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A model for Rydberg-atom induced backgrounds resulting from deposition of Rn progeny in the KATRIN Main Spectrometer

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The KArlsruhe TRItium Neutrino (KATRIN) experiment aims to determine the effective mass of the electron antineutrino
with an unsurpassed sensitivity of 200 meV/c^2 in a direct model-independent approach.
Located at the Karlsruhe Institute of Technology (KIT) the experiment uses a MAC-E filter type
electrostatic Main Spectrometer (MS) to investigate the tritium β-decay spectrum close to the kinematic endpoint at 18.6 keV.
With a target count rate for the spectrometer design of about 10^{-2} cps in the endpoint region it is in the same order of magnitude as the signal.
The 1240-m^3 ultra-high vacuum vessel of the MS, with its 1222-m^2 of inner stainless steel surfaces, represents the major background contributer in the experiment.

From 2013 - 2016, the characteristics of the MS background were studied in a series of dedicated commissioning measurements.
The findings could not be reconciled with any background models for MAC-E filter spectrometers at that time, thus requiring the development of a new model.
The background is best described by the generation of low-energy background electrons in the volume of the MS via the ionization of hydrogen Rydberg atoms
by black body radiation from the room temperature walls of the vacuum chamber.
Recent results from measurements in autumn 2016 indicate a link between the generation of these Rydberg atoms
and the deposition of the radon progeny ^{210}Pb on inner surfaces of the spectrometer.

This talk will give an overview of background processes in a MAC-E filter in general,
before discussing in detail the findings of the commissioning measurements with the KATRIN Main Spectrometer.
Based on the characteristics of the MS background, the newly established model for a Rydberg-atom induced background process will be introduced.
The identification of a conversion electron signature from ^{210}Pb decay in the background spectrum of the MS will be presented, which can be linked to the generation of Rydberg atoms.
Finally, possible methods to reduce this unexpected background component and its influence on the sensitivity of the KATRIN experiment will be discussed.

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Summary

A dominant background contribution was found in the KATRIN Main Spectrometer, which cannot be reconciled with any existing background models for MAC-E filter based spectrometers.
This talk will summarize the experimental findings and introduce a newly established background model based on the thermal ionization of Rydberg-atoms, produced in the decay of the Rn progeny ^{210}Pb, deposited on the wall of the spectrometer chamber.

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