



Contribution ID: 182

Type: **Contributed Oral**

ORGAN-Low : Probing Sub- μeV Axion Dark Matter with Optimised Haloscope Design

Friday 5 December 2025 11:25 (15 minutes)

The QCD axion is a well-motivated hypothetical particle that offers simultaneous solutions to two major open questions in physics: the Strong CP problem and the nature of dark matter. If axions make up the dark matter halo of our galaxy, they may be detected through their resonant conversion into microwave photons in the presence of a strong magnetic field—a technique used in the axion haloscope.

To date, haloscope experiments have achieved impressive sensitivity at GHz frequencies, targeting axion masses in the tens of μeV range. However, a significant region of parameter space at lower frequencies ($\sim$ hundreds of MHz), corresponding to axion masses in the sub-to-few μeV range, remains largely unexplored. This is primarily due to engineering challenges in building large-volume, high-Q resonant cavities that are required to probe such low-mass axions effectively.

In this work, we present a comprehensive framework for designing and optimizing axion haloscopes operating in this lower frequency range. We explore the trade-offs involved in cavity geometry, material selection, mode structure, and coupling mechanisms, with the goal of maximizing sensitivity while maintaining experimental feasibility. Our approach includes full 3D electromagnetic simulations using COMSOL Multiphysics to identify cavity configurations that offer high form factors and scan rates.

By addressing key design challenges, our study aims to pave the way for next-generation haloscope experiments capable of probing currently inaccessible regions of axion parameter space. This would significantly enhance our ability to test the axion dark matter hypothesis at lower masses and contribute to solving one of the most profound mysteries in modern physics.

Authors: Dr MCALLISTER, Ben (Swinburne University/University of Western Australia); Prof. BROOKS, Geoffrey (Swinburne University of Technology); TAYLOR, Paige (Swinburne University of Technology); SINGH, Raj Aryan (Swinburne University of Technology)

Presenter: SINGH, Raj Aryan (Swinburne University of Technology)

Session Classification: Astroparticle Physics

Track Classification: Topical Groups: Astroparticle Physics