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Physics Colloquium

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Supersymmetric Quantum Nanostructures

Embedded into the topology of our universe lurks a subtle yet far-reaching spectral ambiguity. There exist drum-like manifolds of different shape that resonate at identical frequencies, making it impossible to invert a measured spectrum of excitations into a unique physical reality. An ongoing mathematical quest has recently compacted this conundrum from higher dimensions to planar geometries. Inspired by these isospectral domains, we introduce a class of quantum nanostructures characterized by matching electronic structure but divergent physical structure. We perform quantum measurements (scanning tunneling spectroscopy) on these "quantum drums" (degenerate two-dimensional electrons confined by individually positioned molecules) to reveal that isospectrality provides an extra topological degree of freedom enabling the mapping of complete electron wavefunctions—including all internal quantum phase information normally obscured by direct quantum measurement.

The robustness of the technique stems from its connection to supersymmetric quantum mechanics, where inequivalent "superpartner" Hamiltonians produce equivalent energy spectra. The methods are general and extensible to other nanostructures and fabrication techniques, and we have recently used variants of these ideas to experimentally detect superposition phase and the Berry phase.

In these experiments we utilize the exciting technology of atomic and molecular manipulation: a custom-built scanning tunneling microscope, operating at low temperature in ultrahigh vacuum, is used to assemble nanostructures atom-by-atom to generate versatile quantum laboratories at the spatial limit of condensed matter.

Monday May 19, 2008 - 4:10PM Room 55 Roessler