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Exploiting higher-order resonant modes for axion haloscopes

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The haloscope is one of the most sensitive approaches to the QCD axion physics within the region where the axion is considered as a dark matter candidate. However, the current experimental sensitivities, relying on the lowest fundamental TM010 mode of a cylindrical cavity, is limited to relatively low mass regions. Exploiting higher-order resonant modes would be beneficial because it enables us to extend the search range with no volume loss and higher quality factors. However, this approach has been discarded mainly due to the significantly degraded form factors and difficulty in frequency tuning. We introduce a new concept of tuning mechanism, which both enhances the form factors and yields reasonable frequency tunability, and demonstrate its feasibility for axion search experiments. In addition, convolution of this concept with the multiple-cell cavity design enables us to widen the search range towards even higher frequencies beyond 10 GHz. We present a simulation study to evaluate this conceptual approach for high mass axion search.

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