Ultra-High Mobility Si Quantum Wells & Search For Non-Abelian Two-dimensional Quantum States

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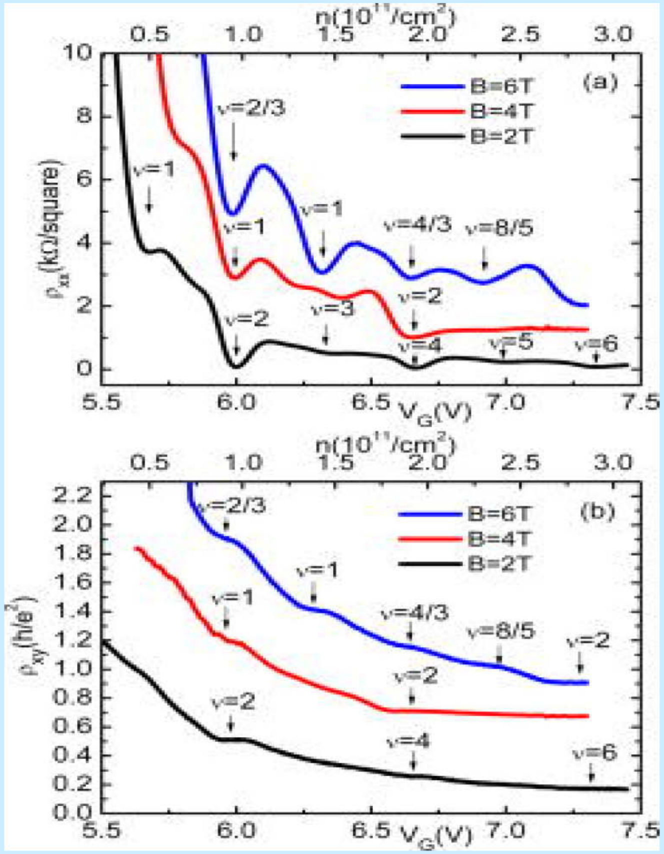
Scientists are pursuing several solid-state schemes for implementing quantum computing. One of these involves searching for exotic (non-abelian) fractional Quantum Hall Effect states in two-dimensional electron gas samples in a high magnetic field. The research has largely focused on electrons in GaAs devices which have a very high mobility. However, a serious drawback in GaAs is its strong spin-orbit interaction. Silicon-based devices, which have negligible spin-orbit interaction, are more desirable, but their electron mobility is generally poor. Recently, Tsui and collaborators have dramatically improved the electron mobility in Si devices, rendering them competitive with GaAs. In the new $Si/Si_{1-x}Ge_x$ devices, the mobility is 50 times higher than in ultra-pure Si-MOSFETS, and nearly comparable to that in the best GaAs devices. At fractional filling (e.g. $\nu = 2/3$), Quantum Hall plateaus are readily observed in the Hall resistivity ρ_{xy} (lower panel of figure). Deep minima in the longitudinal resistivity ρ_{xx} (upper panel) accompany the plateaus. The improved mobility improves the prospects for investigating the non-abelian properties of the quantum states for possible future quantum computing applications.



Quantized Hall and longitudinal conductance in the new devices shows various quantum Hall and fractional quantum Hall states as function of magnetic filling fraction. Similar experiments will be use to search for the proposed topological quantum states.

"Observation of two-dimensional electron gas in a Si quantum well with mobility of 1.6 x 10^6 cm^2*Vs*," T.M. Lu, D.C. Tsui, C.H Lee, and C.W. Liu, Appl. Phys. Lett. 94, 182102 (2009).