

# Cosmological Constraints on Very Dark Photons

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Extensions of the Standard Model (SM) may include relatively light neutral states with tiny couplings to the ordinary particles. A new U(1) vector particle has recently received considerable experimental and theoretical attention, linking the SM with a dark sector through kinetic mixing with the photon. We explore a new regime of coupling for the dark photon, with effective electromagnetic coupling as small as  $10^{-38}$ , rendering such a state very dark and undetectable in terrestrial experiments. We consider 1 MeV - few GeV mass window for dark photons and calculate the freeze-in abundance of the vector particle in the early Universe. Subsequent delayed decays of such particles introduce observable deviations from standard cosmological predictions, either by affecting the primordial elemental abundances or by creating a detectable ionization signal during the CMB epoch. The ensuing constraints on the parameter space of the model are very powerful, and exclude significant ranges of masses and couplings for the dark photon model.

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