論文の要旨

氏　　名　XI Xiaojuan

論文題目 Ultrasonic Studies on Crystal Electric Field Effects and Magnetic Phase Diagrams in Yb-based Compounds Yb*T*Ge (*T*=Pt, Cu) and Kondo Chiral Magnet $YbNi_3Al_9$
（超音波測定を用いたイッテルビウム化合物 Yb*T*Ge (*T*=Pt, Cu)及び近藤キラル磁性体 $YbNi_3Al_9$ の結晶場効果と磁気相図の研究）

Ultrasonic measurements have been performed on three ternary Yb-based single crystals, Yb*T*Ge (T = Pt and Cu) and $YbNi_3Al_9$. Within them, YbPtGe shows the orthorhombic ε-TiNiSi-type structure and it is reported as a heavy-fermion ferromagnet with the magnetic transition temperature of T_C = 5.4 K. Another one with T = Cu, YbCuGe compound has a hexagonal structure and it has been reported as a metallic antiferromagnet with T_N = 4.2 K. It is also proposed that this compound contains geometrical magnetic frustration due to the competition of exchange interaction within the quasi-two dimensional Yb plane of which Yb ions form a triangle. Recent researches suggested that both these Yb*T*Ge (T = Pt and Cu) show magnetic anisotropy which can be ascribed to the crystal electric field (CEF) effect. However, these two compounds contain different type of CEF (orthorhombic and trigonal CEF for YbPtGe and YbCuGe, respectively). Ultrasonic measurements and related theoretical calculation have been performed on these two compounds in order to clarify these CEF effects and to investigate the magnetic phase transition in these compounds.

For YbPtGe, the transverse elastic moduli C_{44}, C_{55}, and C_{66} exhibit a softening characteristic with a peak around 150 K while the longitudinal moduli C_{11}, C_{22}, and C_{33} show a continuous hardening in the temperature (T) range above T_C. For YbCuGe, the transverse elastic moduli C_{44} and C_{66} show similar softening which begins at 120 K and stops at about 20 K. On the other hand, the longitudinal moduli C_{11} and C_{33} modes show a continuous hardening above T_N. Theoretical strain-susceptibility fitting of transverse modes of these two compounds indicate that the softening results from a quadrupole interaction between the ground and excited Kramers doublets of orthorhombic and trigonal CEF for YbPtGe and YbCuGe, respectively.

As for the elastic moduli below T_C, abrupt elastic hardening is observed in C_{22}, C_{33}, and C_{55} while C_{11}, C_{44}, and C_{66} exhibit a step-like softening in YbPtGe. Similar step-like softening below T_N is detected in C_{33} and C_{44} modes in YbCuGe compound, and elastic hardening appears in C_{11} and C_{66} modes. The difference between the softening and hardening of elastic moduli below T_C (T_N) in YbPtGe and YbCuGe may be due to the magnetostriction or a different dominant coupling between a strain and an order parameter. Phase diagrams with a magnetic field (H) parallel to the *a-, b- and c*-axis are obtained by the measurements of the T and H dependences of all the elastic moduli for both of these two compounds.

The third ternary Yb-based compound $YbNi_3Al_9$ is proposed as a helical magnet in 4*f*-electron system. It has a trigonal $ErNi_3Al_9$-type structure which belongs to the enantiomorphic space-group *R*32. The Sommerfeld coefficient of 110 mJ mol^{-1} K^{-2} suggests the heavy fermion behavior of $YbNi_3Al_9$ and it shows typical features of a heavy-fermion antiferromagnet with a Neel temperature of T_N = 3.4 K. The magnetic ordering in $YbNi_3Al_9$ can be the chiral helimagnetic due to interplay of the RKKY and DM interactions in the chiral crystal. Kondo effect combined with the CEF excited state in this compound is also revealed in previous report. To investigate the CEF effect and the antiferromagnetic ordering at $T_{N,}$ we carried out the ultrasonic measurements on a $YbNi_3Al_9$ single crystal. What's more, by this measurement, the possible reaction of the chiral magnetic structure to the ultrasound can be detected and CEF level are clarified by the theoretical fitting. Acoustic de Hass-von Alphen effect is observed in the magnetic field dependence of elastic modulus for the magnetic field parallel to the *a*-axis. The existence of chiral structure in this compound is indicated by the reaction of elastic moduli below T_N with different modes of C_{44} and C_{66}. The possible mechanism of the new rotational invariance effect of this chiral magnet without magnet field was proposed in this work.