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Velocity effects in dielectric haloscopes

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We study the effect of the axion dark matter velocity in the recently proposed dielectric haloscopes, a promising avenue to search for well-motivated high mass (40–400 μeV) axions. We describe non-zero velocity effects for axion-photon mixing in a magnetic field and for the phenomenon of photon emission from interfaces between different dielectric media. As velocity effects are only important when the haloscope is larger than about 20% of the axion de Broglie wavelength, for the planned MADMAX experiment with 80 dielectric disks the velocity dependence can safely be neglected. However, a search experiment using more than $\sim$ 400 dielectric disks will suffer from significant systematic uncertainties from the unknown velocity distribution. Conversely, an augmented MADMAX or a second generation experiment would be directionally sensitive to the axion velocity in the event of a discovery, and thus a sensitive measure of axion astrophysics.

Primary authors: Mr MILLAR, Alexander (Max Planck Institute for Physics); STEFFEN, Frank (MPI Munich); Dr REDONDO MARTIN, Javier (Zaragoza U / MPP Munich)

Presenter: Mr MILLAR, Alexander (Max Planck Institute for Physics)

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