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**Resonant X-ray Scattering Study on the Quadrupolar Ordering in the Filled Skutterudites**

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The filled skutterudite compounds $RT_4X_{12}$ (R = rare earth, T = Fe, Ru, Os, X = P, Sb) have attracted great attention due to remarkable electronic properties originating from the quadrupolar ordering of the $f$ electrons. However, it has not been so easy to detect the quadrupolar ordering because the experimental technique to detect the ordering has been very limited so far. Several years ago we have found that the resonant x-ray scattering (RXS) using synchrotron radiation is very powerful tool to detect the multipolar ordering of $d-$ and $f-$electron systems. The RXS is a technique combined diffraction with spectroscopy. In this study we tune the x-ray energy to L-absorption edge of the rare earth ion: The diffracted x-rays have unique polarization and azimuthal angle (the angle around the scattering vector) dependences reflecting the $4f$ state of the ion. Thus we can detect the site-specific information of the electronic states.

We are planning to apply the RXS technique to the filled skutterudites $PrFe_4P_{12}$, $PrRu_4P_{12}$, $PrOs_4Sb_{12}$, and $SmRu_4P_{12}$ to elucidate the role of the quadrupolar degree of freedom and its fluctuation in the metal-insulator transition and superconductivity. We already started to study on $PrFe_4P_{12}$. This compound shows a transition at $T_A = 6.5$ K: this is considered to be a quadrupolar ordering from various experimental results. We report the RXS experiments at the Pr-$L_3$ absorption edge. Figure 1 shows the scattering intensity of (111) reflection which is forbidden in the structure above $T_A$. This result evidences the ordering of two different electronic states of Pr. In the workshop we will show the preliminary result on $PrRu_4P_{12}$ and the research plan of the RXS studies.

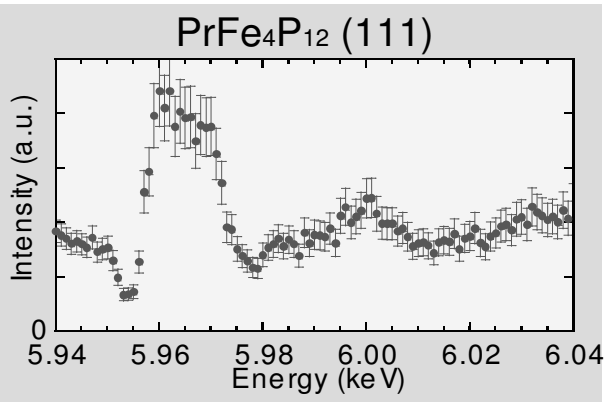


Figure 1: Energy dependence of (111) reflection in $PrFe_4P_{12}$ at T = 12 K.