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Elastic properties in the high-field phase for $PrFe_4P_{12}$

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We have explored the high-field ordered (HFO) phase appearing only in a highly limited angular range for $H//\langle 111\rangle$ in $PrFe_4P_{12}$ by means of ultrasonic measurements for temperatures down to 0.04K. A distinct elastic anomaly was observed in both elastic constants C_L=(C_{11}+2C_{12}+4C_{44})/3 and C_T=(C_{11}-C_{12}+C_{44})/3 when crossing the HFO phase observed between around 7 and 10 T and below $\sim$ 0.5 K. C_L is the elastic constant determined by the longitudinal sound wave propagated along the $\langle 111\rangle$ axis, while C_T is the elastic constant determined by the transverse sound wave propagated along the $\langle 111\rangle$ axis with the polarization parallel to the $\langle 1\bar{1}0\rangle$ axis.

It is worthwhile that a characteristic softening toward the transition temperature was observed in C_L, while no softening was observed in C_T. These findings suggest that the softening in C_L is ascribable to the bulk modulus C_B=(C_{11}+2C_{12})/3, reflecting on the volume strain ε_B=ε_{xx}+ε_{yy}+ε_{zz} with Γ_1 symmetry. At present we have two possible interpretations for the anomaly in C_B as follows. First, it may be due to the coupling between ε_B and a charge distribution derived from a valence fluctuation of the Pr ion. For example, the softening in C_B is s characteristic phenomena in the intermediate-valence compound SmB_6 [1]. Secondly, it may be due to the coupling between ε_B and the Coulomb multipolar moment (Hexadecapole) such as O_B=$O_4{}^0$+5$O_4{}^4$.

We will discuss the possible nature of HFO phase within the framework of the quasi-quartet Γ_1 -$\Gamma_4{}^1$ level scheme [2].

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