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Dark photon conversion in the presence of multiple level crossings

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Dark photons can oscillate into SM photons via kinetic mixing in a way that is analogous to neutrino oscillations. Much like the MSW effect for neutrinos in environments of varying density, the probability for dark photons to convert to photons depends on the properties of the ambient background (density, electromagnetic fields, etc.) Resonances are even possible when there is a level-crossing between the dark photon and background-dependent photon states. The Landau-Zener approximation is used widely in the field, but we will show that it breaks down when there are multiple level-crossings where phase effects can cause interference between the resonance points. In some relevant cases, the breakdown is at the level of a few orders of magnitude. We present a new analytic approximation that is valid in this regime and that can accurately predict the conversion probabilities in a wide range of astrophysical environments, from the dense interiors of stars to the rarefied intergalactic medium.

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