Elastic Constants of $NdCu_2Ge_2$

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The rare-earth compound $NdCu_2Ge_2$ crystallizes into the tetragonal $ThCr_2Si_2$ type structure. Recently, Shigeoka et al. reported the physical properties of $NdCu_2Ge_2$. The magnetic susceptibility along the *c*-axis shows a cusp-like anomaly at $T_N = 4.7$ K. On the other hand, those in the *ab*-plane increase even below T_N and no clear anomaly is detected around T_N.[1] These results imply that the degeneracy of the internal degrees of freedom still exists below T_N. We consider that this characteristic magnetic transition in $NdCu_2Ge_2$ is similar to the "component-separated magnetic transition" in DyB_4[2] or $TbCoGa_5$.[3] Because the degeneracy of quadrupolar degrees of freedom plays an important role in the magnetic transitions in DyB_4 and $TbCoGa_5$, it is necessary to investigate the behavior of the quadrupole moment in $NdCu_2Ge_2$. We grew single crystals of $NdCu_2Ge_2$ and measured their magnetic susceptibility, specific heat, and elastic constants. The magnetic entropy change reaches $R\ln 2$ at $\sim$ 6 K and $R\ln 8$ at $\sim$ 72 K with increasing temperature. This result indicates that the crystalline electric field ground state of $NdCu_2Ge_2$ is a Kramers doublet. In addition, the results of the elastic constants suggest that the degeneracy of quadrupolar degrees of freedom should not remain below T_N.

[1] T. Shigeoka et al., Physica B **346-347**, 117 (2004).
[2] R. Watanuki et al., J. Phys. Soc. Jpn. **74**, 2169 (2005).
[3] N. Sanada et al., J. Phys. Soc. Jpn. **78**, 073709 (2009).