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Elastic properties of filled skutterudite with heavy lanthanide $HoFe_4P_{12}$

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Ultrasonic measurements were made on a polycrystal of the filled skutterudite compound $HoFe_4P_{12}$. We have obtained the longitudinal and transverse elastic constants C_L and C_T. A pronounced elastic softening toward the ferromagnetic transition temperature $T_c = 5$ K was observed in the temperature dependence of the elastic constant $C_L(T)$, followed by the steep drop at ~ 5 K in zero magnetic field. This finding is in accord with an anomaly in the other measurements[1]. The elastic softening was depressed significantly by the applied fields, and was completely suppressed at a field of 5 T as shown Fig.1. In addition, the infection point in the C_L - T curve shifts to higher temperatures and becomes smeared with increasing field, indicating characteristic behavior often observed in ferromagnetic systems. This fact indicates that the low-lying $4f$-levels formed by the crystalline electric field (CEF) effect are close to the ground state. On the other hand, a rather slight softening was observed in the temperature dependence of the elastic constant $C_T(T)$, followed by the step structure at ~ 5 K. Since the C_L consists of the liner combination of a bulk modulus C_B=(C_{11}+2C_{12})/3 and (C_{11}-C_{12})/2, the softening observed in C_L may originate from the Curie term of the quadrupolar susceptibility of the (C_{11}-C_{12})/2. However, we encounter difficulties to explain the absence of the elastic softening in the $C_T(T)$ when we ascribe it to the Curie term. We expect that this discrepancy would be verified by using the single crystalline sample.

[1] I. Shirotani, N. Araseki, Y. Shimaya, R. Nakata, K. Kihou, C. Sekine and T. Yagi, J. Phys.: Condens. Matter **17** (2005) 4383.

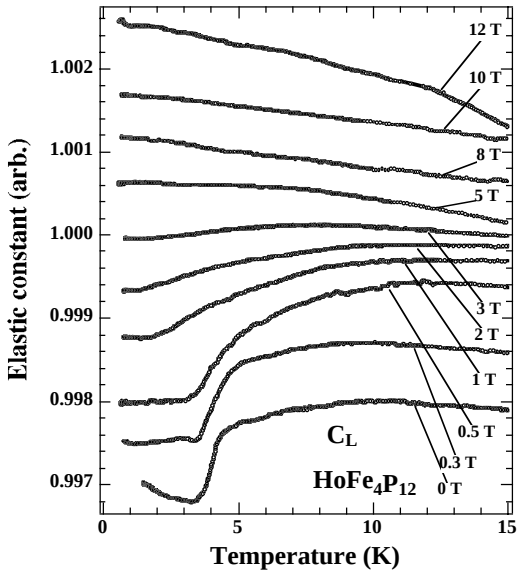

Figure 1: Temperature dependence of the elastic constant C_L under several fields.