TT 60: Cryogenic Detectors and Sensors, Refrigeration and Thermometry

Time: Wednesday 16:00–17:45 Location: H 3025

TT 60.1 Wed 16:00 H 3025

MOCCA: a 4k-pixel molecule camera for the position and energy resolved detection of neutral molecule fragments — •Abdullah Özkara[1], Christian Enss[1], Andreas Fleischmann[1], Lisa Gamer[2], Loredana Gastaldo[1], Daniel Hengstler[1], Christopher Jakob[2], Daniel Kreuzberger[1], Ansgar Lowack[1], Oldřich Novotny[2], Andreas Reifenberger[1], Dennis Schulz[1], and Andreas Wolf[2] — [1]Heidelberg University — [2]Max Planck Institute for Nuclear Physics, Heidelberg

The MOCCA detector is a 4k-pixel high-resolution molecule camera based on metallic magnetic calorimeters and read out with SQUIDs that is able to detect neutral molecule fragments with keV kinetic energies. It will be deployed at the Cryogenic Storage Ring CSR at the Max Planck Institute for Nuclear Physics in Heidelberg, a storage ring built to prepare and store molecular ions in their rotational and vibrational ground states, enabling studies on electron-ion interactions. To reconstruct the reaction kinematics, MOCCA measures the energy and position of the molecule fragments incidenting on the detector, even with multiple particles hitting the detector simultaneously.
We present an improved read-out scheme which uses a logarithmic decay time spacing. This makes it possible to use only 32 SQUID channels for the read-out of 4094 pixels of the detector. In addition, we compare the simulations of this read-out scheme to previous measurements.

TT 60.2 Wed 16:15 H 3025

MMC Array to Study X-ray Transitions in Muonic Atoms — •Daniel Hengstler, Andreas Abeln, Eric Biedert, Thomas Elias Cocolios, Ofir Eizenberg, Christian Enss, Andreas Fleischmann, Loredana Gastaldo, Cesar Godinho, Michael Heines, Paul Indelicato, Daniel Kreuzberger, Klaus Kirch, Andreas Knecht, Jorge Machado, Ben Ohayon, Nancy Paul, Randolf Pohl, Katharina von Schoeler, Daniel Unger, Stergiani Marina Vogiatzi, and Frederik Wauters — for the QUARTET Collaboration

The QUARTET collaboration aims to improve the accuracy of absolute nuclear charge radii of light nuclei from Li to Ne. A proof-of-principle measurement with lithium, beryllium and boron has recently been performed at the Paul Scherrer Institute. Conventional solid-state detectors do not provide sufficient accuracy in the relevant energy range. We use a low temperature Metallic Magnetic Calorimeter (MMC) array for high-precision X-ray spectroscopy of low-lying states in muonic atoms. MMCs are characterized by a high resolving power of several thousand and a high quantum efficiency in the energy range of interest. We present the experimental setup and the performance of the detector used. We discuss the first preliminary spectra and systematic effects in this first measurement. The obtained data in combination with the achieved energy resolution and calibration should allow a more precise characterization of the muonic X-ray lines. With the knowledge gained, a significant improvement in the determination of nuclear charge radii is expected.

TT 60.3 Wed 16:30 H 3025

Optimizing microwave SQUID multiplexers for magnetic microcalorimeter readout — •Martin Neidig[1], Constantin Schuster[1], Lena Hauswald[1], Mathias Wegner[2,1], Stefan Wünsch[1], and Sebastian Kempf[1,2] — [1]Institute of Micro- and Nanoelectronic Systems, Karlsruhe Institute of Technology, Germany — [2]Institute for Data Processing and Electronics, Karlsruhe Institute of Technology, Germany

Magnetic microcalorimeters (MMCs) are cryogenic particle detectors which have achieved a high level of maturity. Thanks to reliable microfabrication processes, large-scale MMC arrays consisting of hundreds or even thousands of detectors are meanwhile feasible, presenting the challenge of developing a suitable multiplexing technique. In this respect, microwave SQUID multiplexing is the current state of the art. Here, the individual detector signals can be frequency-encoded by inductively coupling each detector to a non-hysteretic rf-SQUID which in turn is inductively coupled to microwave resonator with unique resonance frequency. This enables the simultaneous readout of hundreds of detectors using a single transmission line, typically utilizing a bandwidth of 4 to 8 GHz. In this contribution. we discuss the advantages of operating microwave SQUID multiplexers at frequencies above 8 GHz, showcasing increased multiplexing factor, improved readout sensitivity and reduced device dimensions. Additionally, we present first measurements aiming to prove the feasibility of such devices. Finally, we address challenges associated with connecting a microwave SQUID multiplexer to an actual detector chip.

