(P2-18)

Raman Scattering of $YbFe_4Sb_{12}$

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$YbFe_4Sb_{12}$ is regarded as a compound with an intermediate valence state of Yb. The divalent Yb^{2+} ($4f^{14}$) is stable at room temperature[1]. To clarify the effect of the valence of rare-earth ions on the phonons, we have measured Raman scattering spectra of $YbFe_4Sb_{12}$.

The first-order Raman active phonons are $2Ag + 2Eg + 4Tg$ in the skutterudite family with cubic symmetry of $Im\bar{3}$ (T_h^5). These phonons are the vibrations of pnicogens. Figure 1 shows the (x, x) Raman spectra of Sb-based skutterudite measured at room temperature. In these spectra, $2Ag$ and $2Eg$ phonons are observed as denoted by the arrows. Since the $R\mathrm{Os_4Sb_{12}}$ is composed of the large Sb cage, the lattice parameter hardly depends on the substitution of the rare-earth ions in the cage, and as consequence, the energies of the Raman active phonons are similar for each $R\mathrm{Os_4Sb_{12}}$ as shown in the figure.

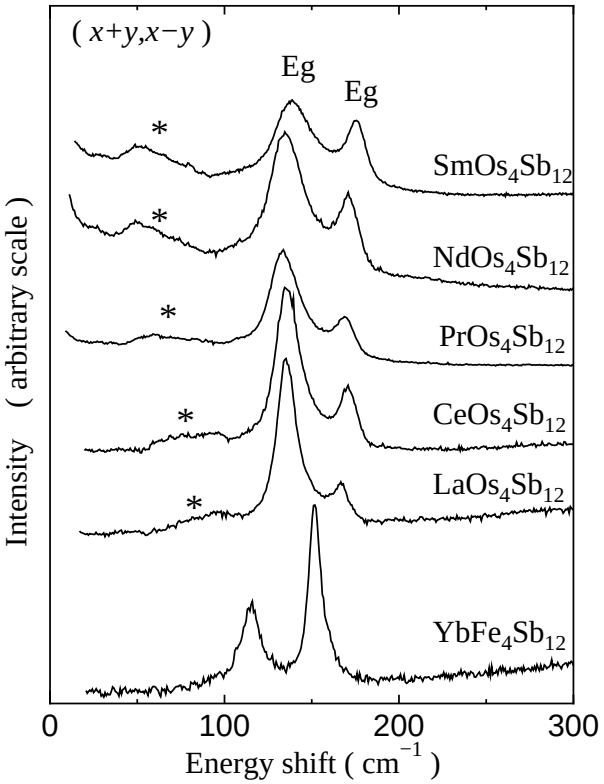

Figure 1: (x, x) Raman spectra of $R\mathrm{Os_4Sb_{12}}$ and $YbFe_4Sb_{12}$ measured at room temperature.

On the other hand, the phonon energies of the $YbFe_4Sb_{12}$ are expected to be higher than those of the $R\mathrm{Os_4Sb_{12}}$, because the lattice parameter (9.157$\mathring{A}$) is slightly small by comparing with the $R\mathrm{Os_4Sb_{12}}$ (9.302$\sim$8$\mathring{A}$). However, the observed energies for $YbFe_4Sb_{12}$ are lower than those for the $R\mathrm{Os_4Sb_{12}}$ as shown in the figure. This result suggests that the cage mode, that is the phonon due to the pnicogen vibration, is strongly affected by the valence of the guest ion in the oversized cage.

The electric transport of all samples behaves metalic conductivity. Therefore

The other experimental results of this coupling between the cage modes and electronic states, such as conduction electrons or valence of the guest ions, are obtained in the spectral shape and the resonance effect of the phonon spectra.

We note that this coupling between the cage modes and the electronic states can be considered as a common feature of the caged compounds, because the similar phenomena are observed in the spectra of rare-earth hexaborides.

[**1**] W. Schnelle, *et al.*, Phys. Rev. B**72**, 020402(R) (2005).