# Higgs pole inflation and its realizations

Hyun Min Lee

Chung-Ang University, Korea

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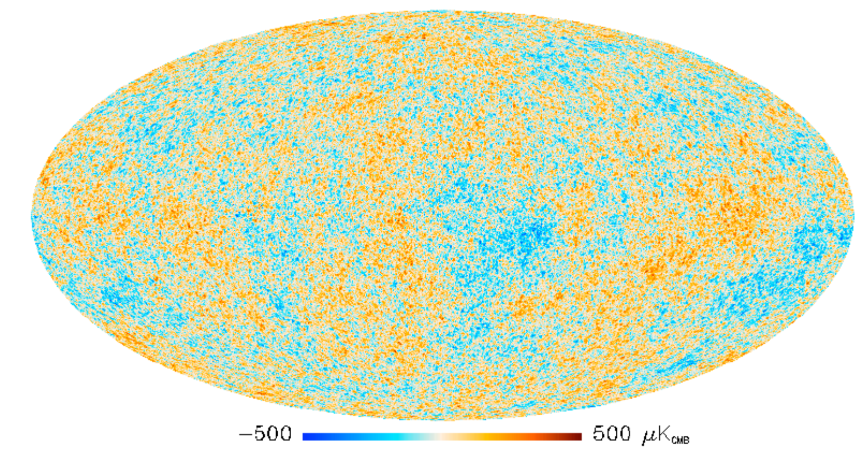
# Outline

- Introduction
- Higgs pole inflation and loop corrections
- UV complete pole inflation
- Conclusions

# Cosmic inflation



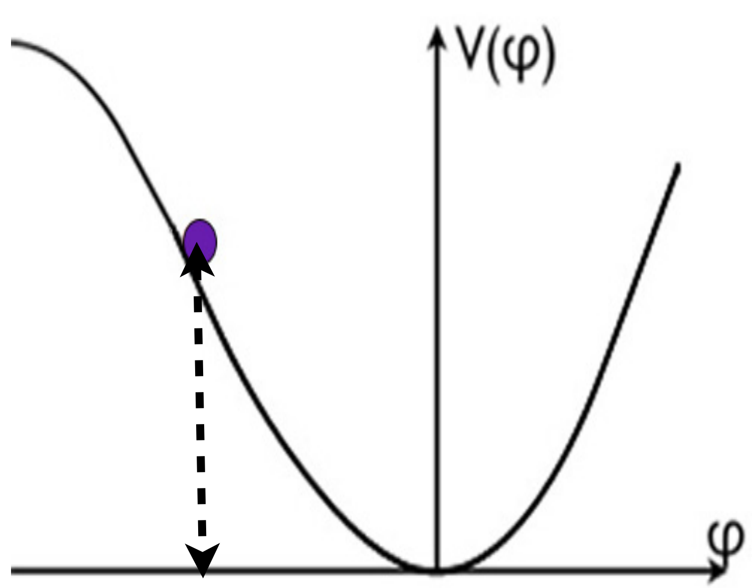
- Cosmic Inflation solves horizon, homogeneity, isotropy, flatness, relic problems, etc.




e.g. Cosmic Microwave Background homogeneous and isotropic at large distances

- "Slowly-rolling scalar (inflaton)" derives inflation and reheats the universe.

