Experimental report

09/02/2016

Proposal: **5-41-834**

Council: 4/2015

Title: Investigation of magnetic structure in Ce2MgSi2 single crystal

Research area: Physics

This proposal is a new proposal

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Samples: Ce2MgSi2

Instrument	Requested days	Allocated days	From	To
D10	8	7	30/11/2015	07/12/2015

Abstract:

Recent preparation of a Ce2MgSi2 single crystal allows us to investigate the physical properties of this Ce-based heavy fermion compound. Ce2MgSi2 crystallizes in the Mo2FeB2-type tetragonal structure and Ce atoms form the so-called Shastry-Sutherland lattice in tetragonal basal plane. This compound belongs to a relatively small group of materials in which the quantum critical point can be reached by varying external conditions. Moreover, the superconductivity dome was not observed near quantum critical point. Ce2MgSi2 has not been investigated using microscopic techniques, therefore the magnetic structure as well as the magnetic propagation vector stay still unknown. The proposed experiment is a first microscopic view into the magnetic structure of a material which exhibits quantum critical behavior under achievable hydrostatic pressures. The experiments under external pressure and in strong magnetic fields will be further steps in our broader investigation of Ce2MgSi2 compound.

We performed a measurement of a magnetic structure of a Ce_2MgSi_2 single crystal using D10 diffractometer.

Ce_2MgSi_2 is an antiferromagnetic heavy-fermion compound which crystallizes in the Mo_2FeB_2-type tetragonal structure and cerium atoms form the so-called Shastry-Sutherland lattice (SSL), in the tetragonal basal plane. Ce_2MgSi_2 orders antiferromagnetically with Néel temperature T_N = 13 K. The magnetization measurement below T_N reveals two distinct anomalies on magnetization curves in fields of 12 and 14 T which can be attributed to the change of magnetic structure. We note, that these magnetic transitions are observed measuring with field applied along the basal plane direction; no anomaly is observed for $H \parallel c$. In the SSL lattice, successive metamagnetic transitions are expected as a result of frustration effect of magnetic moment. Taking into account the metamagnetic transitions observed on magnetization curves, we expect the magnetic moments confined within the basal plane. The investigation of magnetic structure in Ce_2MgSi_2 using CYCLOPS and D10 diffractometers is crucial to obtain unambiguous information on magnetic ground state.

First, we have carried out neutron Laue experiment using CYCLOPS diffractometer. The propagation vector of Ce_2MgSi_2 was determined as $\boldsymbol{k}$ = (0 0 0). In further step, we confirmed the propagation vector measuring nuclear and expected magnetic reflections using D10 single-crystal four-circle diffractometer. After measurement of a set of 230 reflections in both 20 K and 2 K, we determined the magnetic structure as shown in Figure 1. The determined magnetic structure is one of the structures predicted by group theory (representation analysis). The other structures were unambiguously excluded on the basis of measured data. The value of Ce magnetic moment was refined as μ_{Ce} = (1.4±0.1) μ_B, which is well in agreement with our magnetization measurements.

Besides the magnetic structure determination, we measured also temperature evolution of magnetic and/or magnetic + nuclear reflection intensities between 2 K and 20 K. Figure 2 shows the temperature dependence of scattering intensity of the (101) reflection. The magnetic intensity appears below 12.5 K (in a good agreement with T_N), increases with decreasing temperature and saturates below 4 K. Resulting temperature dependence of the intensity corresponds well to the mean-field like temperature evolution, which is of the second power of spontaneous sub-lattice magnetization.

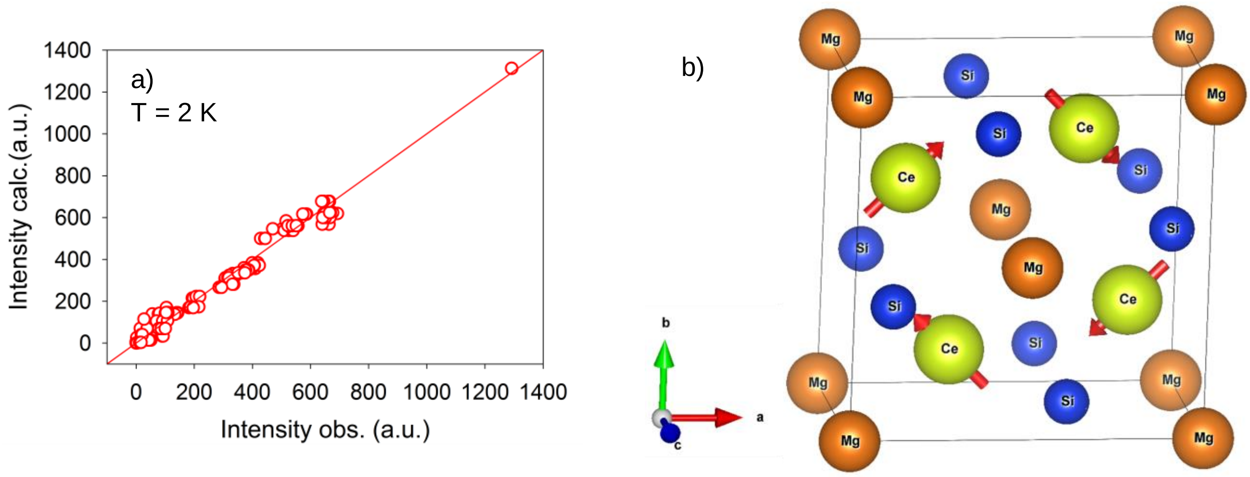

Fig.1 – a) Observed vs calculated intensities on nuclear + magnetic reflections measured on Ce_2MgSi_2 single crystal at 2 K. b) Nuclear and magnetic structure of Ce_2MgSi_2 at 2 K. The magnetic moment on Ce ions 1.4 μ_B.

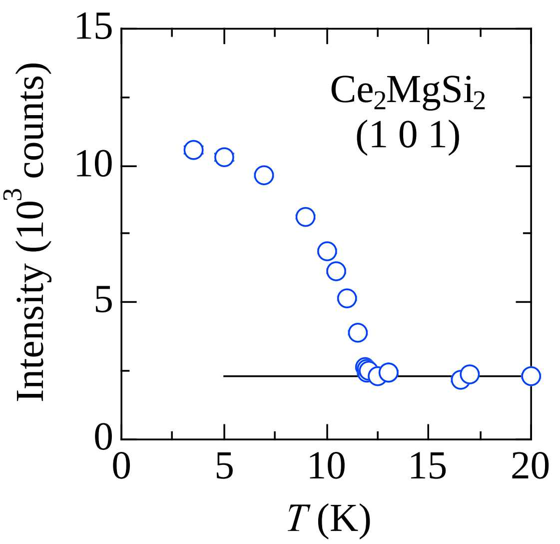

Fig.2 – Temperature evolution of the measured intensity on a magnetic reflection (101). A clear onset of intensity is present at 12 K.