Orbital and Charge Order in Ruthenates Observed by High Resolution Synchrotron Powder Diffraction

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The heavier transition metal oxides often show apparently uncorrelated metallic behaviour, without the charge, spin and orbital degrees of freedom found in the 3d oxides. We have recently re-investigated a number of ruthenate compounds by synchrotron powder and neutron diffraction and found a range of unexpected behaviour. For example, the perovskite $PbRuO_3$ undergoes orbital order on cooling below 90 K. The transition is highly hysteretic and shows a reversal of normal group-subgroup relations and sluggish kinetics governed by lattice strains. We have also characterised the insulating hexagonal materials $Ba_3RERu_2O_9$ (RE = Y, La) which have a nominally mixed valent $Ru^{4.5+}$ oxidation state. Our measurements on ID31 and HRPD detect very long period structure modulations and show that the reported structure, which has a single Ru site, is incorrect. The implications of possible charge order in these materials, and the differences with the known charge ordered compound $Ba_3NaRu_2O_9$ will be discussed.