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How to suppress exponential growth – on the parametric resonance of photons in an axion background

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Axion–photon interactions can lead to an enhancement of the electromagnetic field by parametric resonance in the presence of a cold axion background, for modes with a frequency close to half the axion mass. In this paper, we study the role of the axion momentum dispersion as well as the effects of a background gravitational potential, which can detune the resonance due to gravitational redshift. We show, by analytical as well as numerical calculations, that the resonance leads to an exponential growth of the photon field only if (a) the axion momentum spread is smaller than the inverse resonance length, and (b) the gravitational detuning distance is longer than the resonance length. For realistic parameter values, both effects strongly suppress the resonance and prevent the exponential growth of the photon field. In particular, the redshift due to the gravitational potential of our galaxy prevents the resonance from developing for photons in the observable frequency range, even assuming that all the dark matter consists of a perfectly cold axion condensate. For axion clumps with masses below $\sim 10^{-13}\, M_\odot$, the momentum spread condition is more restrictive, whereas, for more massive clumps, the redshift condition dominates.

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