Experimental report

19/07/2024

Proposal: 4-01-1842 **Council:** 4/2024

Title: Magnetic excitations in UCr2Si2C

Research area: Materials

This proposal is a new proposal

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Samples: UCr2Si2C

Instrument	Requested days	Allocated days	From	To
IN22	7	0		
IN20	7	7	11/06/2024	19/06/2024

Abstract:

A recent classification and description based on spin-symmetry principles proposes that apart from the well-known established magnetic orders a newly distinct class of magnetic materials called ¿altermagnets¿ exists. Theoretically, in altermagnets, due to an anisotropic exchange interaction an alternating chirality splitting is expected to be observed in the magnon bands. This hypothesis so far has not been experimentally observed to our knowledge. One potential candidate material where the splitting of the magnon bands may be pronounced is UCr2Si2C. With an unpolarized neutron scattering experiment we observed hints of such a magnon spin splitting along the theoretically expected high symmetry direction of the tetragonal lattice. To unambiguously determine the nature of the excitations of UCr2Si2C and to confirm the theoretical predictions about this new class of magnetic materials we propose a study with a thermal TAS and polarized neutrons.

Background:
A recent classification based on spin-symmetry principles proposes that, apart from the well-known types of magnetic order, a newly distinct class of magnetic materials exists and has been termed "altermagnets". Like ferromagnets (FMs), altermagnets break time-reversal symmetry. However, like collinear antiferromagnets (AFMs), symmetry dictates that altermagnets have no net magnetization. At first sight, altermagnets resemble collinear AFMs, but there is one qualitative difference: the symmetry that maps one spin sublattice onto the other is neither simply translation nor inversion. This lifts the Kramers degeneracy and a spin-dependent energy splitting is expected to be observed in the electronic band structure, as well as a chirality-dependent energy splitting in the magnon band structure, the latter resulting from spatially anisotropic exchange interactions. Altermagnetic magnons resemble the dispersion relations of simple collinear AFMs, however, the energy degeneracy of the magnon bands is lifted, and they acquire an alternating chirality splitting in zero external magnetic field.

Aim of the experiment:
The aim of this experiment was to perform a polarized INS study on UCr_2Si_2C in the energy range of 0<E<30meV with the thermal TAS IN20 in order to determine the nature of the excitations that were obtained with unpolarized neutrons on IN8 (proposal number DIR-310). The sample was oriented in the [100]/[001] plane of the tetragonal symmetry in order to access excitations along the (*h*00) and (00*l*) directions of reciprocal space. It is reminded that the propagation vector of UCr_2Si_2C is **k**=(0,0,0).

Experimental setup and preliminary results:
The IN20 spectrometer was set up in W configuration. We used a velocity selector, a double focusing Heusler(111) monochromator, a PG filter after the sample, and a horizontally focusing Heusler(111) analyser. All data have been collected with a fixed k_f=2.58Å^{-1}. Polarization analysis was performed by a set of Helmholtz coils generating a guide field (about 15 Gauss), which automatically follows the direction changes of the scattering vector. One flipper was placed after the sample and a flipping ratio of about 20 was measured on Si. The single crystal (with a mass of about 4g) was mounted on an Al holder and was placed inside a cryofurnace.
E-scans at constant **Q** were measured in the focusing mode at T=3K. Data have been collected mainly in the NSF_{xx} and SF_{xx} channels and for selected scans data were obtained also in SF_{yy} and SF_{zz} (NSF and SF refers to non-spin flip and spin flip, respectively). We use the standard (x, y, z) frame where the x-axis is parallel to **Q**, the z-axis is vertical, and the y-axis is perpendicular to **Q** and z. Some representative scans are shown in Figure 1. In the investigated (**Q**,E)-range we have no clear evidence of magnetic excitations (crystal field or spin-waves) and all peaks seem to originate from lattice excitations (acoustic and low-energy optic phonons).

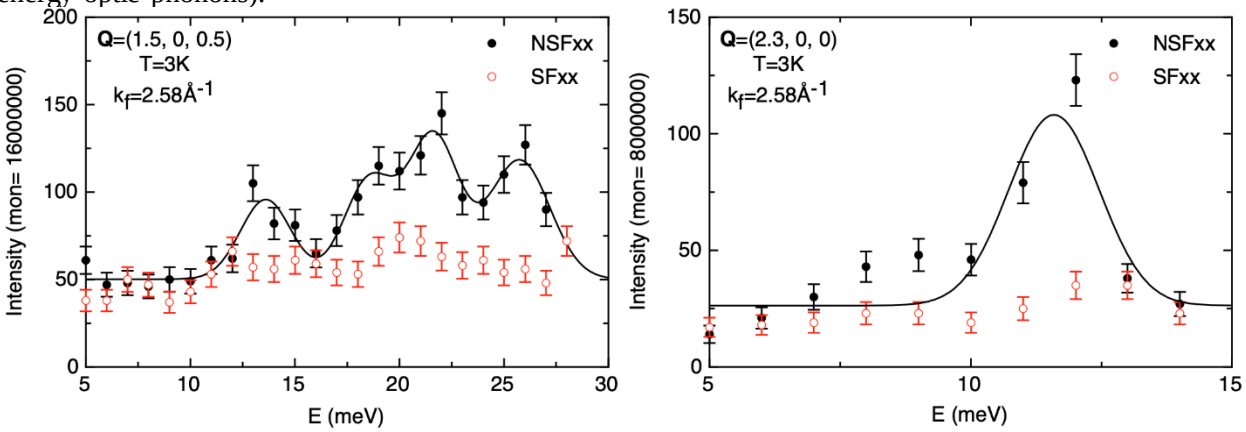


Fig. 1: E-scans obtained at IN20 at T=3K on NSF_{xx} and SF_{xx} with fixed k_f=2.58A^{-1} at const. **Q**=(1.5, 0, 0.5) (left) and at const. **Q**=(2.3, 0, 0) (right). Solid lines indicate fits with Gaussian functions.