μSR Study of Magnetism of $CeRh_2Si_2$ under High Pressure

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Abstract

$CeRh_2Si_2$ shows two antiferromagnetic transitions at ambient pressure (T_{N1}=36K and T_{N2}=27K). Application of pressure suppresses T_N to 0K at P_c ~1GPa. We study the magnetism of the single crystalline sample of $CeRh_2Si_2$ by muon spin rotaion/relaxation(μSR) method up to 0.45GPa. Below T_{N2}, we observed both the spontaneous muon spin precession and the fast muon spin relaxation under zero magnetic field. Although the transition temperature decreases with increasing the pressure, the precession frequency, which is proportional to the saturated sublattice magnetic moment, is nearly independent on the pressure.

Key words: $CeRh_2Si_2$; high pressure ; μSR

A ternary compound $CeRh_2Si_2$ with the $ThCr_2Si_2$ structure shows two successive antiferromagnetic phase transitions at T_{N1}=35K and T_{N2}=25K at ambient pressure. Magnetic Bragg peaks corresponding to $(\frac{1}{2}\frac{1}{2}0)$ magnetic structure for $T_{N2} < T < T_{N1}$ were observed by the neutron diffraction measurements and additional peaks corresponding to $(\frac{1}{2}\frac{1}{2}\frac{1}{2})$ appeared below T_{N2}[1]. Application of pressure suppresses T_N to 0K at P_c ~1GPa[2,3]. Neutron diffraction study under high pressure shows decreasing of the saturated sublattice magnetic moment and the transition temperatures with increasing pressure[4]. It was also reported that a pressure induced superconductivity appears above 1GPa around 0.5K[3,5]. These behaviors indicate the quantum phase transition at quantum critical point and the magnetism in $CeRh_2Si_2$ below P_c is an important subject. There are two models for magnetic structure below T_{N2}, namely, multidomain structure[1] and 4-**q** superposed structure[4]. We study the magnetism in $CeRh_2Si_2$ by means of the muon spin rotation/relaxation (μSR) method under high pressures. μSR possesses high sensitivity for magnetism and an amplitude of μSR signal proportional to the volume fraction. These features give an advantage for the investigation of the complex magnetism of $CeRh_2Si_2$.

High pressure μSR experiment was carried out at M9B beam channel at TRIUMF, Vancouver, Canada. Piston cylinder type high pressure cell, which is made from CuBe alloy, was used. Positive muon of 102MeV/c was implanted into single crystalline sample of $CeRh_2Si_2$. The highest pressure and the lowest temperature for the present experiment are 0.45GPa and 4K, respectively. Calibration of the pressure is done by measuring the superconducting transition temperature of Pb and Sn independently of the μSR measurements.

Figure 1 shows the typical μSR spectra in $CeRh_2Si_2$ under zero magnetic field(ZF) in the high pressure cell. Here about 40% of the implanted muons stopped at the $CeRh_2Si_2$ and rest of the muons are stopped at the CuBe wall or the pressure medium (Flourinate FC77/70). In the flourinate, it is known that the muon spin precession occurs even in a ZF and the small amplitude of the slow precession signal whose, precession frequency is about ~0.4MHz, is seen in all the temperature range[6]. At 40K, which is above T_{N1}, a significant

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structure of the time dependence of the μSR spectrum is seen. However, this structure is originate from the signal from the CuBe or the flourinate, and quite small muon spin relaxation, due to the nucleus magnetic moment of ^{103}Rh, occurs in the paramagnetic phase of $CeRh_2Si_2$. In $T_{N2} < T < T_{N1}$, no spontaneous muon spin precession, but fast relaxation is observed. In the lower magnetic ordering phase, $T < T_{N2}$, we observed both fast relaxation and the spontaneous muon spin precession under ZF, which means that two kind of the local fields exist at muon sites. The temperature dependence of the precession frequency is weak below T_{N2}, which shows the feature of the first order phase transition at T_{N2}. These results are consistent with those at ambient pressure[7]. The transition temperatures T_{N1} and T_{N2} decrease with increasing the pressure, which is in good agreement with other experiments. However, the amplitude of the precession component is decrease below 10K in all the pressure range. In addition, the amplitude also decrease with increasing pressure. The pressure dependence of precession frequency below 10K is plotted in Fig. 2. The precession frequency is nearly constant to the applied pressure up to 0.45GPa. The precession frequency is corresponds to the internal field at the muon site and the internal field is proportional to the saturated sublattice magnetic moment. Thus, this result implies that the internal field and the saturated sublattice magnetic moment around the muon site is nearly independent of the applied pressure. We note that similar μSR result by using polycrystalline sample of $CeRh_2Si_2$ is reported by another group[8]. Whereas it was proposed, based on the assumption of 4-**q** spin structure, that the saturated sublattice magnetic moment decreases with increasing the pressure and disappears around 1GPa[4]. These interpretations are inconsistent with each other. This fact implies that it is necessary to reexamine the magnetic structure. To solve the problem of the magnetic structures, further experiment which examine the pressure dependence of the relaxation component above 0.5GPa is under way.

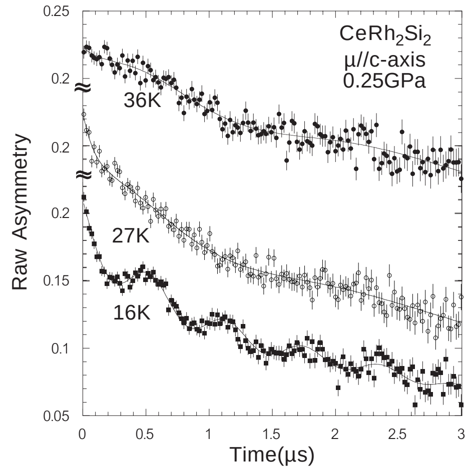

Fig. 1. Typical ZF-μSR spectra of $CeRh_2Si_2$ in the high pressure cell at 0.25GPa and 36K($T > T_{N1}$), 27K($T_{N1} > T > T_{N2}$) and 16K($T < T_{N2}$)

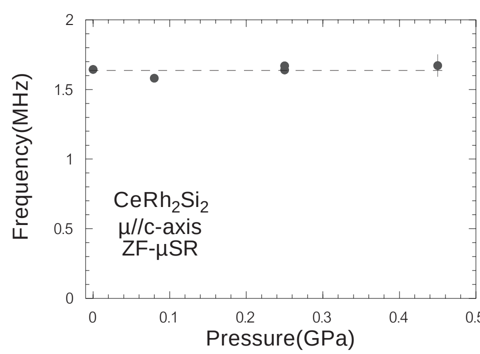

Fig. 2. Applied pressure dependence of the muon spin precession frequency in $CeRh_2Si_2$ under ZF at 4K (0GPa) , 5K (0.08GPa, 0.25GPa) and 9K (0.45GPa).

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