T 108: Neutrinophysik 9 (sterile Neutrinos)

Zeit: Donnerstag 16:45–19:10 Raum: VSH 118

Gruppenbericht T 108.1 Do 16:45 VSH 118

Search for eV Sterile Neutrinos – The Stereo Experiment — •Julia Haser, Helena Almazán, Christian Buck, Manfred Lindner, Christian Roca, and Stefan Schoppmann — Max-Planck-Institut für Kernphysik, Heidelberg

In the recent past major milestones in neutrino physics were accomplished at nuclear reactors: the smallest neutrino mixing angle θ_{13} was determined with high precision and the emitted antineutrino spectrum was measured with unprecedented resolution. However, two anomalies – related to the absolute flux and the spectral shape – have yet to be solved. The flux anomaly is known as reactor antineutrino anomaly and could be caused by the existence of a light sterile neutrino participating in the neutrino oscillation phenomenon. Introducing a sterile eigenstate implies the presence of a fourth mass eigenstate and global fits favor $\sin^2 2\theta = 0.09$ and $\Delta m^2 = 1.8\,\mathrm{eV}^2$ as oscillation parameters. The Stereo experiment was built to finally solve this puzzle. It is one of the first running experiments built to search for eV sterile neutrinos and takes data since end of 2016 at ILL Grenoble (France). At a short baseline of 10 meters it measures the antineutrino flux and spectrum emitted by a compact research reactor. The segmentation of the detector in six target cells allows for independent measurements of the neutrino spectrum at multiple baselines. An active-sterile flavor oscillation could be unambiguously detected, as it distorts the spectral shape of each cell's measurement differently.
This talk will give an overview of the Stereo experiment, including details on the detector design, detection principle and the current status.

Gruppenbericht T 108.2 Do 17:05 VSH 118

Short Distance Neutrino Oscillations with SOX — •Stefan Weinz for the Borexino-Collaboration — Uni Mainz

The Borexino detector has convincingly shown its outstanding performances in the low energy regime and is therefore an ideal tool to perform a state of the art source-based experiment for testing the longstanding hypothesis of a fourth sterile neutrino species with $\approx 2\,\mathrm{eV}$ mass, as suggested by several anomalies accumulated over the past three decades in source-, reactor-, and accelerator-based experiments. The SOX project aims at successively deploying two intense radioactive sources, made of Cerium (antineutrino) and Chromium (neutrino), respectively, in a dedicated pit located beneath the detector. The existence of such an $\approx 2\,\mathrm{eV}$ sterile neutrino would then show up as an unambiguous spatial and energy distortion in the count rate of neutrinos interacting within the active detector volume. This article reports on the latest developments about the first phase of the SOX experiment, namely CeSOX, and gives a realistic projection of CeSOX sensitivity to light sterile neutrinos in a simple (3+1) model.

T 108.3 Do 17:25 VSH 118

Sterile neutrino search at the keV mass scale with TRISTAN — Tobias Bode[1], Tim Brunst[1], Kai Dolde[2], Ellen Förstner[3], Anton Huber[3], Felix Knapp[3], Marc Korzeczek[3], Thierry Lasserre[4], Susanne Mertens[1], David Radford[5], and •Martin Slezák[1] for the KATRIN-Collaboration — [1]Max Planck Institute for Physics, München, Germany — [2]University of Heidelberg, Germany — [3]Karlsruhe Institute of Technology, Germany — [4]Saclay Nuclear Research Center, France — [5]Oak Ridge National Laboratory, USA

Almost all experimental results in neutrino physics are consistent with the picture of three active weakly-interacting neutrinos. Nevertheless, several neutrino oscillation experiments and some cosmological observations indicate a possible existence of additional sterile neutrino states. The TRISTAN project is a planned modification of the KATRIN experiment that will allow to extend the physics reach to search for a keV-scale, mostly sterile, neutrino mass state. The signature of a such a state would be a miniscule kink-like distortion of the tritium beta-spectrum. Precise modelling and understanding of the spectrum over the whole energy range is required to reach the necessary experimental sensitivity needed for observation of such a distortion. In this talk, the project and in particular new analysis and modeling approaches will be presented.

