T 8: Neutrinophysik V

Zeit: Montag 16:00–18:25 Raum: Z6 - HS 0.001

Gruppenbericht T 8.1 Mo 16:00 Z6 - HS 0.001

The Electron Capture in ^{163}Ho experiment — •Clemens Hassel for the ECHo-Collaboration — Kirchhoff-Institute of Physics, Heidelberg University, Germany.

Direct determination of the electron neutrino (m_{ν_e}) and anti-neutrino mass ($m_{\bar{\nu}_e}$) can be obtained by the analysis of electron capture and beta spectra respectively. In the last years experiments analysing the ^{3}H beta spectrum reached a limit on $m_{\bar{\nu}_e}$ of 2 eV. The upper limit on m_{ν_e} is still two orders of magnitudes higher at about 225 eV. The Electron Capture in ^{163}Ho experiment, ECHo, is designed to investigate m_{ν_e} in the sub-eV region and reach the same sensitivity as foreseen for $m_{\bar{\nu}_e}$ in new ^{3}H-based experiments. In ECHo, high sensitivity on a finite m_{ν_e} will be reached by the analysis of the endpoint region in high statistics and high resolution calorimetrically measured ^{163}Ho spectra. To perform this experiment, high purity ^{163}Ho source will be enclosed in a large number of low temperature metallic magnetic micro-calorimeters which are readout using the microwave multiplexing technique. This approach allows for a very good energy resolution of below $\Delta E_{\mathrm{FWHM}} < 5$ eV and for a fast time resolution well below 1 μs. Thanks to the modular approach, the ECHo experiment is designed to be stepwise up-graded. The first on-going phase, ECHo-1k, is characterized by a ^{163}Ho activity of about 1 kBq enclosed in about 100 pixels. The statistics of 10^{10} events in the ^{163}Ho spectrum will allow to improve the limit on m_{ν_e} by more than one order of magnitude. In this talk, the present status of the ECHo-1k experiment will be discussed as well as the plans for the next phase, ECHo-100k.

T 8.2 Mo 16:20 Z6 - HS 0.001

Optimization of metallic magnetic calorimeter arrays with embedded ^{163}Ho for the ECHo experiment — •Federica Mantegazzini for the ECHo-Collaboration — Kirchhoff-Institute for Physics, Heidelberg University, Germany

The ECHo experiment aims to determine the electron neutrino mass via the analysis of the calorimetrically measured electron capture spectrum of ^{163}Ho. The detector technology is based on metallic magnetic calorimeters (MMC) and the implantation of ^{163}Ho has been selected as method to enclose the source in the detectors, showing already good performances for activity values up to 1 Bq. Since the sensitivity of the ECHo experiment strongly depends on the total acquired statistics, the activity per pixel needs to be increased, taking into account two constraints: the resulting unresolved pile-up events fraction and the supplementary heat capacity due to the implanted ions. We have developed a novel experimental technique for the determination of the specific heat per ^{163}Ho ion, based on the simultaneous measurement of two MMC pixels with identical geometry which differ only because of the ^{163}Ho ions implanted in one of the two. At an operational temperature of 20 mK for an activity of about 1 Bq, the heat capacity increases of less than 3%. Therefore, a total activity of the order of 10 Bq per pixel - as required in order to keep the unresolved pile-up fraction under control - can be implanted without strongly affecting the detector performance. In this contribution, the development and the characterisation of the new microfabricated detector arrays is presented.

T 8.3 Mo 16:35 Z6 - HS 0.001

Production, Separation and Implantation of ^{163}Ho for Neutrino Mass Measurements — •Klaus Wendt[1], Holger Dorrer[1], Christoph Düllmann[1,2], Klaus Eberhardt[1], Lisa Gamer[3], Christian Enss[3], Loredana Gastaldo[3], Clemens Hassel[3], Ulli Köster[4], Christoph Mokry[1], Jörg Runke[1,2], and Andreas Türler[5,6] — [1]JGU, Mainz, Germany — [2]GSI, Darmstadt, Germany — [3]Heidelberg University, Heidelberg, Germany — [4]ILL, Grenoble, France — [5]PSI, Villigen, Bern, Switzerland — [6]University of Bern, Bern, Switzerland

