



Contribution ID: 107

Type: **Poster**

Direct Detection of Dark Photons

Tuesday 2 December 2025 15:30 (1 hour)

As dark matter continues to evade direct detection, new physics, such as theoretical particles, must be hypothesised to explain inconsistencies in astrophysical and cosmological observations. One of these proposed hypothetical particles, the dark photon, could be detected by liquid noble gas scintillators, such as the XENON experiment, through ionisation in an atom via the photoelectric effect. In order to verify whether a dark photon signal has been detected in these experiments, the theoretical rate of these interactions must be calculated. However, calculations for this rate in the literature use the electric-dipole approximation, which is estimated to break down for dark photons with masses greater than 27 eV. Additionally, a statistical study using high-energy collider data suggests the existence of a dark photon with a mass of ~ 4 GeV [1]. In my Honours research project, I demonstrated that the electric-dipole approximation, as well as other approximations, are not suitable for modelling dark photons with masses beyond 27 eV. Additionally, scintillators using xenon cannot probe mass beyond ~ 0.1 GeV, making the detection of the dark photon predicted by Ref. [1] just out of reach.

[1] N.T. Hunt-Smith, W. Melnitchouk, N. Sato, A.W. Thomas, X.G. Wang, M.J. White et al., Global QCD analysis and dark photons, *Journal of High Energy Physics* 2023 (2023) 96.

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Session Classification: Poster Session

Track Classification: Topical Groups: Astroparticle Physics