HK 28: Astroparticle Physics I

Time: Wednesday 14:00–15:45 Location: J-HS B

Group Report HK 28.1 Wed 14:00 J-HS B

Searching for neutrinoless double-beta decay with GERDA: results and status — •Ann-Kathrin Schütz for the GERDA-Collaboration — Eberhard Karls Univerität Tübingen

The GERmanium Detector Array (Gerda) experiment aims for the discovery of neutrinoless double beta decay ($0\nu\beta\beta$) decay in ^{76}Ge. It uses HPGe detectors enriched in the isotope ^{76}Ge, which are directly immersed into liquid argon (LAr). In Phase II, the radio-pure cryogenic liquid acts not only as cooling medium for the detectors and passive shielding but also as active shielding. The second phase (Phase II) of Gerda started data taking in Dec 2015 with the design goal of increasing the sensitivity to $T^{0\nu}_{1/2} = O\left(10^{26}\right)$ yr by reducing the background by one order of magnitude. Due to the active veto system detecting LAr scintillation light, the superior energy resolution and an improved background recognition, already the initial release of Phase II showed a background rate in the energy region of interest (ROI), after pulse shape discrimination (PSD) and liquid argon veto cuts, in the range of a few counts/(ROI·ton·yr). This made Gerda the first $0\nu\beta\beta$ experiment being background free up to its design exposure of 100 kg·yr. With the latest data release in mid 2018, Gerda remained in the background free regime. It is the first experiment to surpass a median sensitivity on the half-life of 10^{26} yr for $0\nu\beta\beta$ decay. Meanwhile the experiment has been upgraded by deploying also a new type of germanium detector and by improving the LAr instrumentation. In this talk, a summary of the latest results and an outlook on the performance after the upgrade of the experiment will be given.

HK 28.2 Wed 14:30 J-HS B

Observation of two-neutrino double electron capture in ^{124}Xe with XENON1T — •Christian Wittweg for the XENON-Collaboration — Institut für Kernphysik, WWU Münster

Two-neutrino double electron capture (2νECEC) is a second-order weak process with predicted half-lives that surpass the age of the Universe by far. After indications of 2νECEC in ^{78}Kr and ^{130}Ba, the XENON1T dark matter experiment achieved the first direct observation of 2νECEC in ^{124}Xe with a significance 4.4σ. The corresponding half-life $T^{2\nu\mathrm{ECEC}}_{1/2} = (1.8 \pm 0.5_{\mathrm{stat}} \pm 0.1_{\mathrm{sys}}) \times 10^{22}$ yr is the longest ever measured directly [XENON Collaboration. Nature 568, 532–535 (2019)] and agrees well with recent matrix element calculations [Coello Pérez et al., PLB 797 (2019) 134885]. It provides an important input for nuclear structure models from the proton-rich side of the nuclide chart and is a first step in the search for 0νECEC.

Moreover, decay modes involving positrons such as $0\nu\mathrm{EC}\beta^+$ are energetically allowed, would provide coincidence signatures, and could exhibit half-lives accessible to future detectors. Experimental proof of neutrinoless decays would imply lepton number violation and the Majorana nature of neutrinos. This talk will present the XENON1T result and discuss detection prospects for ^{124}Xe decays involving positrons, both with and without neutrino emission, in the next-generation of xenon-based experiments currently under construction. The work of the author is supported by Deutsche Forschungsgemeinschaft (DFG) through the Research Training Group "GRK 2149: Strong and Weak Interactions - from Hadrons to Dark Matter".

HK 28.3 Wed 14:45 J-HS B

Treatment of systematic uncertainties in the KATRIN neutrino mass analysis — •Leonard Köllenberger — Institute for Nuclear Physics, Karlsruhe Institute of Technology

The KATRIN collaboration aims to determine the neutrino mass with a sensitivity of 0.2 eV/c^2 (90 % CL). This will be achieved by measuring the endpoint region of the tritium β-decay spectrum.

KATRIN's first science run led to an improved upper limit of 1.1 eV (90 % CL) on the neutrino mass, with statistics-dominated uncertainties. Collecting more data in future measurement campaigns will increase the importance of the systematic error contribution.

