PHYSICS DEPARTMENT COLLOQUIUM

"Tidbits About Qubits: Spin Computation in Nanostructures"

BY

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I will provide an introduction to the emerging field of spintronics and spin qubits in this talk. Active control of carrier spin in nanostructures of semiconductors and other electronic materials is projected to lead to new device functionalities in the future. In particular, it may be possible to envision memory and logic operations being carried out on the same 'spintronic' chip. I will discuss various aspects of fundamental physics related to this new research area of spin electronics with the particular emphasis on localized electron spins in semiconductor nanostructures, such as GaAs quantum dots and P donors in Si. A revolutionary possibility in the (perhaps, far) future is using the natural two-level quantum dynamics of electron spin to create robust quantum bits ('qubits') which could be used to carry out solid state quantum information processing or quantum computation. I will discuss in details the questions of entanglement, decoherence, quantum error correction, and quantum gates in semiconductor nanostructure-based solid state spin quantum computer architectures, critically discussing from a theoretical perspective the current status of the field and the prospects for carrying out large-scale quantum computation using solid state spin qubits. If time permits, I will discuss an even more revolutionary idea involving fault tolerant topological quantum computation, where the underlying non-Abelian physics provides quantum immunity from errors, and quantum computation arises from intricate braiding of the space-time paths of the anyonic quasiparticles.

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