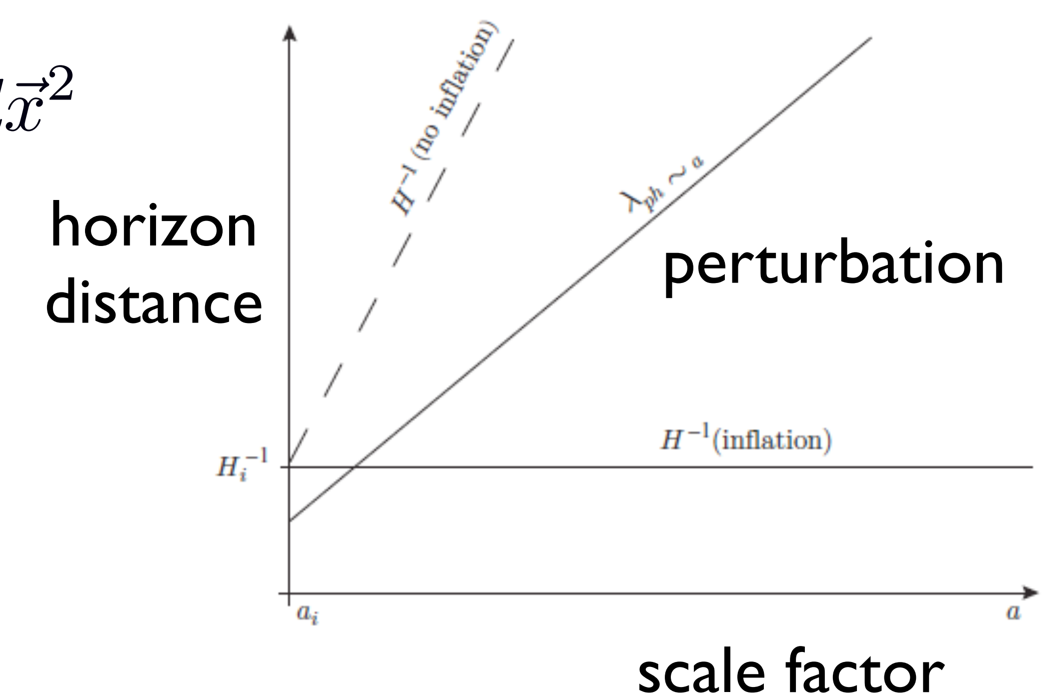
→ CMB anisotropies, galaxies, clusters, dark matter production




