Tritium contamination and decontamination of a new KATRIN Rear Wall material

Master‘s project at IAP-TLK

Motivation

At the end of 2025, KATRIN will finalize its neutrino mass measurement and undergo a major upgrade in 2026 to begin the search for keV sterile neutrinos, a dark matter candidate. Therefore, not only will the new TRISTAN detector be implemented, but new systematics will become relevant.


TRACE setup in the Tritium Laboratory

A new Rear Wall to mitigate backscattering

The Rear Wall, a gold-plated disc at the end of the source, defines the electric starting potential of the electrons. It becomes the largest source of systematic uncertainty for the keV sterile neutrino search. Half of all electrons from the source do not propagate towards the detector but instead travel towards the Rear Wall. A significant number of these electrons backscatter, change angle, lose energy, and are detected. This effect must be mitigated to achieve our target sensitivity. A new Rear Wall material - such as beryllium or microstructured silicon - could reduce this systematic effect.

Tritium accumulation on the Rear Wall

One critical criterion for a new Rear Wall material is how much tritium accumulates on its surface. Electrons from this decay exhibit a different spectrum, creating background and systematic uncertainty for the keV sterile neutrino search. Finding a new Rear Wall material with low backscattering probability, low tritium accumulation, and effective decontamination is key to starting the next phase of the KATRIN experiment.

The TRACE setup

With the Tritium Activity Chamber Experiment (TRACE) at TLK, it is possible to expose solid samples to high-purity tritium gas and monitor their accumulated surface activity via Beta-induced X-ray Spectrometry (BIXS). A recent upgrade with an ozone generator also allows investigation of potential decontamination effects.

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Tasks

The tasks in this Master's project include measuring the tritium accumulation on Rear Wall candidates - such as beryllium and silicon - and investigating the effects of in-situ ozone decontamination at the TRACE setup. Data analysis is also a key component of the work. Additional tasks may include performing Geant4 simulations of electrons and X-rays in the TRACE measurement cell and contributing to the ongoing planning and development of system upgrades, such as integrating UV light into the measurement setup.

Organisation of the master's project

1. Training phase: Learn more about the KATRIN experiment, basics on vacuum technology, sorption, UV/ozone cleaning, and data analysis
   Afterwards, an introductory presentation will be given in the Science Seminar.
2. Experimental phase:
   - Perform tritium accumulation measurements in the Tritium Laboratory
   - Analysis of BIX spectra
   - Interpretation of the data regarding the interaction of gaseous tritium with surfaces
   - Measurement of ozone decontamination
   - Optional: Implementation of UV decontamination in the TRACE setup
   - Optional: Geant4 Simulation of TRACE measurement cell
3. Writing phase: Writing up the master's thesis
4. Final presentation after the submission of the thesis

Relevant Topics

- The KATRIN experiment
- Neutrino physics
- Physical chemistry, especially sorption
- Surface and solid-state physics
- Data analysis, e.g., with Python
- Communication of the results within the team

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Please get in touch with me if you are interested in this topic.
Taking one part of this topic as a bachelor's thesis could also be possible.

This project will take place at IAP-TLK at KIT Campus North.