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PUMA: Thermal three axes spectrometer

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Abstract: Three axes spectrometers allow the direct measurement of the scattering function S(Q, ω) in single crystals at well defined points of the reciprocal lattice vector Q and frequency ω and thus represent the most general instrument type. PUMA, which is jointly operated by the Institute of Physical Chemistry, Georg-August-Universität Göttingen and the Technische Universität München, is characterised by a very high neutron flux as a result of the efficient use of focussing techniques.

1 Introduction

Three different vertical openings and a horizontal slit with a maximum opening of 40 mm define the virtual source, which is two meters before the monochromator. To reduce the primary beam's contamination by epithermal neutrons, a sapphire filter can be placed in front of the monochromator. PUMA has a remote controlled monochromator changing unit which allows to place one out of four different monochromators inside the drum. All of them are equipped with double focussing devices that allow for optimum focussing conditions over a wide range of incident wavevectors k_i. The horizontal divergency of the beam can be defined using a series of four Soller collimators. The two inside the drum, before and after the monochromator, can be remotely changed, whereas the two in the analyzer housing can be changed manually. An Eulerian cradle can optionally be used to access the four dimensional Q-ω-space.

An innovative option of the spectrometer is the multianalyzer/ detector system. It allows a unique and flexible type of multiplexing. Using this option a scattering angle range of 16° can be measured simultaneously and flexible Q-ω paths can be realised without repositioning the instrument. Mapping

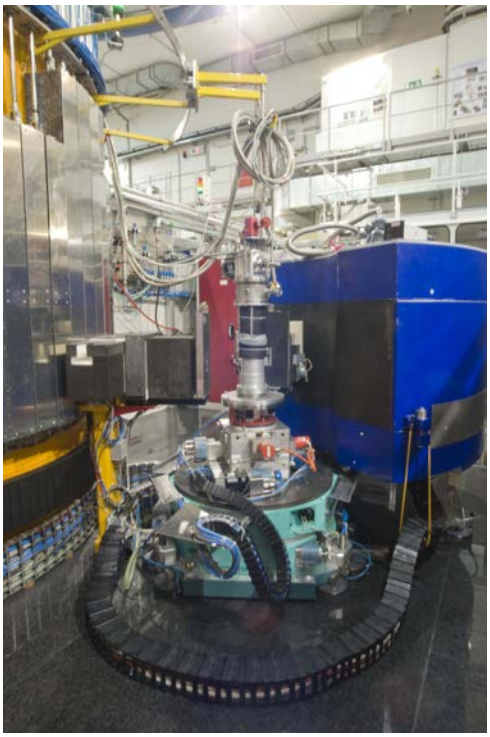

Figure 1: Instrument PUMA (Copyright by W. Schürmann, TUM).

of excitations is equally well possible as kinetic single shot experiments on time scales that have not been accessible so far.

A unique feature of the instrument is the possibility to perform stroboscopic, time resolved measurements of both elastic and inelastic signals on time scales down to the microsecond regime. Using this technique, the sample is periodically perturbed by an external variable such as temperature, electric field, etc. The signal is then recorded not only as a function of momentum and energy transfer, but also given a time stamp, relative to the periodic perturbation.

2 Typical Applications

- Phonons
  - Electron-phonon interaction
  - Phonon anharmocities
  - Soft mode phase transitions
- Magnons
  - Spin waves in (anti)ferromagnets
  - Electron-magnon interaction
  - Unconventional superconductors
  - Crystal fields
- Time resolved/ stroboscopic measurements
  - Temperature cycling (excitations during demixing processes)
  - Electrical field cycling (polarisation processes in ferroelectrics)
  - Temperature/ pressure cycling
- Diffraction; purely elastic signals
  - Superstructures/ satellites
  - Diffuse scattering

