



Figure 6.13: Resistivity as a function of temperature and magnetic field for a series of samples of doped manganese oxides with different compositions. The ferromagnetic transition temperatures  $T_c$  are marked by the arrows.

**paramagnetic** (core spins randomly aligned).

Discuss how the total Free energies of these states differ, and suggest what is the magnetic ground state when  $x = 0$ ; and when  $tx > J_x$ ; give rough estimates of the transition temperatures of the ordered magnetic states toward high temperature paramagnetism.

(f) Fig. 6.13 shows the resistivity as a function of temperature of several samples of  $La_{1-x}Sr_xMnO_3$  with different concentrations  $x$ , as well as the magnetic-field-dependence of the resistivity (which gives rise to the label “colossal” magnetoresistance).<sup>10</sup> Discuss this data in light of the results above.

<sup>10</sup>Urushibara *et al.* Physical Review B **51** 14103 (1995)