E4: The 2-Axis Diffractometer at BER II

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Abstract: The double-axis diffractometer E4 is operated by the Helmholtz-Zentrum Berlin. It is suited for magnetic structure determinations and parametric studies on single crystals in a wide range of external conditions. Pyrolytic graphite and germanium focusing monochromators offer two fixed neutron incident wavelengths of about $1.0\times10^6$ ncm$^{-2}s^{-1}$.

1 Introduction

The instrument is primarily suited for magnetic structure determination under various conditions, which includes magnetic fields up to 17 T, temperatures down to 30 mK and hydrostatic pressures up to 10 kbar. The application of uniaxial pressure and use of auxiliary methods (e.g. electrical resistivity, ac susceptibility, pyroelectric current measurements) is also possible. The most common application is to reveal spatial arrangement ordered spin structures to study magnetic and/or crystal structure phase transitions and construction of phase diagrams. Using the polarized neutrons option facilitates the separation of magnetic contributions from nuclear scattering. The measurement of flipping ratios allows registration of very weak magnetic scattering.

The monochromator shielding contains one beam channel at $2\Theta_M = 42.5^\circ$. This position corresponds to the incident wavelength of 0.24 nm for the vertical focusing PG(002) monochromator and 0.122 nm for the double-focusing Ge(311) monochromator. Both monochromators are operated remotely. Saphire and PG filters offer an effective suppression of unwanted epithermal and $\lambda/2$ (for PG monochromator) neutrons. Before the monochromator position a radial collimator is placed.
The secondary flight path is conical and primarily without collimators that can be placed (with flat monochromator) optionally. Motorized slits offer a possibility to reduce the background. The additional option of polarized neutrons uses a super mirror bender and a $\pi$–flipper. The instrument runs under the system CARESS; automatic control of temperature and magnetic field is provided. An Eulerian cradle can optionally be used to access the four dimensional $Q\omega$-space.

The instrument is equipped with a position sensitive 200x200 mm$^2$ detector before which an oscillating collimator is placed. The detector is mounted assymmetrically so that it covers below the scattering plane about 4 degrees and above about 10 degrees. The coverage in $2\theta$ amounts to about 14 degrees.

![Figure 1: View of E4 with an extensive sample environment installed: the vertical cryomagnet and the dilution refrigerator.](image)

2 **Typical applications**

Typical applications include:

- Magnetic structure determination
- Study of magnetic and structural phase transitions
- Determination of magnetic phase diagrams
- Study of critical points as a function of magnetic field and temperature
- Measurement of correlation functions above the ordering temperature
3 Instrument layout

Figure 2: Schematic view of E4.

1. Filter, Primary Shutter
2. Radial Collimator
3. PG or Ge Monochromator
4. Monitor and Secondary Shutter
5. Sample Table
6. Radial Collimator and Slits
7. PSD
8. Beam Stop
4 Technical Data

<table>
<thead>
<tr>
<th>Beam tube</th>
<th>R 2</th>
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</thead>
<tbody>
<tr>
<td>Collimation</td>
<td>automatic change of $\alpha_1 = 40'$ radial, open geometrical divergence: 60’ manual variation of $\alpha_2$ (optional 10’, 20’, 40’), $\alpha_3$ (oscillating radial)</td>
</tr>
<tr>
<td>Monochromator</td>
<td>PG (002) with variable vertical curvature, Ge (113) double focusing</td>
</tr>
<tr>
<td>Take off angle of monochromator</td>
<td>$2\Theta_M = 42.5'$</td>
</tr>
<tr>
<td>Wave length</td>
<td>$\lambda = 0.244$ nm (PG) or 0.122 nm (Ge)</td>
</tr>
</tbody>
</table>
| Flux            | $0.95 \times 10^6$ n/cm$^2$s (PG)  
$0.9 \times 10^6$ n/cm$^2$s (Ge)  
$0.3 \times 10^6$ n/cm$^2$s polarized (PG+bender) |
| Range of scattering angles | $0^\circ \leq 2\Theta \leq 120^\circ$  
(with configurational restrictions related to sample environment) |
| Angle resolution | Depends on setting |
| Sample size     | From 1 mm$^3$ for topic-focused studies |
| Detector        | 2D detector 200x200 mm$^2$ (removable oscillating radial collimator in front), variable distance (700-950 mm) |
| Polarized neutrons | Yes (super mirror bender)  
Please contact the instrument scientist to discuss in advance |
| Instrument options | Polarization analysis (super mirror analysis) |
| Sample environment | • Horizontal magnetic field < 6 T  
• Vertical magnetic field < 17 T  
• Temperature range 0.03 - 600 K  
• Hydrostatic pressure 0 - 10 kbar  
• 4-circle mode |
| Software        | CARESS, BEAN, set of supporting programs to deal with 2D data |

Table 1: Technical parameters of E4.

References


Liu, T. J., Hu, J., Qian, B., Fobes, D., Mao, Z. Q., Bao, W., … Broholm, C. (2010). From (0,Π) magnetic order to superconductivity with (Π,Π) magnetic resonance in Fe$_{1.02}$Te$_{1-x}$Se$_x$. *Nature Materials*, 9(9), 718–720. http://dx.doi.org/10.1038/nmat2800
