Probing the curvature of the cosmos from quantum entanglement due to gravity

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Gravity mediated entanglement in curved spacetime

- Path integrals: covariant and gauge invariant approach

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- Two massive non-interacting harmonic oscillators in in de Sitter: $ds^2 = a^2(\tau)\left(-d\tau^2 + d\mathbf{x}^2\right)$

dS effects

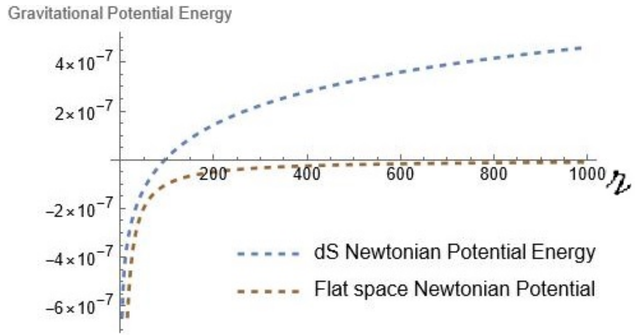

Figure: Gravitational potential energies in the "Newtonian" limits of dS and Minkowski. e consider the oscillators to have unit masses and take $G = 10^{-5}(\mathrm{GeV})^{-2}, H = 10^{-2}\mathrm{GeV}$, in units of $\hbar = c = 1$, to enhance the effect.

dS effects

The new potential is,

$$U_{\rm int}^{\rm dS} = -\frac{G\ m^2}{a\ \mathscr{r}} - 2Gm^2 H\ \ln\left(\frac{a}{aH\mathscr{r}+1}\right),$$

in the “Newtonian limit of dS”.

What does this mean for the oscillators and for entanglement?

Entanglement in dS

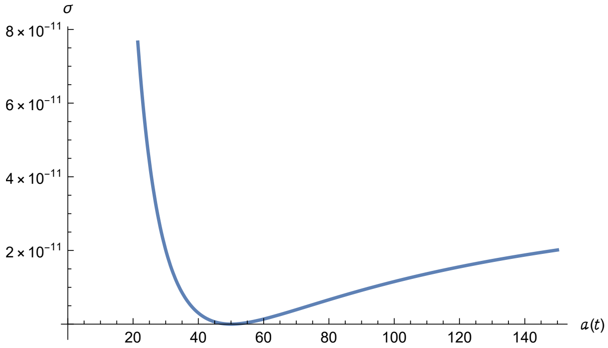

Figure: Entanglement entropy as a function of the scale factor from the gravitational interaction potential in dS. We consider unit masses with parameters $G = 10^{-5}(\mathrm{GeV})^{-2}, \omega = 0.1\mathrm{GeV}, H = 10^{-2}\mathrm{GeV}, d = 2\mathrm{GeV}^{-1}$ in units of $\hbar = c = 1$, to enhance the effect.

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- CMB photons and inflation