Prof. Dr. Wolfgang Wernsdorfer
Karlsruher Institut für Technologie
Physikalisches Institut
Contact: wolfgang.wernsdorfer@kit.edu
Web: https://www.phi.kit.edu/wernsdorfer.php

PhD Job Offer

Axion-like Dark Matter Detection using Low-Temperature Quantum Technologies (ERC Synergy: 'Dark Quantum')

Context:

The search for axion-like dark matter candidates requires extreme sensitivity to detect very weak signals generated by the expected conversion of axion-like particles into resonant single photons in the presence of large electromagnetic fields. This project leverages next-generation quantum sensing technologies, specifically combining large-scale cavity resonance under strong magnetic fields with ultra-low-noise (quantum-limited) amplification of its expected minute signal. The experimental setup involves a 1-meter-long copper (Cu) cavity with a tunable resonance frequency (290–350 MHz). The cavity will be cooled to millikelvin (mK) temperatures inside a large CERN magnet (Helmholtz configuration: ~1.2 m radius, ~5 T at 1000 Amperes).

The Wernsdorfer group at KIT plays a crucial role in this international effort. Our expertise is utilized for cooling down the large cavity to 20 mK and performing low-temperature axion-search experiments at CERN. The primary signal amplification will be achieved using a SQUID amplifier characterized by a sub-Kelvin (quantum-limited) noise temperature, enabling the detection of the expected very rarely occurring resonant photon signals.

Objective:

The objective of this PhD project is the experimental realization and optimization of the cryogenic detection chain for axion searches, focusing on:

- Participation in the efficient cool-down and thermalization of the large Cu cavity to the 20 mK regime within the CERN magnet.
- Implementation and characterization of SQUID-based amplifiers with sub-Kelvin noise temperature for quantum-limited signal detection.
- Contribution to the execution of low-temperature axion-search experiments at CERN using the optimized setup.

Work Plan:

The project will proceed through the following phases (often parallelly):

1. **Cryogenic Integration**: Integration and thermalization of the 1-meter Cu cavity in dilution refrigerators at CERN.
2. **SQUID Deployment**: Installation and characterization of SQUID-based amplifiers at millikelvin temperatures to achieve sub-Kelvin noise performance.
3. **Signal Optimization**: Noise temperature measurements and optimization of the complete amplification chain to maximize sensitivity to rare resonant photons.
4. **Data Acquisition**: Conducting low-noise RF measurements during axion-search runs in the prototype setup.

Candidate Profile:

Applicants should hold a master's degree in physics or a related field and have a strong interest in experimental low-temperature physics, quantum technologies. Experience in the following is preferred:

- Cryogenics and dilution refrigerator operation/ RF Cavities.
- Superconducting electronics (ideally SQUID- or other parametric- amplifiers) and microwave techniques. Experience on noise-characterization of low-T amplifiers will be appreciated.

Application:

Interested candidates should send a CV and a short motivation letter directly to Prof. Dr. Wolfgang Wernsdorfer (wolfgang.wernsdorfer@kit.edu).