Several approaches to account for systematic uncertainties can be applied within the analysis. Among these are the use of pull terms, the covariance matrix method, Monte Carlo propagation, and Markov Chain Monte Carlo (MCMC). A comparative discussion of these approaches will be presented. The MCMC approach is used in the KaFit framework and is investigated for treatment of systematics in future neutrino mass analysis.

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HK 28.4 Wed 15:00 J-HS B

Investigation of the KATRIN tritium source properties — •Fabian Friedel for the KATRIN-Collaboration — Karlsruher Institut für Technologie

The aim of the **Ka**rlsruhe **Tri**tium **N**eutrino (KATRIN) experiment is to determine the effective mass of the electron antineutrino with a sensitivity of 200 meV/c^2 (90% C.L.). This will be achieved by measuring the β-spectrum of tritium close to the kinematic endpoint at 18.6 keV. The tritium gas is injected into the center of the **W**indowless **G**aseous **T**ritium **S**ource (WGTS) with an inlet flow of 1.8 mbarℓ/s. The neutral gas is pumped at both ends of the 10 m long WGTS beam line while the charged particles are guided by a magnetic field of up to 3.6 T. In order to assure stable conditions for the neutrino mass measurement the source parameters like temperature and gas density have to be stabilized on the per mille level. In addition, a number of systematic effects have to be understood. One of them is related to the formation of a plasma consisting of tritium ions as well as β- and thermal electrons. This may lead to spatial and temporal potential inhomogeneities which would smear out the measured β-spectrum. During two measurement campaigns with tritium in 2019 the WGTS properties and systematics have been studied in detail. The most important results of these investigations will be presented with the main focus on the investigations of the tritium plasma. This work has been supported by BMBF (05A17VK2), KSETA and the Helmholtz Association.

HK 28.5 Wed 15:15 J-HS B

Atmospheric neutrino physics with JUNO — •Giulio Settanta[1], Stefano M. Mari[2,3], Cristina Martellini[2,3], Paolo Montini[2,3], Christoph Genster[1], Yuhang Guo[1,5], Alexandre S. Göttel[1,4], Philipp Kapmann[1,4], Runxuan Liu[1,4], Livia Ludhova[1,4], and Yu Xu[1,4] — [1]Institut für Kernphysik, Forschungszentrum Jülich — [2]Università degli Studi Roma 3 — [3]INFN, sezione di Roma 3 — [4]Physikalisches Institut B, RTWH Aachen University — [5]School of Nuclear Science and Technology, Xi'an Jiaotong University,Xi*an 710049, China

The atmospheric neutrino flux represents a continuous source that can be exploited to infer properties about Cosmic Rays and neutrino oscillation physics. The JUNO observatory, a 20 kt liquid scintillator currently under construction in China, will be able to detect the atmospheric flux, given the large fiducial volume and the excellent energy resolution. In this study, a sample of Monte Carlo events has been generated from theoretical models of the atmospheric neutrino flux, through the Genie software. To evaluate the JUNO performance, the events have then been processed by a full Geant4-based simulation. The different time evolution of light on the PMTs allows to discriminate the flavor of the primary neutrinos. A probabilistic unfolding method has been used, in order to infer the primary neutrino energy spectrum from the detector output. JUNO will be particularly sensitive in the energy range (100-1000) MeV, where neutrino-induced events can be fully contained within the instrumented volume. Future perspectives about atmospheric neutrino oscillation physics are presented.

HK 28.6 Wed 15:30 J-HS B

Pulse shape analysis in GERDA — •Vikas Bothe for the GERDA-Collaboration — Max Plank Institute for Nuclear Physics, Heidelberg

The GERDA experiment searches for the neutrinoless double-beta decay of 76Ge using enriched high purity Germanium diodes as a source as well as a detector. For such a rare event search, the sensitivity of the experiment can be improved by employing active background suppression techniques. Pulse shape analysis of the signals generated by the interaction of radiation within a detector is employed to discriminate background events. Analysis of time development of pulse can discriminate between the interaction of electron, an interaction of alpha and interaction of Compton scattered photon inside the detector.

In Phase II, GERDA operates 35.6 kg HPGe detectors which include 6 semi-coaxial detectors and 30 BEGe detectors. Different pulse shape analysis techniques are employed for these two types of detectors due to their different geometries. We will discuss the results from the pulse shape analysis of these detectors in GERDA.