Journal of large-scale research facilities

Journal of large-scale research facilities, 1, A28 (2015) http://dx.doi.org/10.17815/jlsrf-1-26

Published: 19.08.2015

KWS-1: Small-angle scattering diffractometer

Heinz Maier-Leibnitz Zentrum
Forschungszentrum Jülich, Jülich Centre for Neutron Science

Instrument Scientists:
- Henrich Frielinghaus, Jülich Centre for Neutron Science (JCNS) at Heinz Maier-Leibnitz Zentrum (MLZ), Forschungszentrum Jülich GmbH, Garching, Germany, phone: +49(0) 89 289 10706, email: h.frielinghaus@fz-juelich.de
- Artem Feoktystov, Jülich Centre for Neutron Science (JCNS) at Heinz Maier-Leibnitz Zentrum (MLZ), Forschungszentrum Jülich GmbH, Garching, Germany, phone: +49(0) 89 289 10746, email: a.feoktystov@fz-juelich.de
- Ida Berts, Jülich Centre for Neutron Science (JCNS) at Heinz Maier-Leibnitz Zentrum (MLZ), Forschungszentrum Jülich GmbH, Garching, Germany, phone: +49(0) 89 289 10758, email: i.berts@fz-juelich.de
- Gaetano Mangiapia, Jülich Centre for Neutron Science (JCNS) at Heinz Maier-Leibnitz Zentrum (MLZ), Forschungszentrum Jülich GmbH, Garching, Germany, phone: +49(0) 89 289 54810, email: g.mangiapia@fz-juelich.de

Abstract: The KWS-1, which is operated by JCNS, Forschungszentrum Jülich, is a small-angle neutron scattering diffractometer dedicated to high resolution measurements.

1 Introduction

KWS-1 is dedicated to high resolution measurements (Feoktystov et al., 2015) due to its 10 % wavelength selector. This property is interesting for highly ordered or highly monodisperse samples. With the foreseen chopper the wavelength uncertainty can be reduced further to ca. 1 %. The scientific background of KWS-1 is placed in magnetic thin films. Magnetic samples will be studied with the full polarisation analysis including incident beam polarisation and polarisation analysis of the scattered neutrons. In front of the collimation, a 3-cavity polariser with V-shaped mirrors is placed. The full bandwidth of 4.5 to 20 Å will be covered with min. 90 % (95 % typical) polarisation. A radio frequency spin flipper allows for changing the polarisation. The polarisation analysis will be realised with ^{3}He-cells which will be optimised for the used wavelength and scattering angle. Vertical magnets will be provided to render the magnetic field at the sample position. Thin films can be well studied in the grazing incidence geometry – the method is called grazing incidence small angle neutron scattering (GISANS). A newly installed hexapod will allow for positioning the sample with 0.01 mm and 0.01° precision.

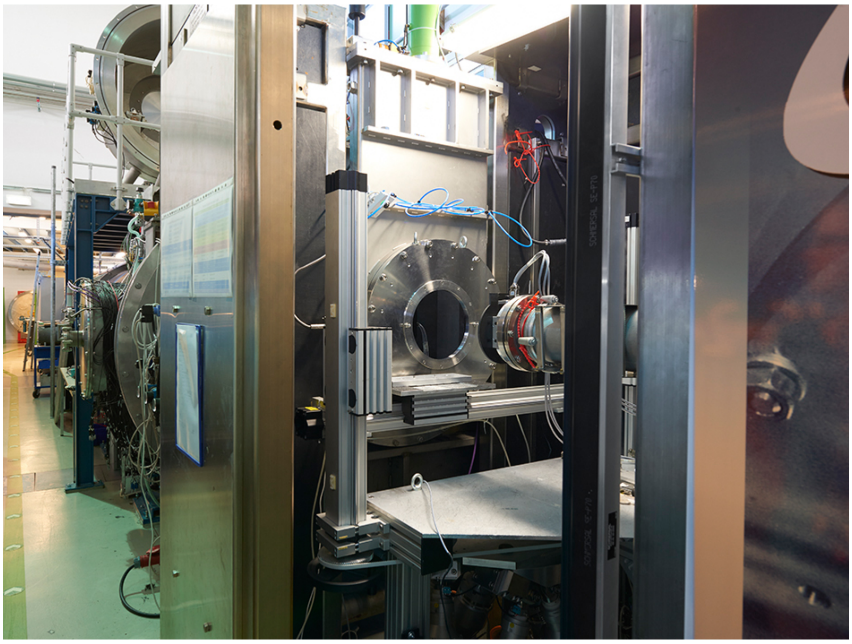

Figure 1: Instrument KWS-1 (Copyright by W. Schürmann, TUM).

Classical soft-matter systems will be investigated on KWS-1 if the resolution is needed. Biological samples can be handled due to the detector distance of ca. 1 m, which will allow for maximal scattering angles of Q = 0.5 $Å^{-1}$.

The MgF_2 lenses are used for the high flux mode with large sample areas, while the resolution stays in the classical SANS range. These enhanced intensities allow for real time measurements in the 1/10 second region (typical 1 s).