The ECHo collaboration aims at measuring the electron neutrino mass by recording the spectrum following electron capture of ^{163}Ho. For this purpose dedicated metallic magnetic calorimeters (MMCs) are used. The radioisotope ^{163}Ho is produced from enriched ^{162}Er in the ILL high flux nuclear reactor, separated and purified by chemical and laser mass spectrometric means for final embedding within the 180x180 μm^2 Au-absorber of the ECHo MMCs. Multi-step resonance ionization at the RISIKO mass separator ensures full elemental and isotopic selectivity for ultra-pure ^{163}Ho ion implantation with a well-controlled sub millimeter beam spot size. Performance of the laser ion source and the implantation process was improved to minimize sample losses. On-line in-situ deposition of Au by pulsed laser deposition (PLD) ensures homogeneous ^{163}Ho/Au layer formation during the implantation process. The quality of the ECHo source material is verified from production up to implantation and data taking using different analytical techniques, which include γ-ray spectrometry, NAA, ICP-MS and RIMS.

T 8.4 Mo 16:50 Z6 - HS 0.001

The ^{163}Ho electron capture spectrum — •Loredana Gastaldo for the ECHo-Collaboration — Kirchhoff-Institut fuer Physik, Universitaet Heidelberg

The analysis of high statistics and high resolution calorimetrically measured ^{163}Ho electron capture spectra, obtained within the ECHo experiment, clearly indicated that a theory based on first order excited states could not describe the data at the few percent level. Several theoretical models have been developed by different groups in order to improve the agreement with the experimental results.In this talk, we discuss the proposed theories and compare them to the available data.

In experiments as ECHo, designed to investigate the electron neutrino mass in the sub-eV region by the analysis of the ^{163}Ho electron capture spectrum, the precise knowledge of the processes involved in the decay, and therefore, in turn, of the spectral shape, is extremely important for the reduction of systematic uncertainties. We present new experimental approaches addressed to gain more information on the electron capture process in ^{163}Ho as well as in other nuclides undergoing electron capture, characterized by a low energy available for the process, Q_{EC}. Our aim is to provide high resolution and high statistics electron capture spectra to theorists to test new models.

Gruppenbericht T 8.5 Mo 17:05 Z6 - HS 0.001

TRISTAN: the search for keV-scale sterile neutrinos in the tritium beta decay with KATRIN — •Konrad Altenmüller for the KATRIN-Collaboration — Technische Universität München

The TRISTAN project is an extension of the KATRIN experiment to search for the signature of keV-scale sterile neutrinos in the tritium beta decay spectrum. To investigate the effective neutrino mass KATRIN does an integral measurement of the tritium spectrum close to the end point of 18.6 keV. For this purpose an electromagnetic filter is used that allows only electrons above a certain energy threshold, i.e. a tiny fraction of all electrons emerged from the tritium, to reach the detector, where they are counted. This talk will give an overview on TRISTAN, which will measure the entire tritium spectrum and is thus confronted with much higher count rates than KATRIN. For a first measurement in 2018 – TRISTAN phase-0 – the tritium spectrum will be scanned down to low electron energies without any hardware change, but with a lowered source strength to not exceed the detector's rate constraints. For TRISTAN phase-1 the KATRIN setup will be modified after the neutrino mass measurements are finished to conduct a differential and integral measurement of the entire tritium spectrum. The current detector will be replaced by a novel 4000-pixel silicon drift detector system that has an outstanding energy resolution of a few hundred eV and can handle rates up to 10^9 counts per second as they occur when the filter is turned off. Prototype detectors were successfully tested and first tritium data was taken at the Troitsk ν-mass spectrometer to study systematics and develop analysis methods.

T 8.6 Mo 17:25 Z6 - HS 0.001

Search for keV-scale sterile Neutrinos with the first Light of KATRIN — •Anton Huber[1], Guido Drexlin[1], Susanne Mertens[2,4], and Thierry Lasserrre[3] for the KATRIN-Collaboration — [1]Karlsruhe Institut für Technology (KIT), ETP, Postfach 3640, 76021 Karlsruhe — [2]Max-Planck-Institut für Physik, München — [3]Technische Universität München — [4]Centre CEA de Saclay, Paris

