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TOFTOF: Cold neutron time-of-flight spectrometer

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Abstract: TOFTOF, operated by the Technische Universität München, is a direct geometry disc-chopper time-of-flight spectrometer located in the Neutron Guide Hall West. It offers an excellent signal-to-background ratio, high energy resolution and high neutron flux. Adaptable for a wide range of sample environments, TOFTOF is ideal for investigations of fundamental concepts and challenges in physics and materials science.

1 Introduction

TOFTOF is suitable for both inelastic and quasi-elastic neutron scattering and the scientific questions addressed range from the dynamics in disordered materials in hard and soft condensed matter systems (such as polymer melts, glasses, molecular liquids, or liquid metal alloys), properties of new hydrogen storage materials to low-energy magnetic excitations in multiferroic compounds, and molecular magnets.

A cascade of seven fast rotating disc choppers which are housed in four chopper vessels is used to prepare a monochromatic pulsed beam which is focussed onto the sample by a converging supermirror section. The scattered neutrons are detected by 1000 ^{3}He detector tubes with a time resolution up to 50 ns. The detectors are mounted at a distance of 4 m and cover 12 m^2 (or 0.75 sr). The exterior of the detector housing along with the sample chamber outfitted with the CCR Cryostat is shown Figure 1. The high rotation speed of the chopper system (up to 22 000 rpm) together with a high neutron flux in the wavelength range of 1.4 -14 Å allows free tuning of the energy resolution between 3 meV and 2 µeV. A schematic overview of the TOFTOF instrument is depicted in Figure 2.

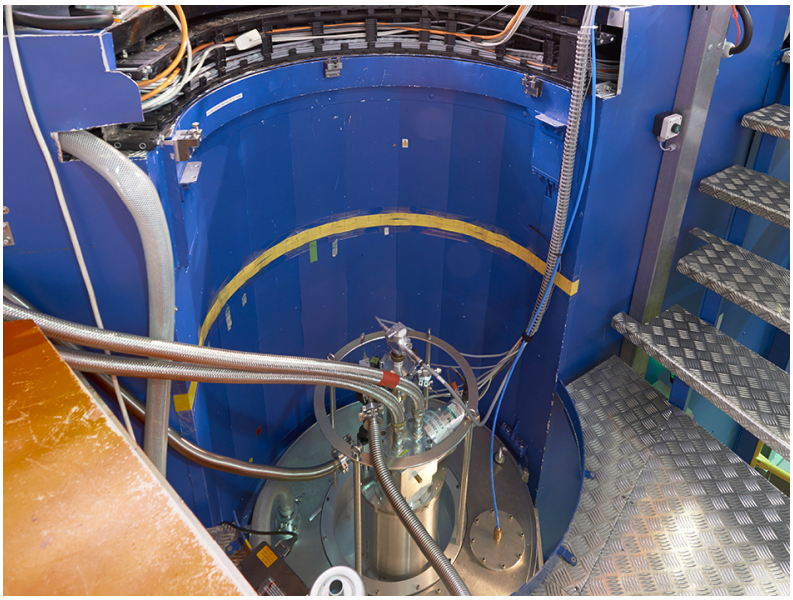

Figure 1: Top view of the CCR Cryostat inserted into the TOFTOF sample chamber. The blue panelling visible is the exterior of the detector housing (Copyright by W. Schürmann, TUM).

The 60 m primary neutron guide has an s-shape which efficiently suppresses fast neutron background. This enables the investigation of weak signals. The prototype of a new focussing neutron guide has been installed recently, as alternative option in the last section of the guide system. The existing linearly tapered neutron guide yields a beam spot size of 23 x 47 mm^2. Using the focussing guide, an intensity gain up to a factor of 3 (wavelength dependent) is observed on a sample area of 10 x 10 mm^2.

