QUANTUM COMPUTATION: SPINNING TOWARDS SCALABLE CIRCUITS

HUALONG GERVAIS
DEPARTMENT OF PHYSICS, STONY BROOK UNIVERSITY

Abstract. The laws of quantum mechanics allow for the elaboration of algorithms that can solve certain problems more efficiently than the procedures afforded by classical computation. One example is the factoring of an integer into its prime divisors, a problem whose difficulty lies at the heart of the RSA encryption scheme. Unfortunately, building hardware that can implement those quantum algorithms turns out to be a colossal challenge. Part of the reason for this is that one tries to balance two contradictory effects. On the one hand, we want to harness strong interactions between the so-called qubits (quantum bits of information) and external fields in order to initialize, manipulate, and read out the qubits. On the other hand, one also wants to turn off these interactions to preserve the phase coherence between quantum states during calculations. The groups of Bassett and Awschalom have succeeded in building a qubit that meets these two requirements and has the potential for becoming a scalable computing architecture. Their qubit is the spin of an electron bound to a phosphorus atom which is embedded in a silicon substrate. Various properties of silicon protect the electron spin from decoherence, namely the low density of nuclear spins and the weak coupling of electron orbital motion to their spin. The qubit is manipulated for performing computations using a rapidly oscillating magnetic field produced by a microwave electrode.

I will begin by introducing the main ideas of quantum computing and then illustrate their computational advantage over classical computers with the Deutsch-Jozsa algorithm. Then, I will proceed to describe in details the workings of this new silicon based qubit and how it is microfabricated. Finally, I will outline its advantages and future prospects.

References

[1] Awschalom D.D., Bassett L. C.; *Quantum computation: Spinning towards scalable circuits*; *Nature* 489, 505507 (27 September 2012)