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Probing Axion Like Particles Using Time Dependent Magnetic Field

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From years ago, there have been established many different experiments for the detection of Axion Like Particles (ALPs) as a promising candidate of dark matter. The coupling of ALPs with the standard model particles has been explained with some interaction Lagrangians. Many experiments try to detect ALPs by their interaction with photons in the context of a static magnetic field using the well known interaction Lagrangian, $\mathcal{L}_{a\gamma\gamma} = \frac{1}{4}\, g_{a\gamma\gamma}\phi F_{\mu\nu}\widetilde{F}^{\mu\nu}$, where ϕ is the ALP field, $F_{\mu\nu}$ is the electromagnetic field with $\widetilde{F}^{\mu\nu} = \frac{1}{2}\epsilon^{\mu\nu\rho\sigma}F_{\rho\sigma}$ its dual, and $g_{a\gamma\gamma}$ is the coupling constant.

However, we try a sinusoidal magnetic field in order to check the effect of such a magnetic field pattern on the detection. Starting from Feynman diagrams and calculating the second-order S-matrix, the oscillating magnetic field generates two peaks in the Hamiltonian integrand. This results in an enhancement of the phase deviation of the interacting photon.

Also, Our setup is designed in a practical manner. A tabletop Fabry-Perot cavity is used and two perpendicularly polarized photons pump in the cavity. We show that one of these polarizations interact with ALPs and the other remains intact. Therefore, both polarizations will feel the same noise and there is no problem about different noise effects on the interacted and reference photons.

All in all, the resulting exclusion region illustrates the advantage of the setup. Using a 10 cm cavity with the finesse of 10^6 and also a magnetic field with the amplitude and frequency of 10 T and 1 MHz, respectively, one can detect ALPs with the coupling constant of $g_{a\gamma\gamma} > 10^{-13}$.

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