State of the art and prospects for quantum computing

M. I. Dyakonov
Laboratoire Charles Coulomb, Université Montpellier II, CNRS, France

In 2002, a team of distinguished experts in quantum information established the roadmap for quantum computing [1], produced for the Advanced Research and Development Activity agency (ARDA) of the United States Government with the following goals for 2007 and 2012:

"by the year 2007, to

encode a single qubit into the state of a logical qubit formed from several physical qubits,
perform repetitive error correction of the logical qubit, and
transfer the state of the logical qubit into the state of another set of physical qubits with high fidelity,

and

by the year 2012, to implement a concatenated quantum error-correcting code."

The 2007 goal requires "something on the order of ten physical qubits and multiple logic operations between them", while the 2012 goal "requires on the order of 50 physical qubits, exercises multiple logical qubits through the full range of operations required for fault-tolerant QC in order to perform a simple instance of a relevant quantum algorithm."

While the 2007 goals can be considered as partially achieved during recent years, the 2012 goals remain far away. The purpose of this talk is to present the current state of the art in the field: I will briefly discuss the rather modest experimental results as well as the amazing multitude of proposals for various "candidates" for qubits.

The cornerstone on which all the hopes for eventual large-scale (*e.g.* useful) quantum computing rely is the theory of quantum error correction. I will discuss the numerous assumptions underpinning this theory and draw attention to some annoying properties of the physical world that are ignored in the existing picture of how quantum computing and quantum error correction are supposed to work.

The fallacy of the theoretical schemes for quantum error correction will be pinpointed to the irrational belief that the theoretical assumptions can be realized exactly, with an infinite precision, while in reality this is possible only within a certain margin.

[1] Quantum Information Science and Technology Experts Panel, *A Quantum Information Science and Technology Roadmap, Part 1: Quantum Computation.*, see http://qist.lanl.gov/qcomp-map.shtml