Hexagonal BaTiO$_3$ is one of the two polymorphic forms of BaTiO$_3$: the other is the well known perovskite type (cubic BaTiO$_3$). Hexagonal-BaTiO$_3$ undergoes a structural phase transition from the hexagonal phase (space group P6$_3$/mmc) to the orthorhombic phase (C2221) at $T_0 = 222$ K. This phase transition is believed to be caused by freezing of a soft E$_{2u}$ silent mode at the zone center. Below $T_0$, the E$_{2u}$ mode becomes two Raman-active soft optical mode, Omega1 and Omega2. With further decreasing temperature, it undergoes a ferroelectric phase transition related to a c$_{66}$ soft acoustic mode at $T_C = 74$ K.

We have studied in order to clarify the mechanism of the phase transitions in hexagonal BaTiO$_3$ and difference in physical property between hexagonal- and cubic-BaTiO$_3$. As the first step, we performed inelastic neutron scattering experiments on the hexagonal BaTiO$_3$ by using the triple-axis spectrometers (4G and T1-1) at JRR-3M in JAERI (Tokai). Single crystals were grown from the molten BaTiO$_3$. A crystal with the dimensions of 5 $\times$ 5 $\times$ 6 mm was used for the neutron experiment. The data collections were carried out in the h0l and hhl scattering planes. The measurements of phonon dispersion were performed along the lines 006-106, 006-116, where the indices are referred to the unit cell of the hexagonal phase, and so on.

Figure 1 shows the phonon dispersion curves at 300 K in the major symmetry directions M-K-Gamma-A. The E$_{2u}$ soft mode was clearly confirmed at about 3 meV around Gamma point and shows a weak softening as the temperature approaches $T_0$ from above. It was difficult to observe the whole branches, because some parts of branches were so broad and weak.

On the other hand, the presence of E$_{2u}$ soft mode has not been clearly confirmed in the major symmetry directions M-Gamma-A. The Bragg reflections at the position hhl: l=odd appeared at $T_0$ and increased in intensity with decreasing temperature. Data analysis is now in progress.