TT 24 Superconductivity: Cryodetectors

Time: Wednesday 16:30–19:00 Room: HSZ 02

Invited Talk

TT 24.1 Wed 16:30 HSZ 02

Cryogenic detectors — •Gabriel Chardin — DAPNIA/SPP, CEA/Saclay, F-91191 Gif-sur-Yvette, France

Over the last 15 years, cryogenic detectors have developed rapidly, resulting in devices with unprecedented energy resolutions and identification properties of the experimental background. I will present some of the major developments involving massive detectors (dark matter and double beta decay searches) and microcalorimeters (neutrino mass, X-ray spectroscopy). I will also briefly review some of the developments involving cryogenic detector matrices for X-ray, infrared and CMB missions.

TT 24.2 Wed 17:00 HSZ 02

Detector Development for Calibration Measurements in CRESST — •Wolfgang Westphal, Chiara Coppi, Franz von Feilitzsch, Christian Isaila, Jean-Côme Lanfranchi, Sebastian Pfister, Walter Potzel, Wolfgang Rau, Michael Stark, and Doreen Wernicke — Physik Department E15, Technische Universität München, James-Franck-Straße, D-85748 Garching

In the CRESST experiment the simultaneous measurement of the heat signal and the scintillation light from events in $CaWO_4$ is used to discriminate the background electron recoil events from nuclear recoil events. The detectors consist of $CaWO_4$ crystals equipped with transition edge sensors (TES) for the measurement of the heat signal and a light detector made of silicon, also equipped with a TES. The two detector parts are mounted together in a reflective housing for improved light collection. A potentially harmful background in CRESST are recoiling nuclei from surface alpha decays. At the TU München we are performing calibration measurements to characterize that background. For this purpose we are developing modified detectors capable of measuring the expected higher count rates in these experiments.

TT 24.3 Wed 17:15 HSZ 02

Reproduzierbare Herstellung supraleitender W-Dünnschichten als Detektorkomponenten für das CRESST Experiment — •Sebastian Pfister[1], Godehard Angloher[2], Chiara Coppi[1], Franz von Feilitzsch[1], Dieter Hauff[2], Christian Isaila[1], Jean-Côme Lanfranchi[1], Emilja Pantic[2], Federica Petricca[2], Walter Potzel[1], Franz Pröbst[2], Wolfgang Seidel[2], Michael Stark[1], and Wolfgang Westphal[1] — [1]Physik Department E15, Technische Universität München, James-Franck-Strasse, D-85748 Garching — [2]Max-Planck-Institut für Physik, Föhringer Ring 6, D-80805 München

Die notwendige Sensitivitätssteigerung von Experimenten zur direkten Suche nach Dunkler Materie erfordert u.a. eine Vergrösserung der Detektormasse. Da die Detektormodule nicht beliebig in der Grösse skaliert werden können muss zwangsläufig ihre Anzahl erhöht werden. Für den Ausbau des CRESST-Experimentes ist somit die reproduzierbare Herstellung supraleitender W-Dünnschichten, die als supraleitendes Phasenübergangsthermometer verwendet werden, von grosser Bedeutung. Untersuchungen zur Reproduzierbarkeit von W-Dünnschichten auf $CaWO_4$-Kristallen (Phonondetektor) und Silizium-beschichteten Al_2O_3-Substraten (Szintillationslichtdetektor) werden durchgeführt.

TT 24.4 Wed 17:30 HSZ 02

Cryogenic light detectors with Neganov-Luke amplification — •Christian Isaila[1], Oliver Boslau[2], Chiara Coppi[1], Franz von Feilitzsch[1], Peter Goldstrass[2], Josef Kemmer[2], Jean-Come Lanfranchi[1], Andreas Pahlke[2], Sebastian Pfister[1], Walter Potzel[1], Wolfgang Rau[1], Michael Stark[1], Doreen Wernicke[3], Wolfgang Westphal[1], and Florian Wiest[2] — [1]Technische Universität München, Physik Department E15, James-Franck Str., 85748 Garching — [2]Ketek GmbH, Gustav Heinemann Ring 125, 81739 München — [3]VeriCold Technologies GmbH, Bahnhofstr. 21, 85737 Ismaning

