Invited lecture: On the structure of quantum algorithms and the role of classical mathematics

Richard Jozsa
University of Bristol, United Kingdom

Abstract

We will review the structure of some principal quantum algorithms, including Shor's algorithm and the more recent algorithms of Hallgren, van Dam and others, for problems in algebraic number theory. All of these algorithms use the quantum fourier transform but (as we will argue) in different ways. Motivated by this review we will propose that quantum algorithms may be interpreted as classical mathematical processes in which the occurring mathematical structures serendipitously overlap with the mathematical formalism of quantum theory. This viewpoint casts an unusual light on the notion of a "quantum programming language" and its prospective utility. In a similar vein we will propose that alternative quantum computational models (such as the recently developed cluster model and the notion of quantum walks) can play a fundamental role as a tool for discovering new ways of exploiting quantum effects and hence developing new quantum algorithms. Finally we will make some remarks on the apparent power of quantum over classical computation and the role of entanglement. Again we will be led to considering quantum theory as a formal structure within the landscape of classical mathematical processes.