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Orbital Ordering of Transition-Metal-Oxides Observed by Resonant X-ray Scattering

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Introduction

Orbital degree of freedom plays important roles in electric and magnetic properties in a strongly correlated electron system. The method of measurement for orbital ordering, however, has been limited so far. Recently it has been pointed out that synchrotron x-ray diffraction is a very powerful tool to observe the ordering. In particular the resonant x-ray scattering (RXS) technique has been developed to detect the orbital ordering for last few years.[1] This is a new technique combined diffraction with spectroscopy. By using this technique the orbital states in various systems have been elucidated.[2]

Experimental Results

Orbital and Charge Ordering in $LaSr_2Mn_2O_7$ [3]

Orbital and charge ordering phenomena in bilayered perovskite manganite $LaSr_2Mn_2O_7$ have been studied by resonant X-ray scattering. Superlattice reflections corresponding to these orderings are observed below 210 K. The in-plane and stacking structure of the orbital and charge order is determined from these reflections. The anisotropy of the anomalous atomic scattering factor of Mn3+ in the orbital ordered state is observed in the azimuthal angle dependence of the reflections. The anisotropy is attributed to the band dispersion of 4p level due to the layered structure as well as the orbital order. In the course of this study, we have found that charge and orbital ordering s collapse simultaneously, maintaining the same correlation lengths with further decreasing temperature.

Orbital Ordering in YVO_3[4]

Synchrotron x-ray diffraction experiments have been carried out in a perovskite-type vanadium oxide YVO3 to elucidate orbital ordering of the system. The change from C- to G-type orbital ordering at the lower magnetic transition temperature was strongly suggested. The long-range orbital ordering appears also in the high-temperature paramagnetic phase. Azimuthal-angle dependence of orbital superlattice reflections indicates that for both orbital-ordering phases the orbital occupation is approximately the $d_{xy}d_{yz}$ and $d_{xy}d_{zx}$ configuration in two sublattices, respectively. These results are in good agreement with a theoretical prediction.

Orbital Ordering of Perovskite Titanates

The orbital state of $YTiO_3$ has been quantitatively made clear. We can change the bond angle of O-Ti-O by a replacement Y with other rare earth metals. The bond angle affects the transfer integral between Ti ions. Then, the orbital states are continuously changed depending on the ion radius of the rare earth metal, though the magnetic states are discontinuously changed between Sm and Gd. The interplay between the orbital and spin degrees of freedom in these systems plays very important roles in these phenomena.

Orbital Ordering in Epitaxial Thin Films of Manganites

The orbital states are influenced by the strain of the lattice because the orbital state of eg electron in manganites is strongly coupled with the Jahn-Teller lattice distortion. It was actually reported that the properties of thin films of $La_{1-x}Sr_xMnO_3$, epitaxially grown on perovskite substrates, depend on the kind of the substrate. Here, we have studied the orbital states of the thin films on different substrates by using resonant x-ray scattering.

References

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