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Elastic properties of filled skutterudite RFe_4Sb_{12} (R=La,Ce,Pr)

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The rattling motion, which is an anharmonic oscillation of guest atoms accommodated in polyhedral cages, has been intensively investigated in filled skutterudite compounds, clathrate compounds and so on. The filled skutterudite compounds, such as $PrOs_4Sb_{12}$ [1], and clathrate compounds, such as $Ce_3Pd_{20}Ge_6$ [2] and $Sr_8Ga_{16}Ge_{30}$ [3], show ultrasonic frequency dependence (ultrasonic dispersion) of elastic constants and ultrasonic attenuation. Ultrasonic dispersion in these caged compounds was explained to originate from the rattling motion. To investigate the rattling motion of guest atoms in RFe_4Sb_{12} (R=La,Ce,Pr) systematically, we have measured temperature T dependence of elastic constants and ultrasonic attenuation on RFe_4Sb_{12} single crystalline samples using the phase comparison-type pulse echo method.

For instance, T dependence of elastic constant C_{44} for various ultrasonic frequencies in $LaFe_4Sb_{12}$ and $PrFe_4Sb_{12}$ are shown in Figs. 1 and 2, respectively. We found ultrasonic dispersion in all elastic constants, suggesting no mode selectivity of ultrasound, at several dozen Kelvin in RFe_4Sb_{12} system. These ultrasonic dispersion are estimated to originate from the rattling motion of guest atoms. The temperature and its range of ultrasonic dispersion from 30 to 225 MHz in $CeFe_4Sb_{12}$ are a little smaller than that in $LaFe_4Sb_{12}$ and $PrFe_4Sb_{12}$. In $LaFe_4Sb_{12}$ and $PrFe_4Sb_{12}$, softening of elastic constants continues down to 0.4 K.

[1] T.Goto *et al.*, Phys. Rev. B **69** (2004) 180511.
[2] Y. Nemoto *et al.*, Phys. Rev. B **68** (2003) 184109.
[3] I. Ishii *et al.*, Physica B **383** (2006) 130.

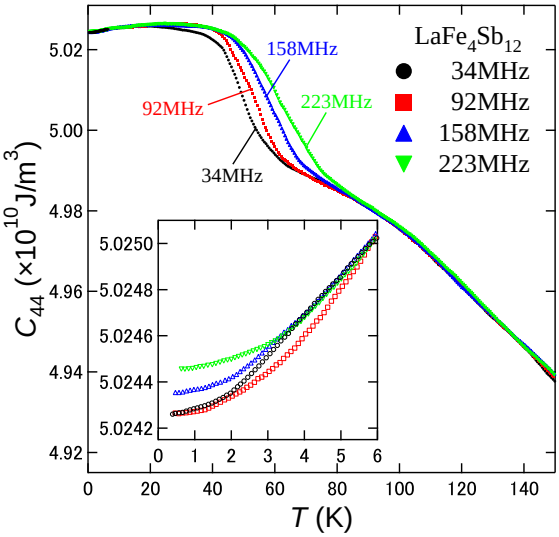

Figure 1: T dependence of elastic constant C_{44} in $LaFe_4Sb_{12}$.

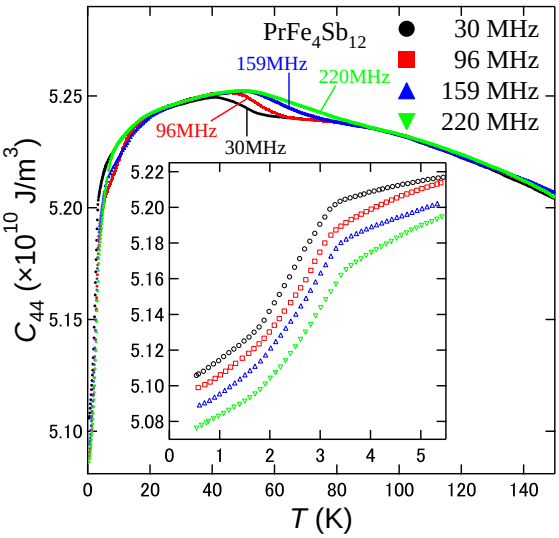

Figure 2: T dependence of elastic constant C_{44} in $PrFe_4Sb_{12}$.