Journal of large-scale research facilities

Journal of large-scale research facilities, 1, A30 (2015) http://dx.doi.org/10.17815/jlsrf-1-38

Published: 19.08.2015

SPHERES: Backscattering spectrometer

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Abstract: SPHERES (**SP**ectrometer for **H**igh **E**nergy **RES**olution), operated by JCNS, Forschungszentrum Jülich, is a third-generation neutron backscattering spectrometer with focussing optics and a phase-space-transform chopper. It enables the investigation of atomic and molecular dynamics with an energy resolution of about 0.65 μeV in a dynamic range of ± 31 μeV.

1 Introduction

The high energy resolution of a backscattering spectrometer is achieved by Bragg reflection from perfect monochromator and analyzer crystals under angles close to 180°. Due to this geometry a primary beam deflector and a duty-cycle chopper is needed. At SPHERES, both functions are realised in one by a chopper with deflector crystals on its circumference. As an additional advantage, the fast motion of the deflector crystals achieves a phase-space transformation of the primary spectrum, thereby enhancing the usable flux at the monochromator. A schematic view of this compact spectrometer layout is shown in Figure 2.

The principal figures of merit qualify SPHERES as one of the best of its class (Wuttke et al., 2012). Count rates and signal-to-noise ratio have been improved by filling the instrument housing with argon, thereby avoiding air scattering in the secondary spectrometer. Another gain in flux will be achieved by a more efficient phase-space transform chopper which is in the commissioning phase. The new designed chopper will be more efficient due to optimised rotation speed and higher reflectivity and mosaicity of the graphite crystals. The resolution of the small angle detectors have been improved by reducing the azimuth angle range of the analyzers (Wuttke & Zamponi, 2013).

Figure 1: View inside SPHERES: the large array of Si(111) analyzer crystals covers a solid angle of about 2.5, which is 20 % of 4 π (Copyright by A. Heddergott, TUM).

As a multi-detector instrument with relaxed angular resolution, SPHERES is particularly suited for studying tagged-particle motion by incoherent scattering. Typical applications include for example dynamical processes in polymers and biological systems (Gallat et al., 2012). The high resolution and sensitivity of the spectrometer allows to investigate the dynamics of water in confined geometry and deep in the supercooled state (Doster et al., 2010). The high count rates allow inelastic temperature scans (Häußler et al., 2011) and real-time kinetic experiments (Léon & Wuttke, 2011). Further applications are hyperfine splitting in magnetic materials (Chatterji et al., 2008) and rotational tunneling (Bator et al., 2013).

2 Typical Applications

- Hyperfine splitting
- Molecular reorientations and rotational tunneling
- Dynamic signature of phase transitions
- Hydrogen diffusion
- Liquid dynamics
- Polymer relaxation
- Protein aggregation

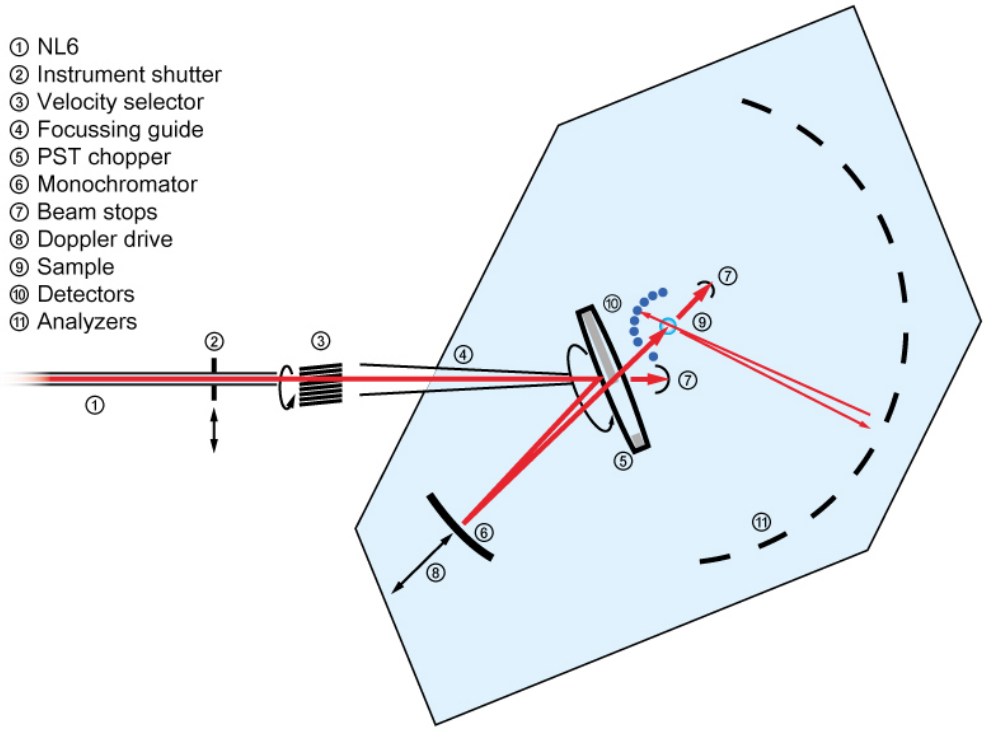

Figure 2: Schematic drawing of SPHERES.

3 Sample Environment

- Cryofurnace 3...700 K
- Dilution inset 20 mK
- Furnace

4 Technical Data

4.1 Primary beam

- Neutron guide: NL6-S
- Neutron wavelength: 6.27 Å
- Neutron energy: 2.08 meV

4.2 Main parameters

- Resolution FWHM 0.62 – 0.65 μeV
- Dynamic range ± 31 μeV
- Q range 0.2 – 1.8 $Å^{-1}$
- Flux after selector 10^{10} s^{-1}
- Flux at sample $1.8 \cdot 10^{6}$ s^{-1}
- Illuminated area 40 x 30 mm^2

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