MAGNETIC ORDER AND SUPERCONDUCTIVITY IN RUTHENATES, RUTHENOCUPRATES, AND OTHER LAYERED OXIDES

Abstract

by

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There exist several classes of materials that simultaneously exhibit superconductivity and anomalous magnetic order, where both effects are homogeneous throughout the material. No cohesive explanation for this "apparent ferromagnetism" has ever been published. In the $Ln_{1-x}Ce_xSr_2Cu_2MO_{10}$ and in the $LnSr_2Cu_2RuO_8$ (Ln=Ln,Y; M=Ru,Nb) families of materials, it is shown via diffraction, SQUID magnetometry, and electron spin resonance that the metamagnetism in these materials is due to CuO_2 ferromagnetic order in the *ab*-plane, with adjacent layers stacked ferromagnetically; this CuO_2 magnetic order coexists with superconductivity in these materials. The implications of this on models of high-T_C superconductivity may be profound.

Another controversial class of superconducting material, $Ba_2LnRu_{1-x}Cu_xO_6$ (Ln=Ln,Y) is examined and the compound $Ba_2YRu_{1-x}Cu_xO_6$ is shown to be superconducting with simultaneous Cu magnetic order at temperatures near that of YBCO, without CuO_2 planes. The magnetic and crystal structures of several members of the Ln series are examined by SQUID magnetometry, electron spin resonance, and x-ray and neutron diffraction, with discovery of simultaneous superconductivity and Cu magnetic order in only $Ba_2DyRu_{1-x}Cu_xO_6$.

A third related class of materials, La_2CuMO_6 (M=Ru,Nb,Ti,Ir,Sn) is also examined for superconductivity. The magnetic structure of these materials is investigated by diffraction and SQUID magnetometry, and new high-temperature synthesis techniques are performed that dramatically improve the structural and magnetic properties of the compound La_2CuRuO_6; electron spin resonance has identified Cu antiferromagnetism in this material for the first time. Hole doping (with Ba or Sr) and electron doping (with Ce or Th) fails to generate superconductivity in this material. The high-temperature synthesis techniques are unsuccessful in processing of other members of the La_2CuMO_6 family due to the stability of $La_2M_2O_7$-type compounds at high temperatures. The compound La_2CuSnO_6 forms distinct CuO_2 and SnO_2 chemical layers, yet shows no superconductivity.