Results of axion searches at 34 µeV with RADES haloscope and prospects for searches in BabyIaxo

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The RADES group uses the haloscope technique to search for axions at frequencies between 8 and 9 GHz.

A figure of merit for our experiment is given by:

$$F \sim g_{a\gamma}^2 m_a^2 B^4 V^2 T_{\text{sys}}^{-2} G^4 Q$$

To resonate at these frequencies without decreasing in volume RADES employs rectangular cavities joined by irises.

**Figure 1**: Scheme of a dark matter haloscope experiment [1].
RADES inductive irises prototype

- Consists of 5 sub-cavity structures joined by inductive irises.
- One can choose the working frequency by changing the dimension of the unit cell.
- Afterwards, the dimensions are optimized using simulations to achieve the best geometric factor.

Figure 2: RADES first prototype [2].
Inductive irises prototype

**Figure 3:** Electric field configuration of the 5 modes [2].

**Figure 4:** Transmission parameter: measurement (green) and theoretical model (gray). Red is axion coupling for the 5 modes [2].
RADES setup at CAST

Figure 5: CAST magnet

Figure 6: RADES setup at CAST [2].
Approximately 103 hours of data were recorded in 2018.

The characterization of the setup yielded the following values:

- $\beta = 0.50$.
- $Q = 11009$.
- $T = 7.8$ K
- $\Delta \nu = 4577$ Hz
- $B = 8.8$ T
- $G = 0.65$
- $V = 0.03$

**Figure 7:** Amplitude of a fit for an axion signal.
First CAST-RADES axion search results

Figure 8: RADES exclusion limit. https://arxiv.org/abs/2104.13798
Cavity developments

- To grow in volume more sub-cavities were added to manufacture a new ~ 1 m long cavity.

- For the BabyIAXO magnet, the height of the cavity can also be increased without affecting the resonance frequency.
Longer and taller cavities

Figure 9: 1 meter long cavity prototype [3].

Figure 10: Tall cavity prototype. Photo made by J.M. García
Figure 11: Preliminary RADES prospects for the long cavity at CAST (red) and the tall cavity at BabyIAXO (green) assuming 3 months of data.
RADES is looking for a dark matter candidate called axions using RF cavities resonating at frequencies between 8 and 9 GHz.

Data acquired with a 5-cavity pathfinding prototype in the CAST magnet provided first results at this frequency.

The volume can be increased by adding more sub-cavities or increasing the height of the short prototype.

RADES is also doing R&D toward tuning as well as using superconductive cavities.
[1] Frank T. Avignone III.  
Homing in on Axions?  

Axion Searches with Microwave Filters: the RADES project.  
*JCAP*, 05:040, 2018.

Scalable haloscopes for axion dark matter detection in the 30µeV range with RADES.  