T 108.4 Do 17:40 VSH 118

KATRIN Sensitivity on Right-Handed Currents with Light Sterile Neutrinos — •Nicholas Steinbrink for the KATRIN-Collaboration — Institut für Kernphysik, WWU Münster

The KATRIN experiment aims to determine the absolute neutrino mass by measuring the endpoint of the Tritium beta spectrum. As a large-scale experiment with a sharp energy resolution, high source luminosity and low background it may also be capable of testing certain theories of neutrino interactions beyond the standard model (SM). An example of a non-SM interaction are right-handed currents mediated by right-handed W bosons in the left-right symmetric model (LRSM). In this extension of the SM, an additional $SU(2)_R$ symmetry in the high-energy limit, which naturally predicts sterile neutrinos and the seesaw mechanism. In tritium β decay, interference between left- and right-handed currents thus leads to slightly modified kinematics, which enhances or suppresses certain regions near the endpoint of the beta spectrum. In this work, the sensitivity of KATRIN to right-handed currents is estimated for the scenario of a sterile neutrino with a mass of some eV. This has been performed with a Bayesian analysis using Markov Chain Monte Carlo (MCMC). The sensitivity and parameter correlations are further discussed under the hypothetical premise of a constrained tritium Q-value and with respect to the lack of knowledge about the sterile neutrino mass. The results are compared with current experimental limits on right-handed weak bosons.

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T 108.5 Do 17:55 VSH 118

Systematic effects at the detector section of KATRIN and their impact to a sterile neutrino search — •Marc Korzeczek for the KATRIN-Collaboration — 2Institute of Experimental Nuclear Physics (IEKP), Karlsruhe Institute of Technology (KIT), Wolfgang-Gaede-Str. 1, 76131 Karlsruhe, Germany

The KATRIN (KArsrluhe TRItium Neutrino Experiment) investigates energy endpoint of the tritium beta-decay to determine the effective mass of the electron anti-neutrino with a precision of 200 meV (@90CL) after an effective data taking time of three years. A possible future extension of KATRIN is the search for a sterile neutrino signature in the tritium beta-decay. Such a search requires to measure the whole energy spectrum of tritium beta-decay and thus requires a redesign of the detector section, as the total rate at the detector is increased by several orders of magnitude. Moreover systematic effects, such as detector backscattering and the detector deadlayer, which lead to drastic modifications of the measured energy spectrum, have to be investigated and modeled in order to achieve high sterile neutrino sensitivities. This talk discusses the impact of such systematics and shows the status of the modeling approaches.

T 108.6 Do 18:10 VSH 118

Calibration studies with a ^{68}Ge-^{68}Ga β^+ source in the SOX experiment — •Michael Nieslony for the Borexino-Collaboration — Johannes Gutenberg-Universität Mainz

Several experiments showed anomalous behavior in the neutrino sector which could be explained by the existence of a 4th, sterile neutrino with mass in the eV range. The existing 3 neutrino generations would then be able to oscillate into the sterile state, enabling the appearance of new oscillation phenomena at short baselines. The aim of the SOX experiment (Short distance Oscillations in BoreXino) is to test this hypothesis by placing a ^{144}Ce-^{144}Pr antineutrino source below the Borexino detector located deep underground in the Gran Sasso laboratories. SOX will search not only for a rate reduction in inverse beta decays induced by active antineutrinos but also for the presence of an oscillation pattern in space and energy related to the prompt positron signals.

This talk will present plans and the current status of the calibration campaign with a ^{68}Ga-^{68}Ge β^+ source that will be essential to assess the detector response to the neutrino-induced positrons and the connected systematic uncertainties. A calibration source design and an optimized scheme of calibration points will be outlined.

