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Geometrical quadrupolar frustration in DyB_4

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Frustration, that is, a geometrical prohibition against satisfying the lowest-energy state of each bipartite bond, leads to a variety of unusual physical properties. In recent year, characteristic behaviors in compounds whose magnetic ions form the so-called *Shastry-Sutherland lattice* (SSL) have much attention. Physical properties of dysprosium tetraboride DyB_4 in which the magnetic atoms form SSL have been studied by the magnetization, specific heat, electric resistivity, powder neutron diffraction and ultrasonic measurements. DyB_4 occurs successive phase transitions at $T_{C1} = 20.3$ K and T_{C2} =12.7 K. The successive phase transition of DyB_4 is characterized by the ordering of the z and xy components at the independent temperatures. Entropy change suggests that the degeneracy due to the internal degrees of freedom is still remained in spite of the formation of magnetic order in the intermediate phase II ($T_{C2} < T < T_{C1}$). The elastic constant C_{44} shows a remarkable softening of 40% in the phase II. Furthermore, the echo signal of C_{44} shrinks considerably in the phase II. The attenuation of the echo signal of C_{44} may be caused by the quadrupolar fluctuation of O_{yz} and O_{zx}. The sucsessive phase transition and the quadrupolar fluctuation in DyB4 originates from the geometrical quadrupolar frustration effects on the Shastry-Sutherland lattice formed by Dy^{3+} ion. The quadrupolar system of DyB_4 is strongly influenced of the geometrical quadrupolar frustration and the quadrupolar transition temperature is supressed lower than a magnetic transition temperature.

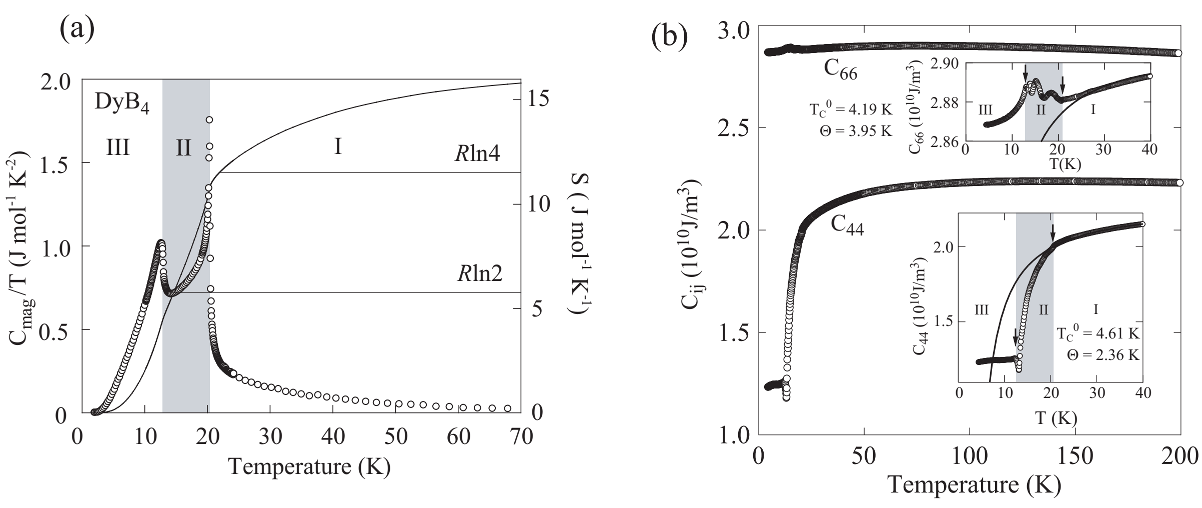

Figure 1: (a)Magnetic Specific heat divided by temperature C_{mag}/T (left axis) and corresponding entropy S (right axis) vs. temperature for DyB_4. The horizontal broken lines indicate the values of entropy for one and two Kramers doublets. (b)Temperature dependence of the elastic constants of DyB_4. The transverse modes C_{44}, and C_{66} was measured at frequencies of 8 MHz. The insets show the low temperature data of the transverse modes. The solid liens are fits to the data using $C_\Gamma(T) = C_\Gamma^0(T - T_C^0)/(T - \Theta)$.