Simulation Studies Of The MADMAX Dielectric Haloscope For Dark Matter Axion Research

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Abstract

The axion is an excellent cold dark matter (CDM) candidate, originally proposed to solve the strong CP problem in strong interactions. A novel method to detect galactic axions is by using their conversion to electromagnetic waves from boundaries between materials of different dielectric constants under a strong magnetic field. This method will be exploited by the MAgnetized Disk and Mirror Axion eXperiment (MADMAX), that is the first dielectric haloscope to search for axions in the mass range 40 to 400 μeV. The axion-electrodynamics theory can be expressed with modified Maxwell equations and can be realized in Finite Element Methods (FEM). FEM in 2D axisymmetric and in 3D simplified models have been performed, to simulate the E-fields created by the dielectric haloscope. Diffraction, near field effects and dielectric losses, are investigated as also the coupling of the power emitted by the dielectric haloscope with a receiver i.e. a horn antenna.
Simulation studies have been performed using the COMSOL Multiphysics, to examine the horn antenna design (RF module) and the dielectric haloscope disks setup (booster) performance using the Wave Optics Module. The antenna - booster system could be optimized by investigating various effects and thus obtaining the maximum booster power emitted.