(28a3)

Neutron scattering study of antiferro-quadrupolar ordering and heavy-electron state in $PrFe_4P_{12}$

K. Iwasa[1], L. Hao[2], K. Kuwahara[2], M. Kohgi[2], H. Sugawara[2], Y. Aoki[2], T. D. Matsuda[3], H. Sato[2], J.-M. Mignot[4], A. Gukasov[4], M. Nishi[5],

1 - Department of Physics, Graduate School of Science, Tohoku University, Aramaki-aza-aoba, Sendai, 908-8578, Japan
2 - Department of Physics, Graduate School of Science, Tokyo Metropolitan University, Minami-Ohsawa, Hachioji, Tokyo 192-0397, Japan
3 - Advanced Science Research Center, Japan Atomic Energy Research Institute, Shirakata, Tokai, Ibaraki, 319-1195, Japan
4 - Laboratoire Léon Brillouin, CEA-CNRS, CEA/Saclay, Gif sur Yvette, 91151, France
5 - Neutron Science Laboratory, Institute for Solid State Physics, The University of Tokyo, Shirakata, Tokai, Ibaraki, 319-1106, Japan

Neutron diffraction experiments of $PrFe_4P_{12}$ in the ordered phase revealed antiferromagnetic structures composed of two different magnetic moments induced along the magnetic fields along the [1 0 0] and [0 1 1] axes. This fact indicates that the antiferro-quadrupolar ordering appears with the ordering wave vector $\mathbf{q} = (100)$ [1]. Recent inelastic neutron scattering experiments for the single-crystal sample elucidated two sharp peaks around 1.45 and 3.0 meV appearing in the ordered phase as depicted in the Fig. 1, in consistent to the previous polycrystalline data [2]. It is remarkable that the intensity at 1.45 meV shows a maximum at (2 0 0) corresponding to the zone center of the high-temperature structure with $Im\bar{3}$ and decreases with approaching the zone boundary. Such characteristic feature indicates ferromagnetic correlation mediated strongly by the quadrupolar ordering. We also measured a polarized neutron diffraction intensities under magnetic field at the reciprocal-lattice points corresponding to the ordering wave vector $\mathbf{q}$. There are clear interference between the scattered neutrons by the antiferromagnetic structure and the crystal-lattice distortion. The dominant atomic displacement of Fe ions is represented as $[\delta, \delta, \delta']$ which couples with the quadrupole O_2^0.

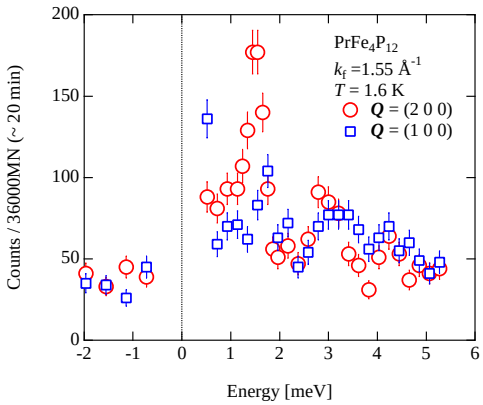

Figure 1: Inelastic neutron scattering spectra at $\mathbf{Q} = (2\ 0\ 0)$ and (1 0 0) of $PrFe_4P_{12}$ at 1.6 K.

[1] L. Hao, K. Iwasa, M. Nakajima, D. Kawana, K. Kuwahara, M. Kohgi, H. Sugawara, T. D. Matsuda, Y. Aoki, and H. Sato, Acta Physica Polonica B **34** (2003) 1113.
[2] K. Iwasa, L. Hao, M. Nakajima, M. Kohgi, H. Sugawara, Y. Aoki, H. Sato, and T. D. Matsuda, Acta Physica Polonica B **34** (2003) 1117.