2 Typical Applications

TOFTOF represents a versatile instrument combining high energy resolution, high neutron flux (also at short wavelengths), and an excellent signal-to-background ratio. It is perfectly suited for both inelastic and quasielastic neutron scattering and scientific topics include e.g.:

- Diffusion in liquid metals and alloys
- Hydrogen dynamics in soft matter systems such as molecular liquids, polymer melts or colloids
- Molecular magnetism, quantum criticality in heavy fermion compounds, low energy excitations in multiferroic materials and novel magnetic phases
- Dynamic properties of energy storage materials, such as solid state hydrogen storage materials, electrolytes for batteries and fuel cells, or gas storage materials
- Energy-resolved quasi-elastic neutron scattering on proteins, vesicles, and biological materials
- Kinetic studies of hydrogen binding, e.g. in concrete
- Aging effects in disordered media and low frequency dynamics in glasses
- Biological activity and functionality of proteins and cells under pressure

3 Sample Environment

Standard sample environment:

- CCR Cryostat (4 - 600 K)
- ^{3}He insertion device (down to 0.5 K)
- Circulation thermostat furnace (255 – 450 K)
- High temperature furnace (300 – 2100 K)
- 2.5 T magnet

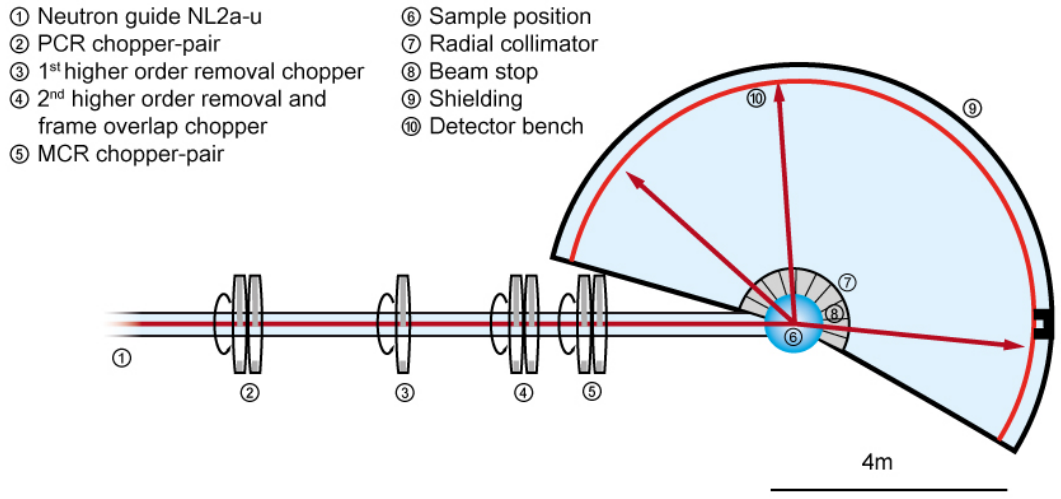

Figure 2: Schematic drawing of TOFTOF.

Sample environment provided by collaborators:

- Electromagnetic levitator
- Electrostatic levitator
- Hydraulic pressure cells (up to 3.5 kbar)
- Clamp pressure cells (few GPa)

4 Technical Data

4.1 Primary beam

- Neutron guide: NL2a-u
- Number of chopper discs: 7
- Chopper frequency range: 400 min^{-1} – 22000 min^{-1}
- Diameter of chopper disc: 600 mm
- Cross section of neutron guide at the entrance: 44 x 100 mm^2
- Cross section of neutron guide, 20 cm in front of sample position: 23 x 47 mm^2
- Cross section of focussing guide: minimal 12 x 25 mm^2

4.2 Main Parameters

- Adjustable range of incident neutrons: 1.4 – 16 Å
- Elastic energy resolution: 2 µeV – 3 meV
- Range of energy transfers: -30 meV – 50 meV
- Integral neutron flux of the white beam at sample position: 10^{10} n cm^{-2} s^{-1}
- Angular range of the detector bank: -15° to -7° and 7° to 140°