CRESST (Cryogenic Rare Event Search with Superconducting Thermometers) searches for nuclear recoils induced by particle dark matter. For an active suppression of the background due to electron recoils both phonons and scintillation light generated in a CaWO4 crystal are detected simultaneously. While the phonon signal is read out by a transition edge sensor (TES) on the CaWO4 crystal, the scintillation light is measured by a cryogenic light detector consisting of a silicon absorber equipped with a TES. As only a small fraction (about 1%) of the energy of the incident particles is transferred into light, very sensitive light detectors are needed. The threshold of the light detectors can be improved by applying an electric field to the silicon crystal leading to an amplification of the thermal signal due to the Neganov-Luke effect. Measurements with an applied Neganov-Luke voltage will be presented.

TT 24.5 Wed 17:45 HSZ 02

Metallic Magnetic Calorimeters (MMC) for high-resolution spectroscopy of x-ray quanta and energetic particles — •Andreas Burck, Markus Linck, Hannes Rotzinger, Tim Scarbrough, Andreas Fleischmann, and Christian Enss — Kirchhoff-Institut für Physik, Heidelberg, Germany

Metallic magnetic calorimeters (MMC) are non-dispersive low temperature particle detectors. They combine the high spectral resolution of dispersive spectrometer and the high efficiency of solid state spectrometer. Their calorimetric detection principle allows for a variety of absorber materials and detector geometries. Metallic magnetic calorimeters consist of an absorber and a metallic paramagnetic temperature sensor which is situated in a weak magnetic field. The deposition of energy in the absorber causes a rise in temperature and results in a change of magnetization of the paramagnetic sensor which is measured by using a low-noise high-bandwidth dc-SQUID. We present the state of development of the current prototype detectors. The observed noise contributions and the energy resolution in MMC's will be discussed. Furthermore the results achieved with prototype detectors for some applications such as high resolution spectroscopy and absolute activity measurements of low-energy emitting radionuclides in metrology will be shown.

TT 24.6 Wed 18:00 HSZ 02

3D-scanning microscopy for microwave frequencies with Josephson cantilevers — •Andre Kaestner, Felix Stewing, and Meinhard Schilling — Institut für Elektrische Messtechnik und Grundlagen der Elektrotechnik, TU Braunschweig, Hans-Sommer-Straße 66, 38106 Braunschweig

In recent semiconductor communication technology frequencies between a few GHz up to 100 GHz are employed. In the future much higher frequencies up to the THz regime are in reach. Therefore we develop a new method for measuring the near-field radiation of a microwave source with small dimensions. We use a scanning microscope equipped with a Josephson junction on a cantilever to measure a near-field power distribution in three dimensions around a microwave chip.

To detect the microwave radiation we use Josephson junctions sensitive to frequencies between several GHz to a few THz. The Josephson junctions are made of the high-temperature superconductor $YBa_2Cu_3O_7$ on $LaAlO_3$ bicrystal substrates. The 3D-positioning stage of the scanning microscope system allows us to measure the power distribution in a volume of 15x15x15 mm^3 with a spatial resolution of 100 nm. For demonstration first results for the power distribution of a 98 GHz source are presented.

TT 24.7 Wed 18:15 HSZ 02

Development of an array of calorimetric low temperature detectors for heavy ion physics — •S. Ilieva[1,2], A. Bleile[1,2], P. Egelhof[1,2], A. Kiseleva[1], O. Kiselev[1], S. Kraft-Bermuth[1,2], and J. P. Meier[1,2] — [1]Gesellschaft für Schwerionenforschung, Darmstadt, Germany — [2]Institut für Physik, Johannes Gutenberg Universität, Mainz, Germany

