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Searching for Dark Photon Tridents Through Primordial Black Hole Signatures

The detection of gamma-ray signals from primordial black holes (PBHs) could provide compelling evidence for their role as a dark matter candidate, particularly through the obser- vation of their Hawking radiation. Future gamma-ray observatories, such as e-ASTROGAM, and the next-generation telescopes, are poised to explore this possibility by measuring both Standard Model (SM) and beyond-the-SM particle emissions. A particularly promising avenue involves production of dark photons by PBHs, which is a hypothetical particle that decays into photons. In this work, we investigate the trident decay of dark photons focusing on their primary emission from PBHs. We assume that the dark photons produced via Hawking radiation decay into photons well before reaching Earth, thereby enhancing the detectable gamma-ray flux. The energy spectrum of the photons decaying from the dark photons is dis- tinct from that of direct Hawking-radiated photons due to higher degree of freedom, leading to observable modifications in the gamma-ray signal. Using the asteroid-mass PBHs as a case study, we demonstrate that future gamma-ray missions could detect dark-photon signatures and distinguish them from conventional Hawking radiation. This approach enables the explo- ration of previously inaccessible parameter spaces in dark photon mass mA′ and their coupling to photons, offering a novel pathway to uncover the properties of dark sectors and the nature of PBHs.

Primary author: C.J., Ouseph (Seoul National University of Science and Technology)

Co-authors: CHEUNG, Kingman (National Tsing Hua Univ / Konkuk Univ); Prof. TSENG, Po-Yan (National Tsing Hua University); KANG, Sin Kyu (Seoul Tech)

Presenter: C.J., Ouseph (Seoul National University of Science and Technology)