MAGNETIC EXCITATIONS IN AN ITINERANT 5f ANTIFERROMAGNET UPt$_2$Si$_2$*

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The magnetic excitation in a 5f antiferromagnet UPt$_2$Si$_2$ was studied by means of neutron inelastic scattering. A remarkable low energy quasi-elastic component has been observed around the antiferromagnetic zone center (100). We concluded that the low energy quasi-elastic response would be the excitation of the quasi-particles due to hybridization between 5f and conduction electrons.

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1. Introduction

The wide variety of behavior exhibited by 5f electrons is one of the most intriguing problems in strongly correlated electron systems. The spectrum, encompassing localized, heavy fermion, non-fermi liquid and itinerant aspects, depends on the strength of the hybridization with valence and ligand electron states. Materials in the UT$_2$Si$_2$ system play an important role in our understanding as the hybridization can be controlled by varying the transition metal element T. In this respect the unusual transition at $T_0 = 17$K and the superconductivity in URu$_2$Si$_2$ are especially interesting with, on the other hand, UPt$_2$Si$_2$ being considered as an example of an antiferromagnet with localized 5f states. UPt$_2$Si$_2$ has the CaBe$_2$Ge$_2$-type structure with

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space group P4/nmm. The uranium magnetic moments along the $c$-axis ($M = 1.7\mu_B$) order antiferromagnetically with $Q = (001)$ below $T_N = 37$K as shown in Fig. 1(a). The susceptibility [1] and specific heat [2] of the latter material were understood in terms of the crystalline electric field (CEF) levels suggested by a previous neutron scattering study on a polycrystalline sample [3] whilst the large drop of the resistivity at $T_N$ and the anisotropic behavior remained unexplained [3]. The purpose of this study is to reveal the magnetic excitations of UPt$_2$Si$_2$ in single crystalline samples.

![Diagram](image)

(b) The intensity of the (100) antiferromagnetic peak and the inelastic component at $\Delta E = 0.4$ meV.

2. Experimental

Single crystalline samples were grown by the Czochralski-pulling method in a tetra-arc furnace under argon gas atmosphere. The magnetic excitation was measured with three single crystal rods aligned within the accuracy of 0.3 degrees on a triple axis spectrometer LTAS with fixed $E_f = 3.5$ meV.

3. Result and discussion

The temperature dependence of the (100) antiferromagnetic Bragg intensity is plotted in Fig. 1(b). The intensity exhibits a clear nature of the magnetic order parameter. The intensity at the neutron energy loss $\Delta E = 0.4$ meV increases with elevating temperature and showed a maximum at $T_N$. It means that there is a low energy magnetic excitation.

The existence of the low energy component is clearly demonstrated by the inelastic scattering profile shown in Fig. 2. On the (100) antiferromagnetic zone-center we observed pronounced quasi-elastic peak at $T = 38$K, slightly above $T_N$. This quasi-elastic scattering can be fitted by Lorentzian
Fig. 2. The inelastic scattering profile at $Q=(100)$ and $(1.300)$, denoted by circles and triangles, respectively. The spectra were measured at 3.1 K (closed symbols) and 38 K (open symbols), respectively.

Line shape with the full width of 0.15 meV. This excitation decreases in intensity with decreasing temperature. At $Q=(1.300)$ a weaker and broader quasi-elastic scattering with width of 0.4 meV was observed. Fig. 3 shows the magnetic excitation spectra of UPt$_2$Si$_2$ measured as a function of $Q$.

Fig. 3. Constant-$Q$ profile of UPt$_2$Si$_2$ as a function of $Q$ measured at $T = 38$ K.
The low energy quasi-elastic scattering has a maximum intensity around the antiferromagnetic zone center (100). Our preliminary neutron inelastic scattering experiments observed the magnetic excitation continuum above 5 meV with no CEF excitation. Therefore, we concluded that this low energy quasi-elastic component would be the spin fluctuations of the heavy quasi-particles due to hybridization between 5f and conduction electrons. Very recently similar low energy excitation and two component magnetic excitation have been observed in heavy fermion superconductors UPd$_2$Al$_3$ [4], UPt$_3$ [5], and 5f itinerant antiferromagnet UGa$_3$. [6] It is also found even in a localized 5f antiferromagnet, U$_3$Pd$_{20}$Si$_6$. [7] Therefore, these phenomena would be a general feature in uranium intermetallic compounds, because 5f electrons in uranium has rather strong hybridization effect.

REFERENCES

[7] N. Metoki et al., to be published.