Anomalous MCD signal of paramagnetic $CeFe_4P_{12}$

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$CeFe_4P_{12}$ is known to remain paramagnetic even at very low temperatures and shows no magnetic order, while $LaFe_4P_{12}$ becomes ferromagnetic below 4 K. We measured MCD signals of Ce 3d core excitation region and Fe 2p excitation region at about 50 K. It was expected that even at the paramagnetic state small amount of MCD signals could be detected due to a small spin polarization induced by the applied magnetic field, which was about 1.4 tesla.

Figure 1 shows the obtained MCD signal of Ce 3d excitation region, while we could not detect any MCD signal at the Fe 2p excitation region. Though the magnitude of the MCD signals was 10^{-3} smaller than the absorption structure, it was detected because of high intensity of the incoming beam but rather noisy because of some mechanical instability of the beamline

Surprisingly, the sign of the MCD signal of Ce 3d region is unchanged both in $3d_{5/2}$ and $3d_{3/2}$ regions. This means that the small magnetic moment induced by the external field is mainly consists of orbital moment and the spin contribution is negligible. It may be interpreted as follows:

The Ce 4f state has a large localized orbital moment which is thermally fluctuating. Then the applied magnetic field induces small orbital moment. The spin moment could be polarized because the spin-orbit interaction is about 250 meV which is much higher than kT at 50 K. However the effect of the spin selection rule in dipole transition is small because there are still many empty up-spin and down-spin 4f states.

On the other hand the non-detectable MCD signal in the Fe 2p region suggests the following important point:

If the Fe is in a localized low-spin state, which means that the orbital moment is quantum-fluctuating, the applied external field is supposed to polarize the orbital moment similarly to the case of Ce. The detected signal could be larger than in Ce considering the atomic concentration. Therefore unobserved MCD signal of Fe 2p excitation strongly suggest that Fe 3d state is very itinerant, which makes it very hard to polarize the orbital moments as is understood in the de Haas-van Alphen effect.

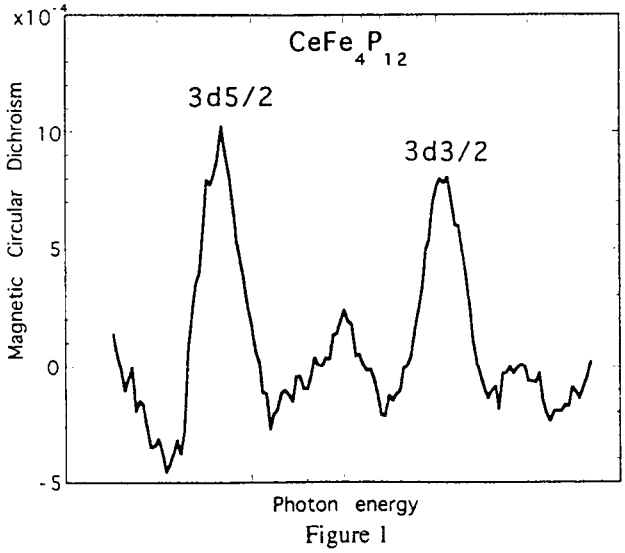

Figure 1