High-pressure x-ray diffraction study on $Pr_{0.65}Ca_{0.35}MnO_3$

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Introduction

The mixed valence system of manganese oxides with distorted perovskite structures, $A_{1-x}B_xMnO_3$, shows the colossal magnetoresistance and other novel phenomena. These phenomena have been interpreted by the strong coupling among the charge, orbital, spin and lattice. In $Pr_{1-x}Ca_xMnO_3$ ($0.3 \leq x \leq 0.5$), the charge ordering transition takes place at T_{CO}~230K[1]. The cooperative Jahn-Teller ordering associated with the orbital ordering simultaneously occurs, and this results in the doubling of the crystallographic unit cell. The charge and orbital ordered insulating phase is transformed into the disordered metallic phase by applying magnetic fields. Recently we have measured the temperature and pressure dependences of the superlattice reflections attributed to the charge and orbital ordering in $Pr_{0.65}Ca_{0.35}MnO_3$. We found an indication of an additional phase transition in a limited region of pressure and temperature where the superlattice reflection intensity shows an anomalous increase. We have conducted x-ray diffraction experiments at low temperatures and high pressures in the compound with x=0.35 in order to reveal the characteristics of the pressure-induced phase.

Experimental

The x-ray diffraction measurements were performed at the BL-1B of the Photon Factory. The x-ray energy was 18.0 keV. A single crystal of $Pr_{0.65}Ca_{0.35}MnO_3$ was placed in a diamond anvil cell. Ruby fluorescence scale was used for pressure determination. The diamond anvil cell was mounted on a cold head of a closed-cycle refrigerator. The diffracted intensities were recorded on an image plate.

Results and Discussion

Figure 1 shows a typical oscillation photograph taken at 180K and 1.85GPa, where the charge and orbital ordered state is stable. The superlattice reflections were observed below T_{CO}. These reflections can be indexed as (h, k+1/2, l) on the basis of the fact that the sample consists of the domains due to the pseudo-cubic structure. For further increasing pressure and lowering temperature, the superlattice reflections abruptly disappear. This indicates that the charge and orbital ordered phase is transformed into the ferromagnetic metallic phase. The anomalous changes in the superlattice reflection intensities were also observed in the limited pressure and temperature region. These changes suggest that rearrangement of charge and orbital ordering takes place. No additional reflections were observed, but there is a possibility that new reflections at specific positions are not distinguishable due to the existence of the pseudo-cubic domains.

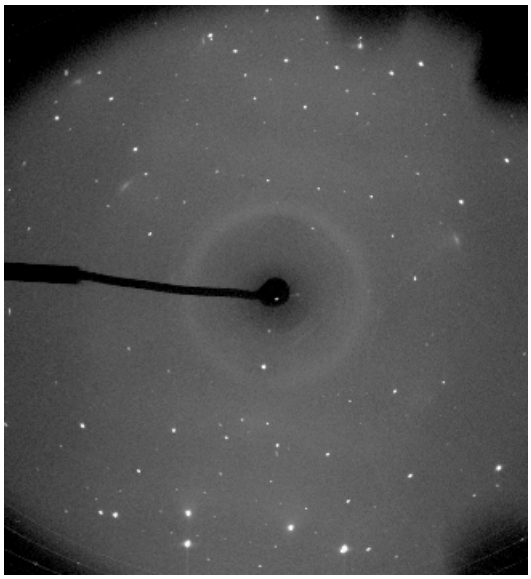

Fig.1 An x-ray oscillation photograph of $Pr_{0.65}Ca_{0.35}MnO_3$ taken at 180K and 1.85GPa.

References

[1] Y. Tomioka et al., Phys. Rev. B 53, R1689 (1996).

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