TT 60.4 Wed 16:45 H 3025

PrimA-LTD: Advanced magnetic microcalorimeters for radionuclide metrology — •Michael Müller[1], Alexander Göggelmann[2], and Sebastian Kempf[1,3] — [1]Institute of Micro- and Nanoelectronic Systems (IMS), Karlsruhe Institute of Technology — [2]Physikalisch-Technische Bundesanstalt (PTB) Braunschweig — [3]Institute for Data Processing and Electronics (IPE), Karlsruhe Institute of Technology

High uncertainties of available radioactive decay data are more and more a limitation for many applications in science, medicine and industry. Therefore, the EMPIR project “PrimA-LTD” aims to demonstrate advanced decay energy spectroscopy using magnetic microcalorimeters (MMCs), that, in contrast to conventional techniques, provide very low energy threshold and nearly 100 % detection efficiency. In MMCs, the temperature-dependent magnetization of paramagnetic temperature sensor is used to sense the temperature rise resulting from particle absorption in a thermally coupled absorber with utmost precision. We developed two detector types, one being a high energy resolution spectrometer for improving fundamental decay data of ^{55}Fe that is ion-implanted into microfabricated particle absorbers. The other type demonstrates high flexibility in metrological activity measurements by introducing a reusable MMC setup that allows using wire-bonded external absorber/source composites. To estimate their performance, we introduced a simulation framework based on a state space model, applicable to arbitrary detector configurations and benchmarked this model with measured data acquired within the project.

TT 60.5 Wed 17:00 H 3025

Tilting of a small scale 4 K pulse tube cryocooler driven by a low input power oil-free Helium compressor — •Jack-Andre Schmidt[1,2], Bernd Schmidt[1,2], Jens Falter[2], Jens Höhne[3], Sebastian Schaile[4], and André Schirmeisen[1,2] — [1]Justus-Liebig-Universität Giessen, Giessen, Germany — [2]TransMIT GmbH, Giessen, Germany — [3]Pressure Wave Systems GmbH — [4]attocube systems AG

Among the family of regenerative cryocoolers, GM-type pulse tubes (PTC) in particular stand out because they have no moving mechanical parts at cryogenic temperatures. The working principle of PTCs relies on the cyclic pressure waves of Helium gas at relatively high pressure differences around 1 MPa. These pressure levels are commonly provided by dedicated Helium gas compressors, which represent the main unit of energy consumption in the cryo system with input powers ranging from 1 kW to above 10 kW. Here we present a combination of the smallest so far reported 4 K PTC Susy driven by an oil-free low power compressor technology IGLU achieving cooling powers necessary for typical optical quantum components below 4.2 K. The IGLU compressor is based on a mechanism with hydraulically driven metal bellows, providing minimum maintenance and maximum mobility. This combination reaches the physical minimum temperature of 2.2 K at no load, and a cooling capacity of 240 mW at 4.2K, with the compressor operating at maximum speed at 1.3 kW input power. Additionally we present the results of tilted operation of the whole setup.

TT 60.6 Wed 17:15 H 3025

Experimental investigations and numerical simulations of the pressure drop in different regenerator fillings of a single stage GM-type pulse tube cooler — •Elias Eisenschmidt[1,3], Jack-Andre Schmidt[2,3], Bernd Schmidt[2,3], Jens Falter[3], and Andre Schirmeisen[2,3] — [1]Technische Hochschule Mittelhessen, Giessen, Germany — [2]Justus-Liebig-University, Giessen, Germany — [3]TransMIT-Center for Adaptive Cryotechnology and Sensors, Giessen, Germany

In this talk, numerical flow simulations and measurements of a single stage pulse tube cryocooler (PTS 8030, TransMIT GmbH) will be discussed. The goal of the investigation is to get a closer look at the pressure drop of different regenerator fillings. The numerical simulations in particular allow a deeper understanding of the flow pattern inside the different regenerator-fillings. [1, 2]

The results of the experiments can for example be used to build a holistic numerical simulation. Similar simulations were already performed, but in most papers, pressure and mass flow were assumed to be sinusoidal. With the conducted pressure measurements, it is possible to perform simulations using the experimental pressure wave as the inlet condition.

[1] L.M.Qiu, Y.L.He, Z.H.Gan, X.B.Zhang, G.B.Chen, Cryogenics 47 (2007) 49

[2] P. P. Steijaert, Thermodynamical aspects of pulse-tube refrigerators, Technische Universiteit Eindhoven, 1999

TT 60.7 Wed 17:30 H 3025

Development of a miniaturized, modular, nuclear demagnetization stage — •Leo Maximov[1], Nico Huber[1], Andreas Bauer[1], Yusuke Nago[2], Keiya Shirahama[2], and Christian Pfleiderer[1] — [1]Physik-Department, Technical University of Munich, D-85748 Garching, Germany — [2]Keiyo University, Hiyoshi 3-14-1, Kohoku-ku, Yokohama, Japan

Experimental studies of condensed matter systems at sub-milli Kelvin temperatures are effectively only possible by virtue of nuclear adiabatic demagnetization refrigeration (NADR). While copper is the most commonly used refrigerant for NADR, both the development and operation of copper based NADR-stages are technically demanding and limited due to the very low starting temperatures needed for demagnetization. To overcome these limitations, hyperfine-enhanced refrigerants may be used. Here, we present the design and implementation of a compact, miniaturized, modular nuclear demagnetization stage for optional use with a conventional dilution refrigerator. Comprising a superconducting aluminum heat switch, a demagnetization stage using $PrNi_5$ with a bespoke superconducting coil, and a CMN thermometer, the setup is conceived for exploratory studies in the milli-Kelvin regime and below. Moreover, we report the successful crystal growth of polycrystalline $PrNi_5$ as well as a comprehensive study of its low-temperature properties, particularly with regard to the potential use as a cooling medium.