Search for sub-eV Axion-Like Particles with an Analysis Method for Discriminating Atomic Process Backgrounds in a Stimulated Resonant Photon-Photon Collider

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The dark components, which account for approximately 95 % of the total energy density balance of the universe, are still unidentified. Axion and axion-like particle (ALP) have been proposed as candidates for those. Axion [1, 2] is a pseudoscalar field for which the relationship of its mass and coupling constant has been predicted from several models. On the other hand, ALP is a generalized particle that does not require the relationship. A *miracle* scenario [3] can explain both dark matter and inflation with a single ALP and predicts that coupling constant to photons is $g/M = O(10^{-11})\,\mathrm{GeV}^{-1}$ at $0.01 \sim 1\,\mathrm{eV}$ mass.

We have searched for sub-eV axion-like particles by focusing two near-infrared short-pulsed beams at Institute for Chemical Research in Kyoto University [4]. One is called "creation beam" and two photons in this beam collide at the focal point to generate an ALP. The other is called “inducing beam” and stimulates its decay into two photons. The decayed photon (hereafter, signal) can be detected by observing different wavelength from that of the inducing beam. The signal wavelength is similar to that of background photons generated by atomic four-wave mixing processes. In particular, optical elements used for laser beam propagations are one of the main sources of background photons because they are composed of large amounts of atoms. Since the background photon generation is enhanced with increasing laser intensity, a quantitative evaluation method is essential for future high-sensitivity searches.

In this study, we numerically calculated the angular distribution of the emission of signal photons generated at the focal point and found that the difference between the expected spatial distributions of signal and background photons. We evaluated that the observed photons in the search experiment can be explained by the background photon generation and updated the upper limit of the coupling-mass relation for ALPs [5] from the previous search [4].

References

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