$$ds^2 = -dt^2 + a^2(t)d\vec{x}^2$$

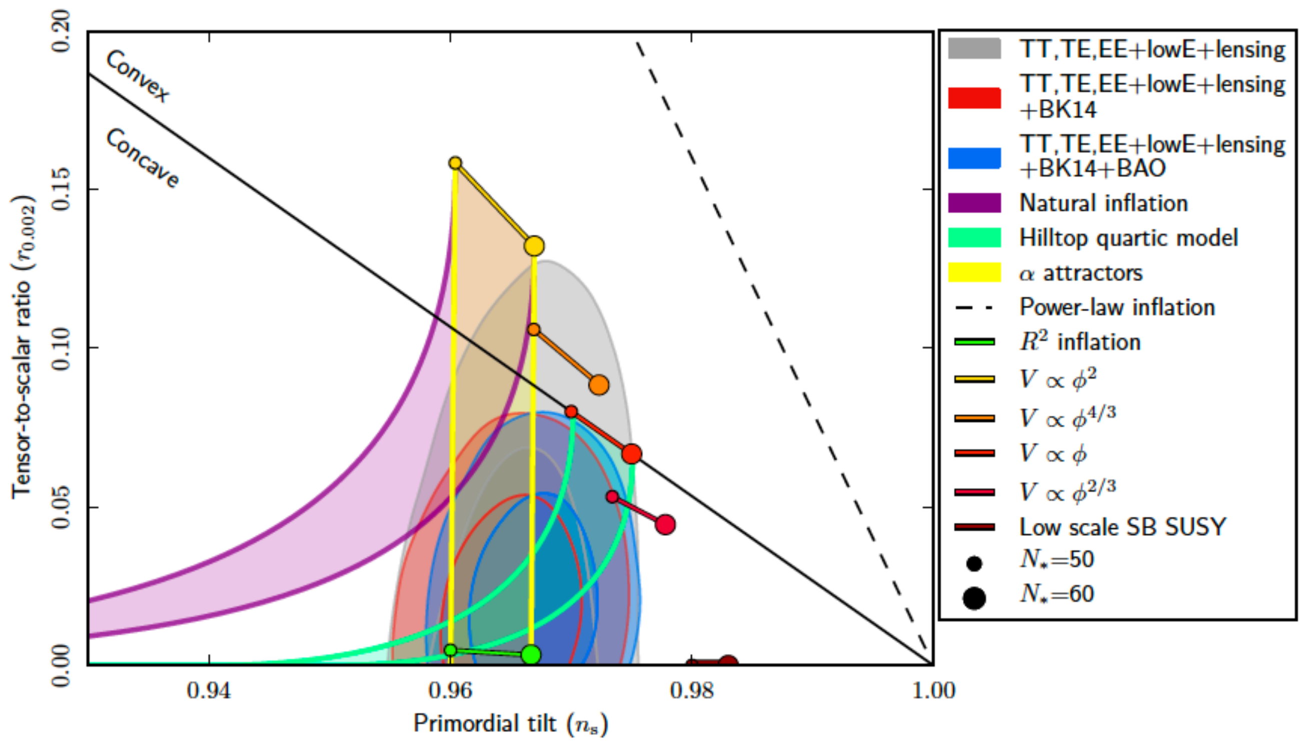
$$e^N = \frac{a_{\text{end}}}{a_*},$$

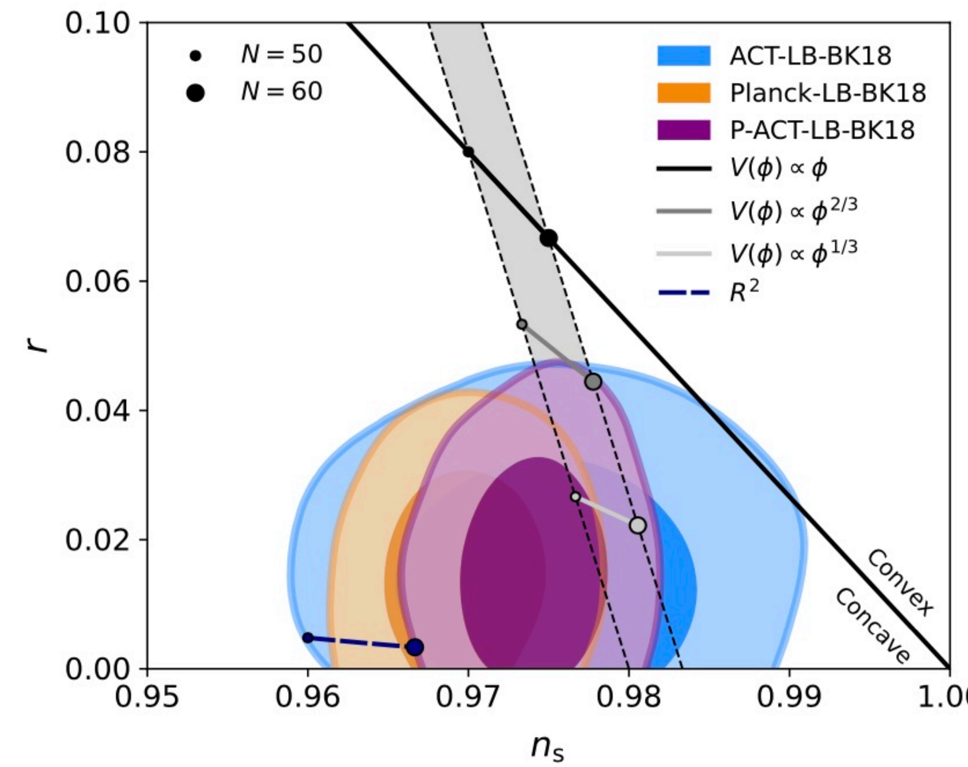
$$N \approx 60.$$



# Planck vs ACT






$n_s$=0.9665±0.0038 [Planck18+BAO] $n_s$=0.9743±0.0034 [Planck+ACT+BAO]

- Spectral tilt: almost scale-invariant CMB at large scales.

$$\langle \mathcal{R}(\vec{k})\mathcal{R}(\vec{k}')\rangle = \delta^3(\vec{k}-\vec{k}')\,\frac{2\pi^2}{k^3}\mathcal{P}_{\mathcal{R}}(k), \qquad \mathcal{P}_{\mathcal{R}}(k) \propto k^{n_s-1}, \quad n_s \approx 1$$

$$n_s = 1 - 6\epsilon + 2\eta, \quad \epsilon = \frac{M_P^2}{2}\left(\frac{V'}{V}\right)^2 \ll 1, \;\; \eta = M_P^2\frac{V''}{V} \ll 1.$$ "slow-roll inflation"

- Tensor perturbation: $r = 16\epsilon,$ r<0.035 [Planck18+BK18+BAO]

- Atacama Cosmology Telescope(2025): less red-tilt!

# Starobinsky model



- Starobinsky-like models are a best fit to Planck data.

$$n_s = 1 - \frac{2}{N}, \; r = \frac{12}{N^2} :$$ successful for N=40-80 at 95% C.L.

- Starobinsky model based on "pure gravity" is dual to a scalar-tensor theory.