The chopper in parallel allows for studying faster dynamics in the ms range. The so-called TISANE mode interlocks the chopper frequency with the excitation field frequency and with the detection binning. The precise consideration of the flight times allows for higher precision compared to classical stroboscopic illuminations.

2 Typical Applications

- Grain boundaries
- Alloys
- Magnetic structures
- Flow lines
- Soft matter and biology (as for KWS-2)
- Complex fluids near surfaces
- Polymer films
- Magnetic films
- Nanostructured films

3 Sample Environment

- Rheometer shear sandwich
- Rheowis-fluid rheometer (max. shear rate 10000 s^{-1})
- Anton-Paar fluid rheometer
- Stopped flow cell

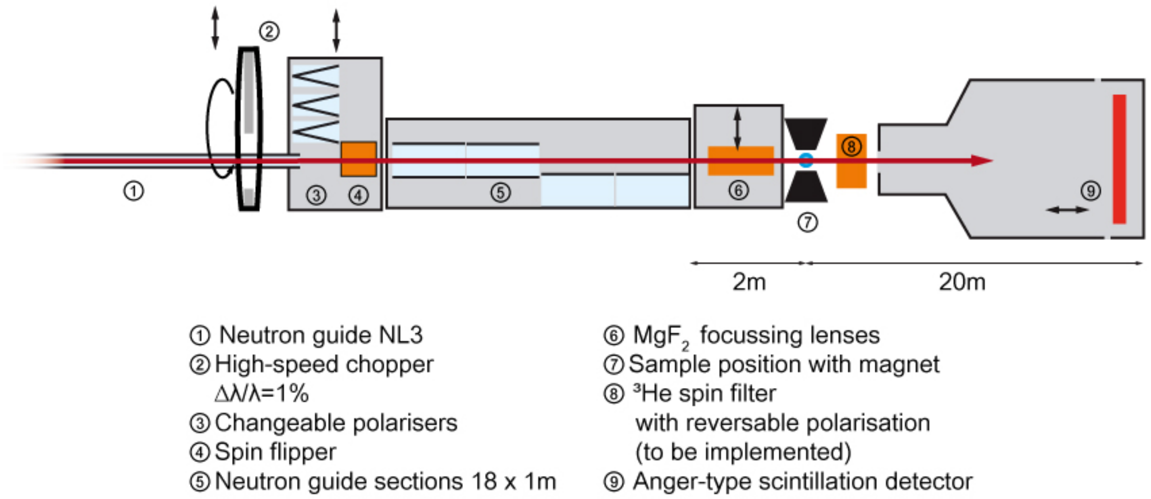

Figure 2: Schematic drawing of KWS-1.

- Sample holders: 9 horizontal x 3 vertical (temperature controlled) for standard Hellma cells 404-QX and 110-QX
- Oil & water thermostats (range -40 °C – 250 °C), electric thermostat (RT – 200 °C)
- 8-positions thermostated (Peltier) sample holder (-40 °C – 150 °C)
- Magnet (horizontal, vertical)
- Cryostat with sapphire windows
- High temperature furnace
- Pressure cells (500 bar, 2000 bar, 5000 bar)

4 Technical Data

4.1 Overall performance

- Q = 0.0007 – 0.5 $Å^{-1}$
- Maximal flux: $1.5 \cdot 10^8$ n cm^{-2} s^{-1}
- Typical flux: $8 \cdot 10^6$ n cm^{-2} s^{-1} (collimation 8 m, aperture 30 x 30 mm^2, λ = 7 Å)

4.2 Velocity selector

- Dornier, FWHM 10 %, λ = 4.5 Å – 12 Å, 20 Å

4.3 Chopper

- For TOF-wavelength analysis, FWHM 1 %

4.4 Polariser

- Cavity with V-shaped supermirror, all wavelengths
- Polarisation better 90 %, typical 95 %

4.5 Spin-flipper

- Radio-Frequency spin flip probability better than 99.8 %

4.6 Active apertures

- 2 m, 4 m, 8 m, 14 m, 20 m

4.7 Aperture sizes

- Rectangular 1 x 1 mm^2 – 50 x 50 mm^2

4.8 Sample aperture

- Rectangular 1 x 1 mm^2 – 50 x 50 mm^2

4.9 Neutron lenses

- MgF_2, diameter 50 mm, curvature 20 mm
- Packs with 4, 6, 16 lenses

4.10 Sample stage

- Hexapod, resolution better than 0.01°, 0.01 mm

4.11 Detector 1

- Detection range: continuous 1.5 m – 20 m
- ^{6}Li-Scintillator 1 mm thickness + photomultiplier
- Efficiency better than 95 %
- Spatial resolution 5.3 x 5.3 mm^2,
- 128 x 128 channels
- Max. countrate 0.6 MHz (τ_{dead} = 0.64 µs)

References

Feoktystov, A. V., Frielinghaus, H., Di, Z., Jaksch, S., Pipich, V., Appavou, M.-S., … Brückel, T. (2015). KWS-1 high-resolution small-angle neutron scattering instrument at JCNS: current state. *Journal of Applied Crystallography*, *48*(1), 61-70. http://dx.doi.org/10.1107/S1600576714025977