CMB Spectral Distortions from the Coherent Oscillations of an Axion-Like Field
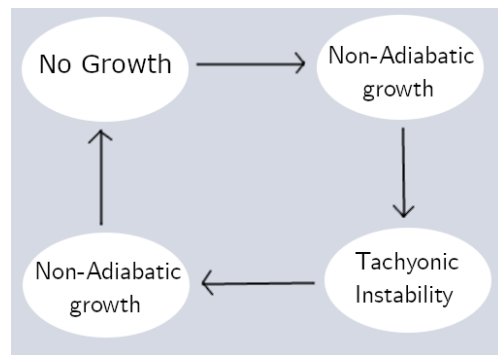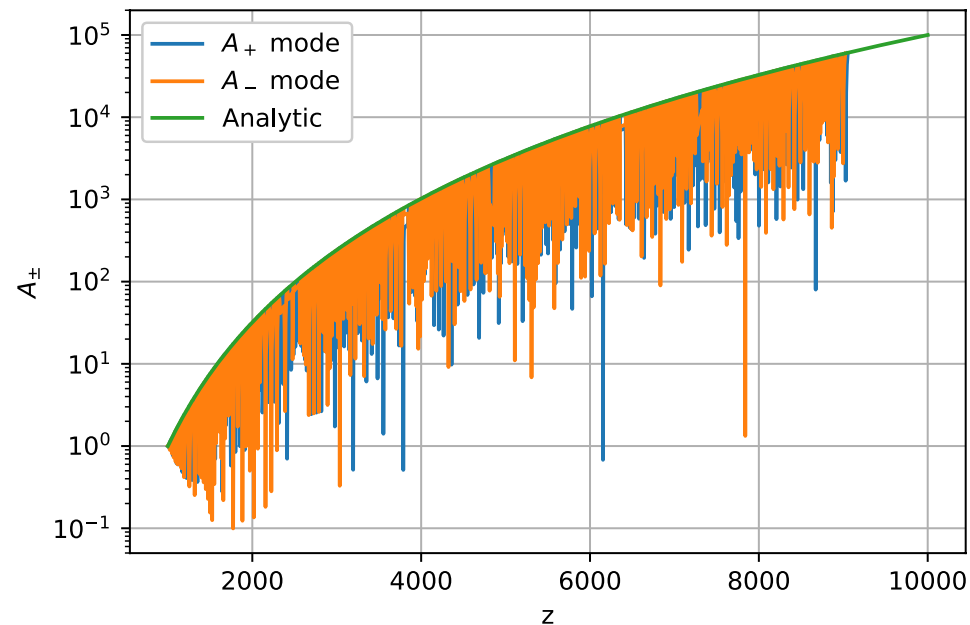
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$$S = \int d^4x \sqrt{-g} \left(-\frac{1}{2}\nabla_\mu\varphi\nabla^\mu\varphi - V(\varphi) - \frac{1}{4}F_{\mu\nu}F^{\mu\nu} - \frac{\alpha}{4f}\varphi F_{\mu\nu}\tilde{F}^{\mu\nu} \right) \qquad V(\varphi) = \frac{\lambda}{4}\varphi^4$$

$$\partial_z^2 \hat{A}_\pm + \left(\kappa_k^2 \pm 2\kappa_k Q \left(\frac{z_*}{z}\right)^{\frac{2}{n-2}} \sin(2(z-z_*)) \right) \hat{A}_\pm = 0$$

Amplitude of $A_\pm$ in the Narrow Resonant Regime

Amplitude of $A_\pm$ in the Broad Resonant Regime