Calorimetric low temperature detectors (CLTDs) for heavy ion detection have been frequently demonstrated to achieve an excellent relative energy resolution of $\Delta E/E$ = 1–5 x 10^{-3} in a wide range of ions and energies (E = 0.1–360 MeV/u). The application of a CLTD in accelerator mass spectrometry achieved an improvement in sensitivity by one order of magnitude. In superheavy element research, CLTDs as high-resolution energy detectors combined with time-of-flight detectors may potentially be used for identification of superheavy nuclei with $Z \geq 113$. The CLTDs developed up to now have an active area of approximately 2x3 mm^2, not sufficient to fully exploit their potential. To increase the active area, an array of CLTDs for heavy ion research is currently subject of design and investigation of performance. The array is designed

to provide an active area of 30 x 80 mm^2, consisting of about 100 pixels. For this purpose, a special windowless ^{4}He bath cryostat with large cooling power has been constructed and adapted to the needs of heavy ion research. As a first step, a 2 x 2 pixel prototype array with four individually temperature-regulated pixels and a total area of 6 x 6 mm^2 is realized and its performance under heavy ion irradiation is investigated. First results of these investigations and perspectives will be discussed.

TT 24.8 Wed 18:30 HSZ 02

First test experiment for precise Lamb shift measurements on hydrogen-like heavy ions with low temperature calorimeters — •V. Andrianov[1], K. Beckert[1], P. Beller[1], A. Bleile[1], P. Egelhof[1], A. Gumberidze[1], C. Kilbourne[2], H. J. Kluge[1], S. Kraft-Bermuth[1], D. McCammon[3], J. P. Meier[1], U. Popp[1], R. Reuschl[1], T. Stöhlker[1], and S. Trotsenko[1] — [1]Gesellschaft für Schwerionenforschung, Darmstadt, Germany — [2]Goddard Space Flight Center, Greenbelt, USA — [3]Univ. of Wisconsin, Madison, USA

The precise determination of the Lamb shift in hydrogen-like heavy ions provides a sensitive test of quantum electrodynamics in very strong Coulomb fields, not accessible otherwise. To increase the accuracy of the Lamb shift measurement on stored $^{238}U^{91+}$ ions at the ESR storage ring at GSI, a high-resolution calorimetric low temperature detector for hard X-rays was developed. The experimental requirements for the detector are a high absorption efficiency and a relative energy resolution of about 10^{-3} for 50–100 keV X-rays. The detector consists of arrays of silicon thermistors and X-ray absorbers made of high-Z material. A test array consisting of 4 pixels was recently applied in a first test experiment for Lamb shift measurement at the ESR. A 89 MeV/u $^{238}U^{92+}$ beam stored in the ESR interacted with a 10^{11} cm^{-3} internal argon gas-jet target. The Lyman-α lines emitted from the charge-exchanged $^{238}U^{91+}$ ions were clearly identified. An energy resolution of $\Delta E = 149$ eV was obtained at $E_\gamma = 70$ keV and a total detection efficiency of 1 x 10^{-7} was reached. The results of this test experiment as well as future perspectives will be discussed.

TT 24.9 Wed 18:45 HSZ 02

Energy loss in down-conversion process in thin superconducting films — •Alexander Kozorezov — Department of Physics, Lancaster University, Lancaster, UK

We have developed theory of photoelectron energy down-conversion in thin superconducting films. Presence of interfaces at a distance which may be comparable to mean free paths for pair-breaking phonons is an important factor allowing pair breaking phonons to escape from the film. Both mean number of quasiparticles generated in the down-conversion process and their fluctuations depend on details of down-conversion process in the vicinity of interface. Theory predicts important contributions to both statistical fluctuations of generated quasiparticles through phonon escape noise and inhomogeneous broadening effects originating from the initial spatial distribution of photoelectrons. We discuss extra limitations to resolving power of single photon detectors based on superconducting tunnel junctions and TES microcalorimeters. Good agreement between theory and experiment for Ta/Al/AlO_x/Al/Ta superconducting tunnel junctions is demonstrated. Implications for optimum design of single photon spectroscopic arrays are discussed.