T 108.7 Do 18:25 VSH 118

Calibration and energy scale reconstruction in the Stereo experiment — •Christian Roca, Helena Almazan, Christian Buck, Julia Haser, Manfred Lindner, and Stefan Schoppmann — Max-Planck-Institut für Kernphysik Heidelberg

The Stereo experiment, running since November 2016 at the ILL Grenoble, aims to test the hypothesis of sterile neutrinos as a possible the cause of the reactor antineutrino anomaly at short baselines. The detector is divided in two main volumes each filled with liquid scintillator. The central volume is segmented in six independent cells corresponding to the neutrino target (NT). Its scintillator is doped with gadolinium to enhance the detection of the correlated neutrino signal produced by the inverse beta decay. Surrounding the NT there is the outer crown (OC) volume, optimized to capture escaping gammas originating from interactions in the NT.

The energy deposited in the detector is measured as scintillation light that is collected by a set of photomultiplier tubes. The readout charge signals are linked to visible energy by a non-linear energy scale. To determine such energy scale and to monitor the detector stability, several gamma and neutron sources are deployed by means of three different calibration systems: an internal set of tubes located within the NT cells, a single tube underneath the detector to introduce sources below the NT and OC, and a rail system optimized for OC calibration.

The calibration runs performed provided Stereo with a better understanding of the detector response and an energy scale reconstruction that will be presented in this talk.

T 108.8 Do 18:40 VSH 118

Pulse Shape Discrimination in the STEREO Neutrino Experiment — •Stefan Schoppmann, Helena Almazán, Christian Buck, Julia Haser, Manfred Lindner, and Christian Roca — Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany

The STEREO experiment is an antineutrino disappearance experiment located at the ILL research reactor in Grenoble, France. Its goal is to test the sterile neutrino hypothesis via oscillations. The detector has a segmented design, to measure the relative effect of neutrino oscillations at six different baselines between 9 and 11 metres. Neutrinos are detected in six Gd-loaded liquid scintillator volumes by the inverse beta decay reaction (IBD). In this reaction, an antineutrino capture by a proton yields a positron, giving a prompt energy deposition and annihilation signal, and a neutron, giving a delayed capture signal after thermalisation.

Due to its proximity to the reactor a significant flux of neutrons reaches the detector. In addition, atmospheric muons produce neutrons via spallation. Neutrons can mimic IBDs as they generate prompt proton recoils followed by their delayed capture. However, the scintillator deexcitation time differs for a proton recoil and a positron or gamma event. Thus, it is possible to distinguish both types of particle signals by analysing the time shape of their scintillation pulses.

This contribution will present in-situ and laboratory measurements of pulse shapes for gamma and neutron events. A strategy for background rejection using scintillation pulse shape will be described and its performance reviewed.

T 108.9 Do 18:55 VSH 118

Background conditions of the first run period of the sterile neutrino search with STEREO — •Felix Kandzia — Institut Laue Langevin, Grenoble, France

Light sterile neutrinos are currently a topic of high interest in neutrino physics. One indication of their possible contribution to neutrino oscillations is the Reactor Antineutrino Anomaly, which unveiled a deficit of about 6% between predicted and observed neutrino fluxes in short baseline reactor experiments. The corresponding new oscillation parameters, obtained from global fits to reactor and beam experiments, result for electron antineutrinos from reactors (1 to 10 MeV) in oscillation lengths of a few meters. As a consequence several very short baseline oscillation experiments at reactors are currently in preparation or have already started.

The STEREO collaboration has commissioned a detector at about 10 m distance from the compact fuel element of the research reactor of the Institut Laue Langevin, Grenoble, France, in November 2016 and is continuously taking data since then. The STEREO detector is installed on ground level in the experimental hall of the reactor building. Nearby neutron beam experiments and cosmic radiation result in challenging background conditions which were compensated by passive and active shielding. In this talk the background situation of the first run period of STEREO will be presented as well as methods employed for background reduction in the data analysis.