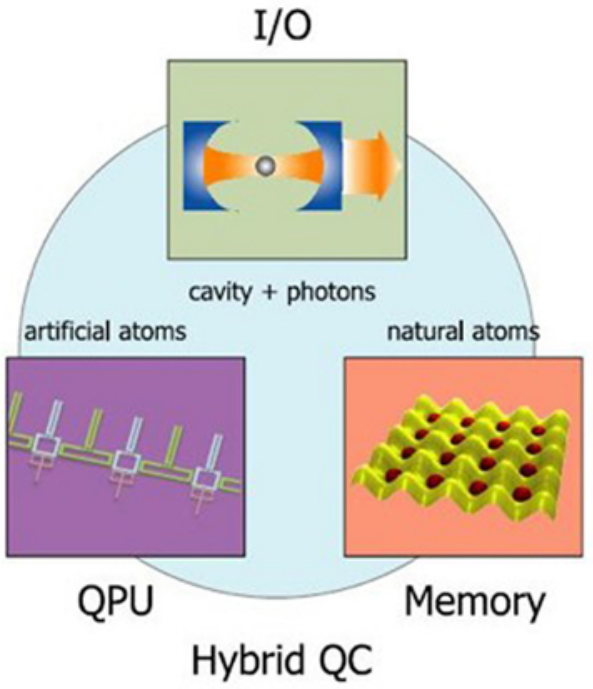

Figure 1

The energy levels in atoms and ions provide natural quantum systems for use as quantum computer bits, or "qubits". But as the report points out, scaling up these systems remains difficult. An alternative is to synthesize controllable energy levels in other systems, creating "artificial atoms".

Harmonic oscillations in superconducting circuits present one type of artificial atom. The amount of charge, the direction of charge transport and the phase of the oscillations can encode information. The quantum mechanical property of "spin" associated with electrons can also be used for qubits. A defect in diamond, where one carbon atom is substituted with a nitrogen atom and another is vacant – a so-called nitrogen-vacancy centre – provides spin states with coherence times in the order of milliseconds.

"For implementing quantum computation we are mainly interested in the following aspects: controllability, scalability and interfaceability," explained the researchers. Natural atoms are intrinsically indistinguishable, whereas accuracy and uniformity in artificial atoms remain a challenge. On the other hand, artificial atoms can be tailored to exhibit desired states.

Exploiting the long coherence times of natural atoms for quantum memory and the customizable properties of artificial atoms for quantum processing units with long-distance communication mediated by photons, present exciting prospects.

The report concluded: "Hybrid devices made of natural atoms, artificial atoms and photons may provide the next-generation design for quantum computers."

The work is reported in *Reports on Progress in Physics*

About the author

Adarsh Sandhu is editor of IOP Asia-Pacific.