Quantum Interference across a Nanometer Scale Semiconductor Tunnel Junction

W. Kang, University of Chicago, DMR-0203679

Semiconductor physics have laid the foundation for the modern electronics industry. Future advances will likely involve devices with new functionalities based on the quantum mechanical properties of electrons. Here we present results in which the interference of individual electrons through a semiconducting tunnel barrier produces coherent motion of electrons. This technique will eventually provide much new information about the behavior of electrons in semiconductor nanostructure, and may some day be used for quantum information processing.

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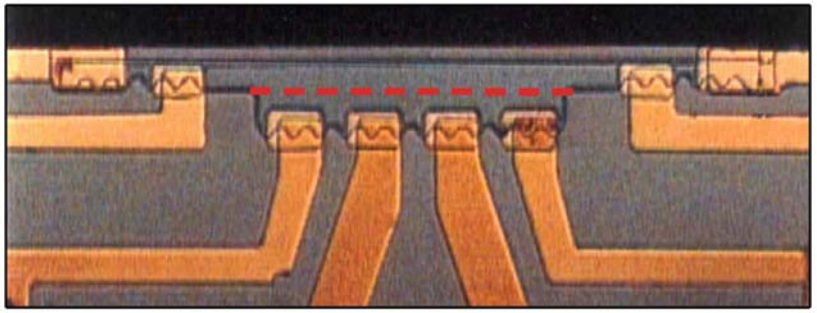
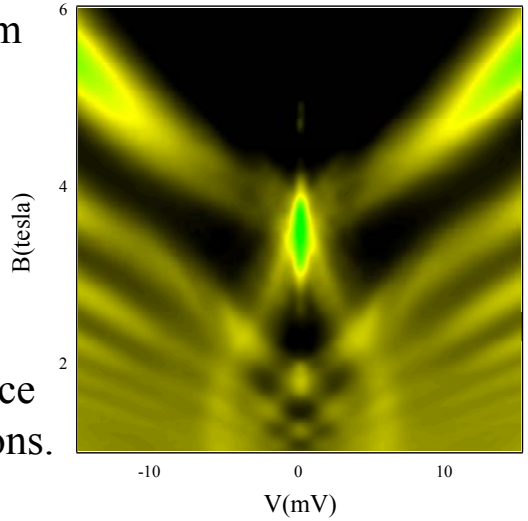


Top: A quantum Hall line junction that couples two sheets of electrons separated by a barrier through quantum mechanical tunneling. The red-dashed line indicates the location of the barrier.

Right: The spectrum of conductance as a function of bias and magnetic field. The energy dependence derives from the quantum interference of tunneling electrons.



Quantum Interference in a One-Dimensional Semiconductor Tunnel Junction

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Education:

Two undergraduates (Judy Kim and Julian Andrews) and two graduate students (Inseok Yang and Pei-Hsun Jiang) contributed to this work. Judy, who was an REU student, will be pursuing graduate study in physics at Stanford University. Julian, who was an honors bachelor's thesis student, will be pursuing a PhD in physics at University of Illinois at Urbana-Champaign. Inseok Yang was awarded the Grainger Graduate Fellowship in the physics department at the University of Chicago for the experiments he performed for this project. Pei-hsun Jiang is currently performing related experiments involving coherent motion of electronic spin.

Outreach:

The PI was a member of the team that coordinated the summer REU program at the University of Chicago. Total of 21 students partook in a number of research and educational activities. Over 90% of the students plan to pursue graduation studies in science and engineering.