MAGNETIC EXCITATIONS IN AN ITINERANT 5f ANTIFERROMAGNET UPt_2Si_2*

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The magnetic excitation in a 5f antiferromagnet UPt_2Si_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_2Si_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 $T_0 = 17\,\mathrm{K}$ and the superconductivity in URu_2Si_2 are especially interesting with, on the other hand, UPt_2Si_2 being considered as an example of an antiferromagnet with localized 5f states. UPt_2Si_2 has the $CaBe_2Ge_2$-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 antiferomagnetically 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_2Si_2 in single crystalline samples.

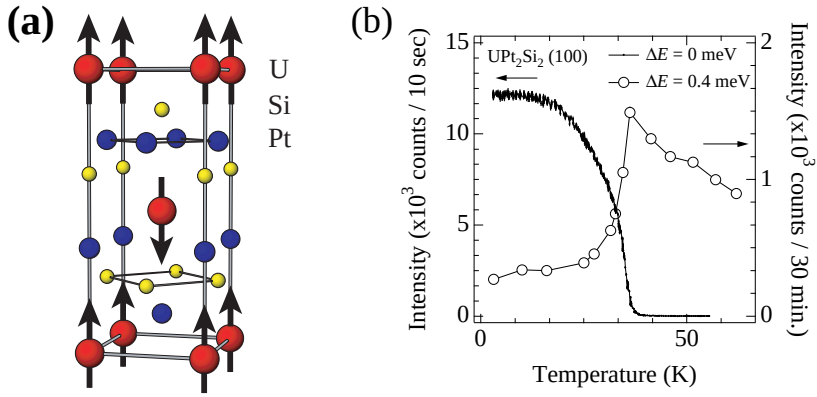

Fig. 1. (a) Crystal and magnetic structure of UPt_2Si_2. (b) The intensity of the (1 0 0) antiferromagnetic peak and the inelastic component at $\Delta E = 0.4$ meV.

2. Experimantal

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 (1 0 0) 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

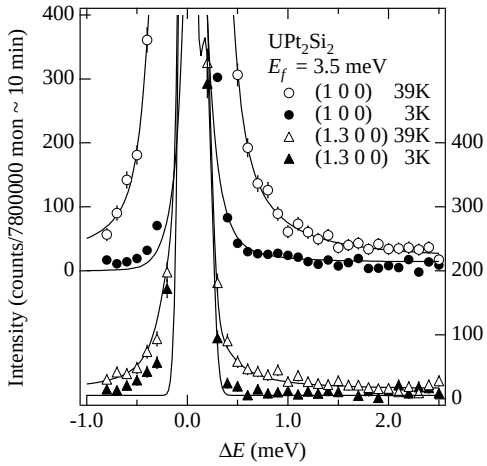

Fig. 2. The inelastic scattering profile at Q =(1 0 0) and (1.3 0 0), denoted by circles and triangles, respectively. The spectra were measured at 3.1 K (closed symbols) and 38 K (open symbols), respectively.

line shape with the full width of 0.15 meV. This excitation decreases in intensity with decreasing temperature. At Q =(1.3 0 0) a weaker and broader quasi-elastic scattering with width of 0.4 meV was observed. Fig. 3 shows the magnetic excitation spectra of UPt_2Si_2 measured as a function of Q.

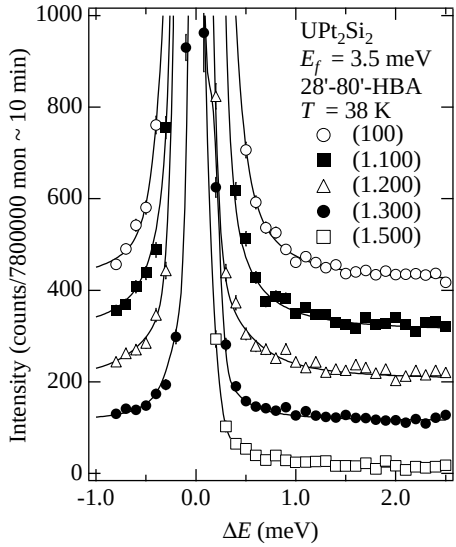

Fig. 3. Constant-Q profile of UPt_2Si_2 as a function of Q measured at $T = 38$ K.

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_2Al_3 [4], UPt_3 [5], and $5f$ itinerant antiferromagnet UGa_3. [6] It is also found even in a localized $5f$ antiferromagnet, $U_3Pd_{20}Si_6$. [7] Therefore, these phenomena would be a general feature in uranium intermetallic compounds, because $5f$ electrons in uranium has rather strong hybridization effect.

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