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Shaping Dark Photon Spectral Distortions

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The cosmic microwave background (CMB) spectrum is an extraordinary tool to explore physics beyond the standard model. Due to the exquisite precision of its measurements, it constitutes a natural place to look for small effects due to the hidden universe. In particular, CMB spectral distortions can unveil the existence of dark photons which are kinetically coupled to the standard photon. In this work, we use the COBE-FIRAS dataset to derive self-consistent and robust limits on photon-to-dark-photon oscillations for a large range of dark photon masses, from 10^{-10} to 10^{-3} eV. We consider in detail the redshift dependence of the bounds, computing CMB distortions due to photon injection/removal using photon linearized Boltzmann equations. Our treatment supersedes previous works, which had set limits studying energy injection/removal rather than photon injection/removal or ignored the redshift dependence of the distortions. The difference between our treatment and previous ones is particularly noticeable in the spectral shape of the distortions, a smoking gun signature for photon-to-dark-photon oscillations. The spectral shape characterisation is crucial for future CMB missions – a pillar of the ESA Voyage 2050 Program – which could improve the present sensitivity by orders of magnitude, exploring regions of the dark photon parameter space that are otherwise extremely difficult to access.

Primary author: GAN, Xucheng (DESY)

Presenter: GAN, Xucheng (DESY)

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