

# Physics Seminar

## Michigan Technological University

October 14 (Friday) 2005, 3:05 to 3:55 pm  
Room 138, Fisher Hall

### Current Transport in Superconducting Single-Electron Transistors

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#### Abstract

With the advances of fabrication techniques in the recent years, it has become possible to fabricate tunnel junctions of increasingly small dimensions. This opens the realm of mesoscopic physics which enables us to study a wide range of novel phenomena. In this talk, I will present the study on superconducting single-electron transistor (SET) - a device in which a small superconductor "island" is weakly coupled to two bias leads through low capacitance tunnel junctions, and capacitively coupled to a gate electrode. The samples are fabricated using E-beam lithography and shadow evaporation techniques. The capacitance of the island (Al) to the external circuit is so small that single-electron charging effects dominate the behavior of the device. The gate voltage modulates the most probable number of electrons on the island. Typical single charge tunneling behavior: Coulomb blockade and current oscillation vs. gate voltage are observed in the  $I - V$  characteristics. When the island is superconducting, its behavior depends strongly on whether it contains an even or odd number of electrons, even when the number is as large as  $10^9$ . This rather remarkable behavior results from electron pairing in the superconductor, and it is referred to as the parity effect.

Next, I will discuss the role the electron spin plays in a superconducting SET coupled to ferromagnetic electrodes. A ferromagnetic single electron transistor (FMSET) combines the advances of magnetic tunnel junctions and single electron transistors. Phenomena such as spin accumulation and superconducting gap suppression have been modeled. Experimental results on the FMSET devices will be shown. The samples consist of double tunnel junctions in orthogonal geometry, with ferromagnetic leads (Co) of different widths perpendicular to the island. Measurements performed in applied magnetic field show bell shaped  $I - H$  curves as a result of the direct influence of the magnetic field on the superconducting gap. In addition, the magnetic moment switching in the Co electrodes from parallel to antiparallel configurations give rises to a rich phenomenon of spin transport. Different transport mechanisms based on the spin accumulation effect and the Meservey-Tedrow effect will be described.