[Starobinsky (1984)]

$$\mathcal{L} = \sqrt{-g}\left(\frac{R}{2} + \xi^2 R^2\right) \Longleftrightarrow \mathcal{L} = \sqrt{-g}\left(\frac{R}{2} + 2\xi\phi R - \phi^2\right)$$

$$\Longrightarrow \quad \mathcal{L}_E = \sqrt{-g_E}\left(\frac{R}{2} - \frac{1}{2}(\partial_\mu\chi)^2 - \frac{1}{16\xi^2}\left(1 - e^{-\sqrt{\frac{2}{3}}|\chi|}\right)^2\right)$$

Canonical kinetic terms

$g_{\mu\nu} \to g_{\mu\nu}/(1+4\xi\phi)$ $1 + 4\xi\phi = e^{\sqrt{\frac{2}{3}}|\chi|}$

One-parameter, $\xi \sim 10^4$

Successful for Planck.

# Pole inflation

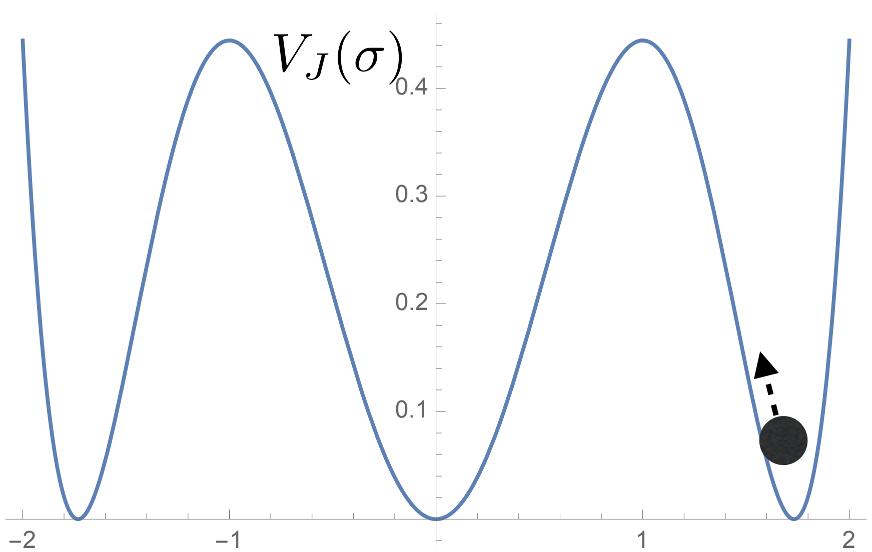


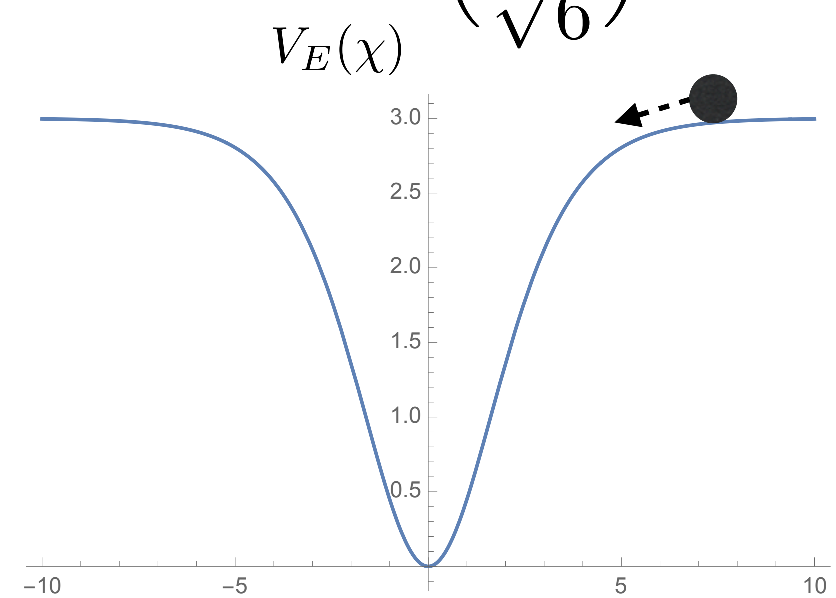
- Singlet scalar field σ with a conformal coupling:

$$\frac{\mathcal{L}_J}{\sqrt{-g_J}} = -\frac{1}{2}\left(1-\frac{1}{6}\sigma^2\right)R + \frac{1}{2}(\partial_\mu\sigma)^2 - V_J(\sigma)\,, \quad V_J = \beta_n\sigma^n\left(1-\frac{1}{6}\sigma^2\right)^2$$

$$\Rightarrow \quad \frac{\mathcal{L}_E}{\sqrt{-g_E}} = -\frac{1}{2}R + \boxed{\frac{1}{2}\frac{(\partial_\mu\sigma)^2}{\left(1-\frac{1}{6}\sigma^2\right)^2}} - \beta_n\sigma^n$$

$$= -\frac{1}{2}R + \frac{1}{2}(\partial_\mu\chi)^2 - 6^{n/2}\beta_n\tanh^n\left(\frac{\chi}{\sqrt{6}}\right)$$




Jordan frame potential

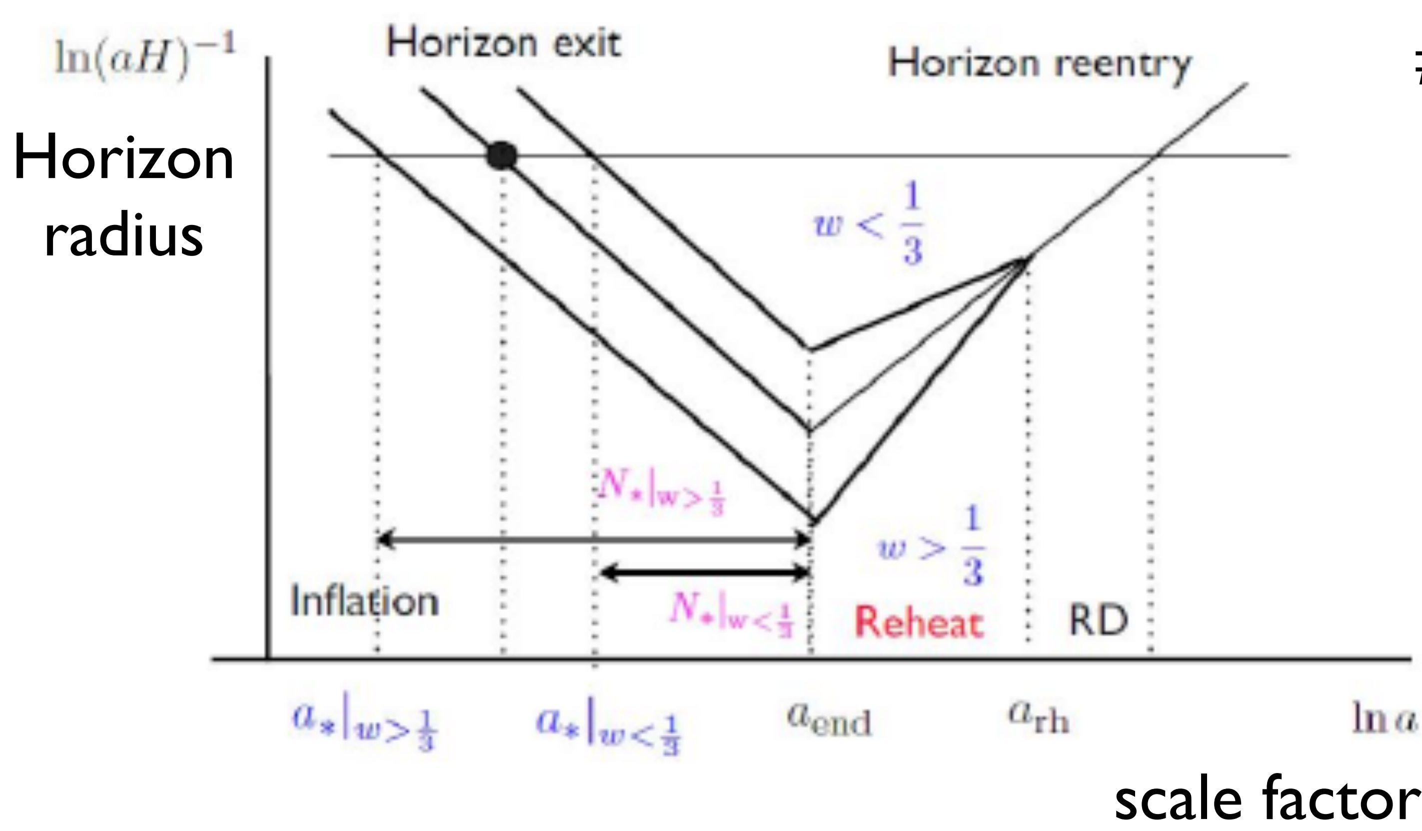
