



ESRF

Experiment Title: Crystal Structure of a Ferromagnetic Superconductor

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The coexistence of ferromagnetism and superconductivity has always been considered impossible except under special conditions, as the large internal field generated by ferromagnetic ordering would break up the Cooper pairs of electrons that carry the supercurrent. Although mutually exclusive, the two phenomena sometimes occur sequentially as found in the re-entrant superconductors HoMo_6S_8 and ErRh_4B_4 [1]. However, very recent work by Dr. J. Tallon and co-workers at the New Zealand Institute for Industrial Research has shown that the two phenomena can co-exist in different atomic layers within a new layered cuprate material of idealised stoichiometry ' $\text{RuSr}_2\text{GdCu}_2\text{O}_8$ '. This has a '1212' structure (referring to the Ru:Sr:Gd:Cu ratio) in which the metal oxide layers repeat in the sequence $-\text{RuO}_2-\text{SrO}-\text{CuO}_2-\text{Gd}-\text{CuO}_2-\text{SrO}-\text{RuO}_2-$ similar to that found in $\text{YBa}_2\text{Cu}_3\text{O}_7$ ($= \text{CuBa}_2\text{YCu}_2\text{O}_7$). Ru-1212 is ferromagnetic below $T_F = 132$ K, and displays a superconducting transition at $T_c = 0-40$ K depending on oxygen

content. It appears that the ruthenate layer behaves ferromagnetically, like those in SrRuO_3 , whereas the cuprate layers show a superconducting transition typical of high- T_c materials. The relatively low T_c 's (compared to 90 K-120 K in other 1212 cuprates) has been ascribed to underdoping of the material rather than magnetic effects.

The Ru-1212 structure is specifically stabilised by Gd, which is highly neutron absorbing so powder X-ray diffraction has been used for structure characterisation. We have studied a sample of Ru-1212 on BM16 using 4 shifts of discretionary time. Data were collected at room temperature and later at 10 K using a wavelength of 0.32 Å. The high resolution and peak-to-background, and large $\sin\theta/\lambda$ range provided by BM16 enabled even the oxygen positions to be refined accurately and the thermal factors and occupancies are not highly correlated. At both temperatures the average structure is tetragonal $P4/mmm$, the metal sites are fully occupied to within 1% and no oxygen non-stoichiometry was found in agreement with thermogravimetric analysis. Large, disordered twisting and tilting of the RuO_6 octahedra were observed, due to the mismatch of Cu-O and Ru-O bond lengths. These results are to be published [2,3].

References

1. J. Etourneau in 'Solid State Chemistry: Compounds' eds Cheetham and Day, p.78-80 (1992).
2. J. L. Tallon, C. Bernard, M. E. Bowden, T. M. Stoto, B. Walker, P. W. Gilberd, M. R. Presland, J. P. Attfield, A. C. McLaughlin and A. N. Fitch, **Nature** (accepted).
3. A. C. McLaughlin, J. P. Attfield, A. N. Fitch and J. L. Tallon, in preparation.