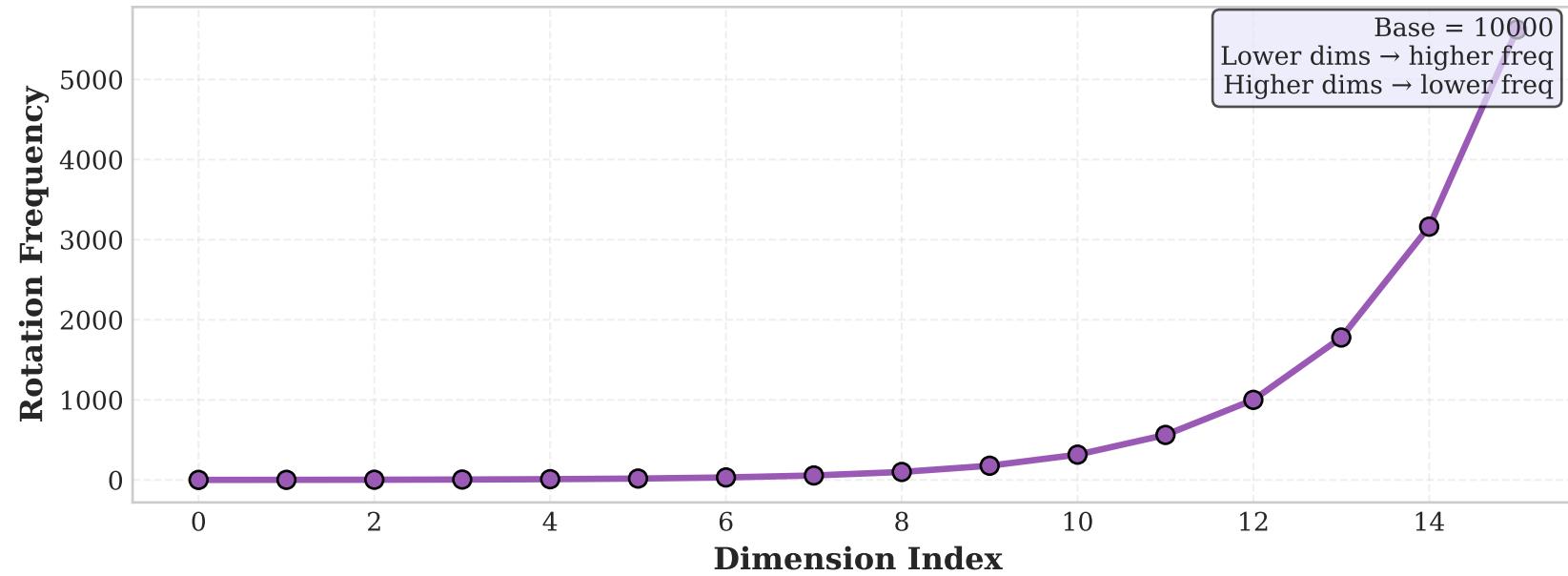
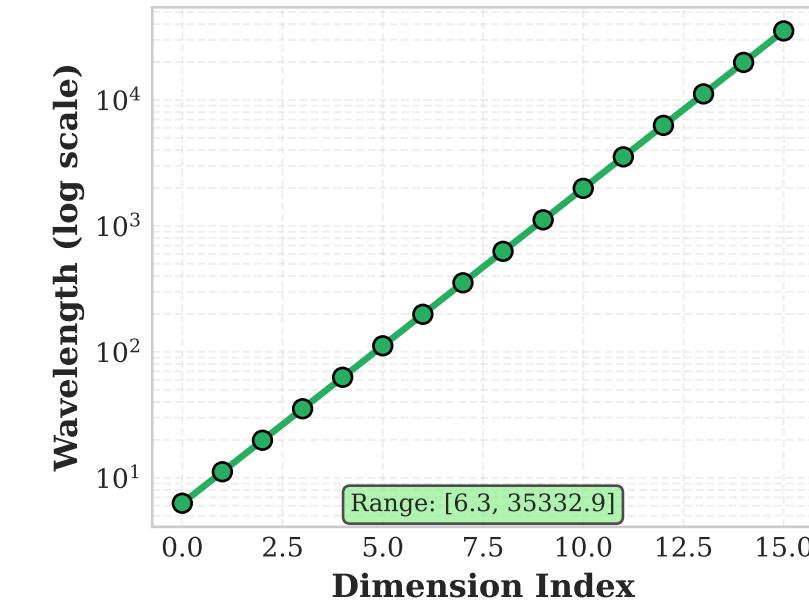


