Session 25aC

Spin Polarized Tunneling 25aC1

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Spin polarized tunneling studies by Meservey and Tedrow, with a superconductor as the spin detector, has shown the capability to study various fundamental problems in physics including the spin dependent density of states in the ferromagnetic metal electrodes. Although it is believed that spin polarization measured for the FM in tunneling experiments to be dominated by $4s$ states, the contribution of the $3d$ states to the tunneling current can be expected. The recent success of observing FM-I-FM tunneling has brought extreme activity in this field – both from basic study as well as for application. A wealth of new phenomena including signature of quantum well states are observed. The presence of a large magnetoresistance (nearly 50%) at a small applied field in these magnetic junction structures, showing nonvolatile memory effect has led to the development of magnetic random access memory (MRAM) element, and read head sensors with potential to achieve storage densities greater than 100 Gb/in^2.

Novel Insight into Nano- and Atomic-Scale Magnetism 25aC2

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To gain fundamental insight into spin-dependent properties at the nano- or even down to the atomic scale we have combined the scanning tunneling microscope (STM) with spin-sensitivity. This is achieved by the use of ferro- and antiferromagnetically coated probe tips offering a high degree of spin-polarization of the electronic states involved in the tunneling process. Magnetic domain imaging with sub-nanometer-scale spatial resolution has been demonstrated for magnetic transition metal as well as rare earth metal films. Ultra-sharp domain walls were discovered in ultra-thin iron films while for antiferromagnetic samples, the different orientation of magnetic moments could directly be made visible at the atomic level. The phenomenon of magnetic hysteresis was observed for the first time at the nanometer length scale and has directly been correlated with microscopic processes of domain nucleation and domain wall motion.

25aC3 Spin-current induced Hall effect in superconductors

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Anomalous Hall effect induced by the spin current in superconductors (SC) is theoretically studied. The spin current flowing in SC are deflected by spin-orbit impurity scattering to yield a charge imbalance in the transverse direction. Overall charge neutrality gives rise to a compensating change in the Cooper pairs. Since the pairs are not accelerated in a steady state, a transverse electric potential appears to maintain the electrochemical potential of the pairs constant in space, producing the Hall voltage. It is proposed that the mechanisms of the Hall effect (side jump or skew scattering) are distinguished by measuring the temperature dependence of the Hall voltage in the superconducting state.

25aC4 Inhomogeneous superconductivity in a ferromagnet

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Ferromagnetism and singlet superconductivity are antagonistic orders. However, if they coexist, the superconducting wave function is modified by the exchange field that couples with the spin of the condensed electrons. A long time ago, Fulde-Ferrel-Larkin-Ochinikov predicted a new superconducting state in which the finite momentum transfer provided to Cooper pairs by the exchange energy, originates an oscillating macroscopic wave function. We observed these oscillations when superconductivity (S) is induced in a weak ferromagnetic thin film (F) by the proximity effect. In the ferromagnet, negative values of pair amplitude are revealed by capsized tunneling spectra. The Josephson critical current oscillates as a function of the ferromagnetic film thickness when coupled with a second superconductor. These results indicate that new coexistence of superconductivity and magnetism is achieved in S/F based nano-structures.