University of Notre Dame
College of Science
Department of Physics

CONDENSED MATTER SEMINAR

Anomalous Magnetism and Superconductivity in Rutheno- and Niobo-cuprates: Clues to the Pairing Mechanism

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One of the most successful theories of physics is the Bardeen-Cooper-Schrieffer (BCS) theory of low temperature superconductivity (LTSC). This theory features the pairing of electrons with opposite spins. Even with the lack of a comprehensive theory of discovery of high temperature superconductors (HTSC), it is broadly accepted idea that similar pairing occurs in the nearly ubiquitous CuO_2 planes of HTSC materials. The observation of a ferromagnetic response in ruthenocuprates, which also show superconductivity, has been a major source of interest and controversy. It has been generally thought that the magnetism is confined to the ruthenium oxide planes, while the superconductivity is thought to reside in the cuprate planes. Neutron diffraction and muon spin rotation data appear to contradict this view. With our observation of the same magnetic phenomena in homologues synthesized with non-magnetic niobium in substitution for magnetic Ru, the popular model is totally falsified. We review the results of our and others' studies on $RSr_2Ru_{1-x}Cu_{2+x}O_{8-y}$, and $R_{2-x}Ce_xSr_2RuCu_2O_{10}$ (where R is a trivalent rare earth), and on their niobium equivalents. These studies shed light on the origin of the magnetism, which must be associated with the Cu ions. We have observed that the diamagnetic response and the ferromagnetic response, in a given sample, have a ratio of approximately 1:4 even when the doping-dependent magnitude of the response changes by several orders of magnitude. This observation implies that the ferromagnetism and diamagnetism arise from the same source, and that the magnetism and superconductivity are cooperative and not competitive, as is generally believed. We suggest a possible common origin for these two phenomena.

*Work carried out jointly with H.A. Blackstead, University of Notre Dame, and others.

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