RoPE Mathematical Properties: Theoretical Analysis

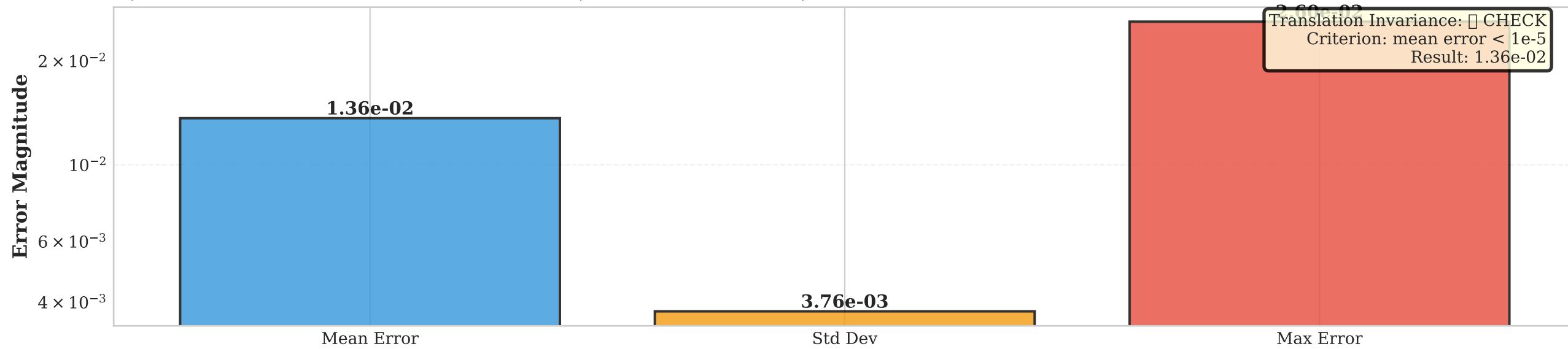
A) RoPE Frequency Spectrum ($\theta_i = 10000^{-2i/d}$, $d=32$)



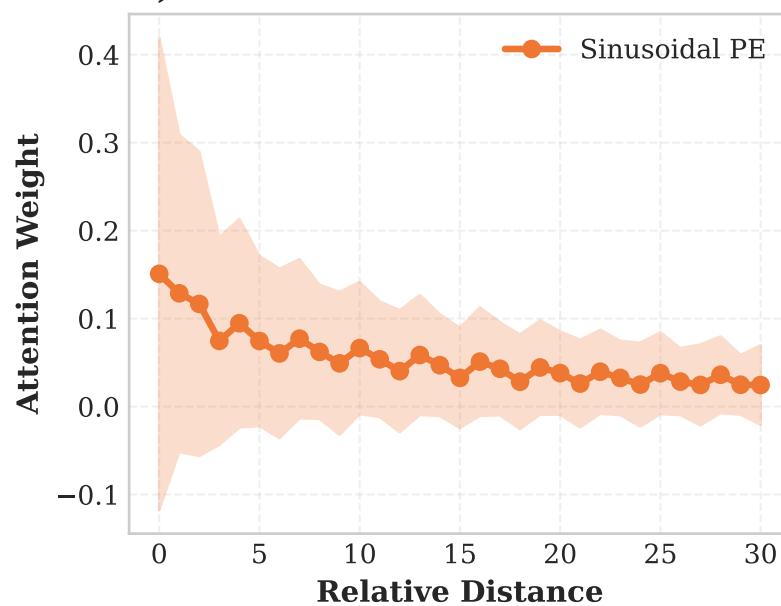
B) Wavelength Distribution



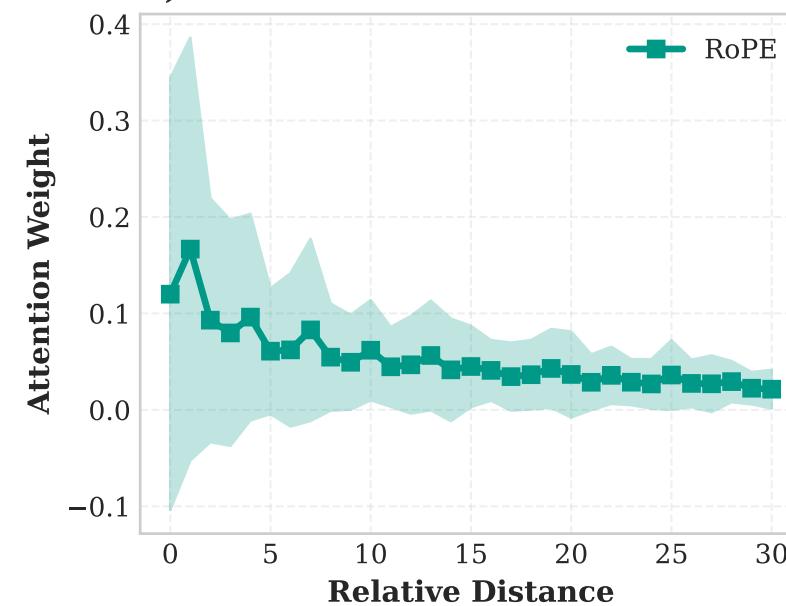
C) Translation Invariance Verification (Position Shift Test)



D) Sinusoidal Attention



E) RoPE Attention



F) Direct Comparison