Sterile neutrinos in the keV-mass regime are a viable dark matter candidate. A sterile neutrino with a mass up to 18.6 keV would be visible in the beta-decay spectrum of tritium as a minuscule kink-like signature and distortion. The KATRIN experiment is designed to determine the absolute neutrinos mass by measuring the beta-decay spectrum of gaseous tritium close to its endpoint. Beyond that, it's unprecedented tritium source luminosity and spectroscopic quality could be used to measure the entire beta-spectrum to search for a kink-like signature of a sterile neutrino. The idea discussed in this talk is a so-called Phase-0 measurement, where the first light data of KATRIN would be used to scan the entire tritium beta-decay spectrum to search for sterile neutrinos. A measurement of only one week with KATRIN has the potential to improve the current laboratory limits for keV-scale sterile neutrinos. This work presents the expected sensitivity, important systematic effects and the experimental realization of this experiment. This work was supported by GRK1694, BMBF (05A17VK2), KSETA, the HGF and the Friedrich-Ebert-Stiftung.

T 8.7 Mo 17:40 Z6 - HS 0.001

TRISTAN measurements at Troitsk nu-mass experiment — •Tim Brunst for the KATRIN-Collaboration — Max-Planck-Institut für Physik, München

The KATRIN (Karlsruhe Tritium Neutrino) experiment investigates the energetic endpoint of the tritium beta-decay spectrum to determine the effective mass of the electron anti-neutrino with a sensitivity of 200 meV (90% C.L.) after an effective data taking time of three years.

The TRISTAN (tritium beta-decay to search for sterile neutrinos) project aims at detecting a keV-scale sterile neutrino signature by measuring the entire tritium beta-decay spectrum with an upgraded KATRIN system. One of the greatest challenges is to handle the high signal rates generated by the strong activity of the KATRIN tritium source. Therefore, a novel multi-pixel silicon drift detector is being designed which is able to handle rates up to 100 Mcps with an excellent energy resolution of 200 eV (FWHM) at 10 keV.

First seven-pixel prototype detectors were successfully installed and operated at the Troitsk nu-mass experiment, one of KATRIN's technological predecessors. This talk presents the results of these measurement campaigns.

T 8.8 Mo 17:55 Z6 - HS 0.001

Modifications of the KATRIN Simulation Software for Sterile Neutrino Search — •Madlen Steven for the KATRIN-Collaboration — Max Planck Institute for Physics — Technical University of Munich

The Karlsruhe Tritium Neutrino (KATRIN) experiment is designed to improve the ν-mass sensitivity to about 0.2 eV/c^2 (90% C.L.) by measuring the shape of the endpoint of the tritium β-decay spectrum. By extending the measurement interval to the whole spectrum it will also be possible to search for so called sterile neutrinos. This hypothetical fourth neutrino flavour eigenstate does not interact via the weak, strong and electromagnetic force. A corresponding mass eigenstate of order keV could be observed as a kink in the β-decay spectrum.

As the current modelling software and in particular the Source and Spectrum Computation (SSC) package of the KATRIN experiment considers only the endpoint of the tritium spectrum, it has to be extended for the sterile neutrino search.

This talk will present the basic idea of this new simulation software and in particular focus on detector-related effects. First results for the detector response to monoenergetic electrons obtained by using the KATRIN simulation software Kassiopeia will be shown.

T 8.9 Mo 18:10 Z6 - HS 0.001

Precise modeling of KATRIN beta spectrum of tritium for keV sterile neutrino search — •Federico Roccati for the KATRIN-Collaboration — Max-Planck-Institute for Physics, Munich, Germany

The KATRIN experiment major task is to probe the effective electron anti-neutrino mass with a sensitivity of 200 meV at 90% confidence level. The KATRIN setup, along with an upgraded detector and readout system, is suitable for keV-scale sterile neutrino search. The signature of a sterile neutrino in the tritium beta decay spectrum is a minuscule kink-like distortion. To enable a sensitive search for this characteristic feature, an ultra-precise modeling of the entire tritium beta spectrum is necessary. For this reason, a novel semi-analytical, multi-dimensional convolution technique has been developed. It tracks both the energy and angular distribution of the electrons as they leave the windowless gaseous tritium source of KATRIN.

In this talk the basic idea and first results obtained with this new technique will be presented. Furthermore, we will present the concept of how to integrate the results in a more general simulation framework for a keV-scale sterile neutrino search with KATRIN.