(28c2)

Raman scattering study of RB_6

M. Udagawa[1,2], N. Ogita[1,2], S. Nagai[2], F. Iga[2], J. Akimitsu[3], A. Kunii[4]

1 - Faculty of Integrated Arts & Sciences, Hiroshima University,
Higashi-Hiroshima, Hiroshima, 739-8521, Japan
2 - Graduate School of Advanced Sciences of Matter, Hiroshima University,
Higashi-Hiroshima, Hiroshima, 739-8530, Japan
3 - Department of Physics, Aoyama-Gakuin University
Sagamihara, Kanagawa 229-8558, Japan
4 - Department of Physics, Graduate School of Science, Tohoku University
Sendai 980-8578, Japan

Raman scattering spectra of RB_6, with R=Ca, La, Ce, Pr, Sm, Gd, Dy and Yb, have been systematically investigated. From the observed spectra, we have obtained the clear valence- or carrier-dependence and the importance of electron-phonon interaction for the trivalent crystals. The observed Raman scattering spectra can be classified into the following three different excitations; Low-energy excitations below 200cm^{-1}, Raman-active three phonons (T_{2g}, E_g, A_{1g}) at 700$\sim$1300cm^{-1}, and higher-energy mode at $\sim$1400cm^{-1}. From the energy comparison with the phonon dispersion curves, the low-energy excitations and the higher-energy mode are assigned as the second order Raman spectra of the acoustic branches and T_{2g} mode, respectively, at Brillouin boundary.

For the divalent crystals (CaB_6, YbB_6), the doublet line shape of the T_{2g} and E_g phonons suggests the anisotropic distribution of a few carrier on B_6. For the trivalent crystals, we summarize the important results obtained by the present experiments.

1. Low-energy excitations
   The intensity decreases with decreasing temperature and this dependence well correlates with the reported thermal movement of R ions. The energy decreases with the increase of the cage size surrounded by the B_6 octahedra. Thus, the low-energy excitations are the vibrations related to the R ion movement.
2. T_{2g} phonon
   The energy of the trivalent crystals is smaller by $\sim$100cm^{-1} than that of the divalent one. The energy-decrease from the divalent-crystal energy corresponds to the valence of R ion. Furthermore, the asymmetric line shape of T_{2g} for the trivalent crystal is the experimental evidence of the electron-phonon interaction.
3. Higher-energy mode
   Its intensity is greater by 20 times than that of the divalent one. To explain this remarkable difference, some kind of coupling between electron and T_{2g} branch is necessary.

Finally, we summarize the remaining problems related to the present RB_6 study.

- The determination of electron-phonon interaction by the first principle calculation, especially for the T_{2g} phonon.
- Measurements of the crystal field excitation in the quadrupole order for CeB_6.

The most part of this presentation was reported in the paper: N. Ogita, S. Nagai, N. Okamoto, M. Udagawa, F. Iga, M. Sera, J. Akimitsu, and S. Kunii, Phys. Rev. B **68** (2003) to be appeared in the last issue.