Experimental report

21/04/2016

Proposal: **5-42-412**

Council: 4/2015

Title: Spin chirality in Mn1-y(Fe1-xCox)ySi

Research area: Physics

This proposal is a new proposal

Main proposer: **Sven-Arne SIEGFRIED**

Experimental team: Sergey GRIGORYEV
Evgeniy ALTYNBAEV
Vadim DIADKIN
Sven-Arne SIEGFRIED

Local contacts: Dirk HONECKER

Samples: Mn1-y(Fe1-xCox)ySi

Instrument	Requested days	Allocated days	From	To
D33	9	4	29/10/2015	02/11/2015

Abstract:

The coupling between the structural and magnetic properties in the non-centrosymmetric cubic B20 helimagnets with the space group P213 is of great interest during the last years.
In these compounds a helical (homochiral) structure is stabilized by the Dzyaloshinskii-Moriya interaction (DMI) below Tc. Recently it has been shown that the flip of the link between the spin helix chirality and the structural chirality is a genetic property of the mixed compounds T11-xT2xSi/Ge (T1, T2 transition metals). In this experiment we want to investigate the behaviour of the spin helix chirality in the cubic helimagnetic system Mn1-y(Fe1-xCox)ySi with the concentrations y and x.

Spin chirality in $Mn_{1-y}(Fe_{1-x}Co_x)_ySi$.

S.-A. Siegfried,[1] S. V. Grigoriev,[2,3] E. Altynbaev,[2,3] D. Chernyshov,[4] V. Diadkin,[4] and D. Menzel[5]

[1]*Helmholtz Zentrum Geesthacht, Geesthacht, 21502, Germany*
[2]*Petersburg Nuclear Physics Institute, Gatchina, St-Petersburg, 188300, Russia*
[3]*Saint-Petersburg State University, Ulyanovskaya 1, Saint-Petersburg, 198504, Russia*
[4]*Swiss-Norwegian Beamlines at the ESRF, Grenoble, 38000 France*
[5]*Technische Universität Braunschweig, 38106 Braunschweig, Germany*

I. INTRODUCTION

The transition metals monosilicides MSi, where M — is Mn, Fe, Co or other atoms of transition metals, crystallizes with B20-type structure. The lack of inversion symmetry leads to the appearance of antisymmetric Dzyaloshinskii-Moryia (DM) interaction. Together with main ferromagnetic exchange interaction it stabilizes the helical magnetic order with handedness defined by the sign of DM constant D [1, 2]. The weakest anisotropic exchange interaction determine the direction of the helical wave vector along the main axes of the structure. For numerical characterization +1 is usually contributed to the right-handed chirality and −1 — to the left-handed chirality.

The investigation of magnetic structure of MSi singlecrystals allows one to determine the unique relationship between the structure, Γ_C, and magnetic, γ_m, chiralities [3–5]. Despite the fact that the values of the product $\Gamma_C \times \gamma_m$ for $Fe_{1-x}Co_xSi$, $Mn_{1-x}Co_xSi$ and $Mn_{1-x}Fe_xSi$ are already well known for all x, the investigation of $Mn_{1-y}(Fe_{1-x}Co_x)_ySi$ with different values of x and y is still of a huge interest.

The structural chirality Γ_C of $Mn_{1-y}(Fe_{1-x}Co_x)_ySi$ samples with $x \in [0.2 \div 0.8]$ and $y \in [0.8 \div 1]$ grown by Czochralski method was measured with X-ray diffraction.

II. PERFORMED EXPERIMENT

The SANS measurements were carried out with polarized neutrons with a mean wavelength of $\lambda = 0.6$ nm. The Sample-Detector distance was set to cover the scattering vector range Q from 0.05 nm^{-1} to 0.5 nm^{-1}. The samples were cooled in zero field from T = 300 K to the T = 5 K. The scattering intensity was measured in magnetic field $H \approx 1.2H_{C1}$ for each sample in order to align the wave vectors of magnetic helices along the direction of magnetic field and perpendicular to the

TABLE I: The values of structural and magnetic chiralities and its product for $Mn_{1-y}(Fe_{1-x}Co_x)_ySi$.

Compound	Structural chirality Γ_C	Magnetic chirality γ_m	Product $\Gamma_C \times \gamma_m$
$Fe_{0.65}Co_{0.35}Si$	−1	+1	−1
$Mn_{0.05}(Fe_{0.5}Co_{0.5})_{0.95}Si$	+1	−1	−1
$Mn_{0.1}(Fe_{0.6}Co_{0.4})_{0.9}Si$	+1	−1	−1
$Mn_{0.2}(Fe_{0.7}Co_{0.3})_{0.8}Si$	−1	+1	−1
$Mn_{0.1}(Fe_{0.7}Co_{0.3})_{0.9}Si$	+1	−1	−1
$Mn_{0.05}(Fe_{0.7}Co_{0.3})_{0.95}Si$	+1	−1	−1
$Mn_{0.1}(Fe_{0.8}Co_{0.2})_{0.9}Si$	+1	−1	−1
$Mn_{0.05}(Fe_{0.8}Co_{0.2})_{0.95}Si$	−1	+1	−1

neutron beam. The value of the magnetic chirality was obtained by the comparison of sANS-maps measured with different direction of neutron polarization.

III. RESULTS

As a result of the experiment the values of magnetic chirality γ_m for each sample were measured. The sign of the unique relationship between the chiralities of structure, Γ_C, and magnetism, γ_m, is presented as product $\Gamma_C \times \gamma_m$ in Table I.

In summary, the results of the experiment have shown that the value of magnetic chirality always opposite to the chirality of the structure for all the compounds under study. This research should be the starting point for further investigations of $Mn_{1-y}(Fe_{1-x}Co_x)_ySi$ compounds with different values of x and y in order to define the origin of the sign of D inversion in transition metals monosilicides.

[1] O. Nakanishia, et al., Solid State Commun., **35** (1980) 995-998.
[2] P.Bak, M.H.Jensen, J.Phys.**C13**, L881 (1980).
[3] Grigoriev S. V., et al. Phys. Rev. Lett. Vol. **110**, 207201 (2013);
[4] D. Morikawa, et al., Phys. Rev. B 88, 024408 (2013);
[5] Siegfried S.-A., et al., Phys. Rev. B. Vol. **91**, 184406 (2015);