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Layered dielectric haloscopes: a new way to detect axion dark matter

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Axions and axion-like particles are among the best-motivated candidates for dark matter. In particular, the QCD axion is capable of not only providing a dark matter candidate, but is also gives a natural explanation for the strong CP problem. Consequently, the detection of dark matter axions is of great interest as it would solve two of the most significant problems of modern physics. To this end, we introduce a new method to detect galactic dark-matter axions using dielectrics. When a dielectric interface is inside a strong parallel magnetic field, the oscillating axion field acts as a source of microwaves, which emerge in both directions perpendicular to the surface. These microwaves compensate for a discontinuity in the axion induced electric field. Crucially, the emission rate can be boosted by multiple parallel layers judiciously placed to achieve constructive interference. Starting from the axion-modified Maxwell equations, we calculate the efficiency of this new "layered dielectric haloscope"approach. This technique may prove useful in the well-motivated high-frequency range of 10-100 GHz (axion mass 40-400 ueV), where traditional cavity resonators have difficulties reaching the required volume. This would allow one to study axion dark matter generated by the topological defects, which occur if the reheating temperature after inflation was lower than the Peccei-Quinn scale. Unlike a cavity resonator it is possible for dielectric haloscopes to conduct a broadband search. In particular, we study the relation between the power generated and the bandwidth, the connection between the emission and reflection functions, the required placement precision for meter-scale disks, and the impact of small but non-vanishing axion
velocities.

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