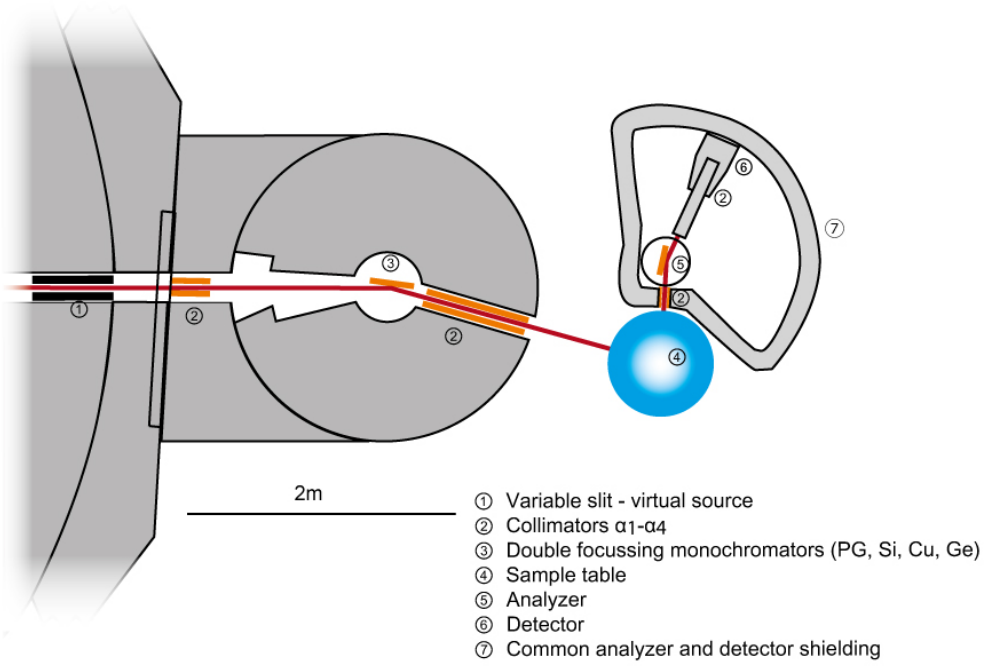

Figure 2: Schematic drawing of PUMA.

3 Sample Environment

Besides standard sample environment, we provide:

- Closed-cycle cryostates 3.5 – 300 K; – 650 K with adaptable heating device
- Cryofurnace 5 K – 750 K
- Paris-Edinburgh type pressure cell p $<$ 10 GPa

Along with the detector electronics required for time resolved measurements, special sample environment for the rapid cycling is available:

- Furnace for fast temperature jumps ($\sim$ 5 K/s cooling rate; $<$ 620 K; ambient atmosphere)
- Switchable HV power supply ($<$ 500 Hz; $+/-$ 10 KV)

4 Technical Data

4.1 Primary beam

- Beam tube SR-7 (thermal)
- Beam tube entrance: 140 x 90 mm^2
- Virtual source dimensions:
  horizontal: 0 – 40 mm
  vertical: (90, 110, 130 mm)

4.2 Distances

- Beam tube entrance – monochromator: 5.5 m
- Virtual source – monochromator: 2.0 m
- Monochromator – sample: 2.0 (± 0.1) m
- Sample – analyzer: 1.0 (± 0.1) m
- Analyzer – detector: 0.9 m

4.3 Collimation

- Remote controlled:
  $\alpha 1$: 20', 40', 60'
  $\alpha 2$: 14', 20', 24', 30', 45', 60'
- Manually changeable:
  $\alpha 3$: 10', 20', 30', 45', 60'
  $\alpha 4$: 10', 30', 45', 60'

4.4 Monochromators

- Crystals: PG(002), Cu(220), Cu(111), Ge(311), size: 260 x 162 mm^2;
- Focus vertically and horizontally adaptable to incident energy

4.5 Analyzer

- Crystals : PG(002), Ge(311); 210 x 150 mm^2
  vertical fixed focus
  horizontally adaptable to incident energy

4.6 Sample table

- Diameter 800 mm
- Max. load 900 kg
- Amagnetic goniometer (± 15°)
- Z translation (± 20 mm)
- Optional Eulerian cradle

4.7 Main parameters

- Monochromator take-off angle:
  $-15° < 2\Theta < -115°$
- Scattering angle sample:
  $-70° < 2\Theta < 120°$ (dependent on monochromator take-off angle)
- Analyzer scattering angle:
  $-120° < 2\Theta < 120°$
- Incident energy range:
  5 meV – 160 meV
- Momentum transfer range:
  < 12 $Å^{-1}$
- Energy transfer:
  < 100 meV