Einstein frame potential

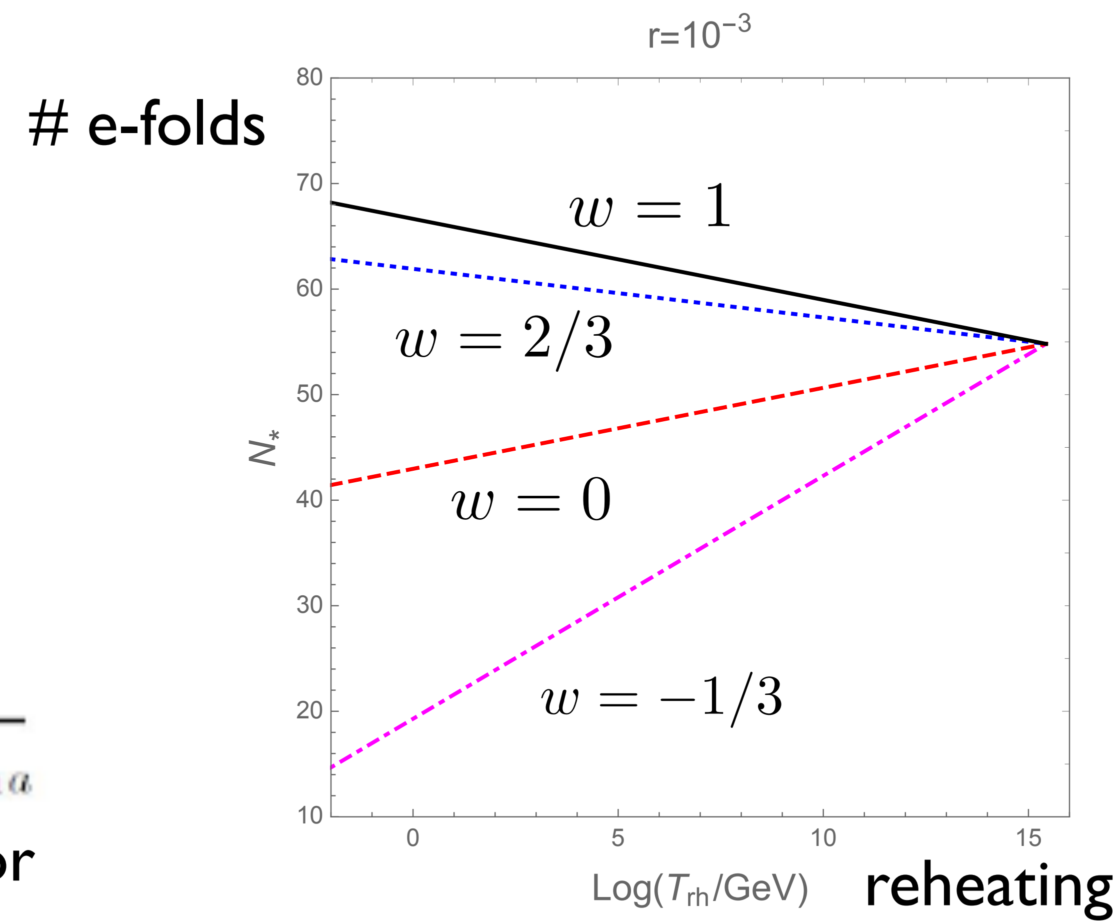
e.g. Kallosh, Linde, Roest (2013)

=> flat potential for slow-roll

# Reheating and spectral tilt






$\ln(aH)^{-1}_{\rm rh} \sim \frac{1}{2}(1+3w)\ln a,$ w: equation of state

[S.-M. Choi, HML (2016)]

The number of e-foldings for solving the horizon problem is subject to the details of reheating dynamics.

$$N_* = 61.4 + \frac{3w-1}{12(1+w)}\ln\left(\frac{45}{\pi^2}\frac{V_*}{g_*(T_{\rm rh})T^4_{\rm rh}}\right) - \ln\left(\frac{V_*^{1/4}}{H_*}\right).$$

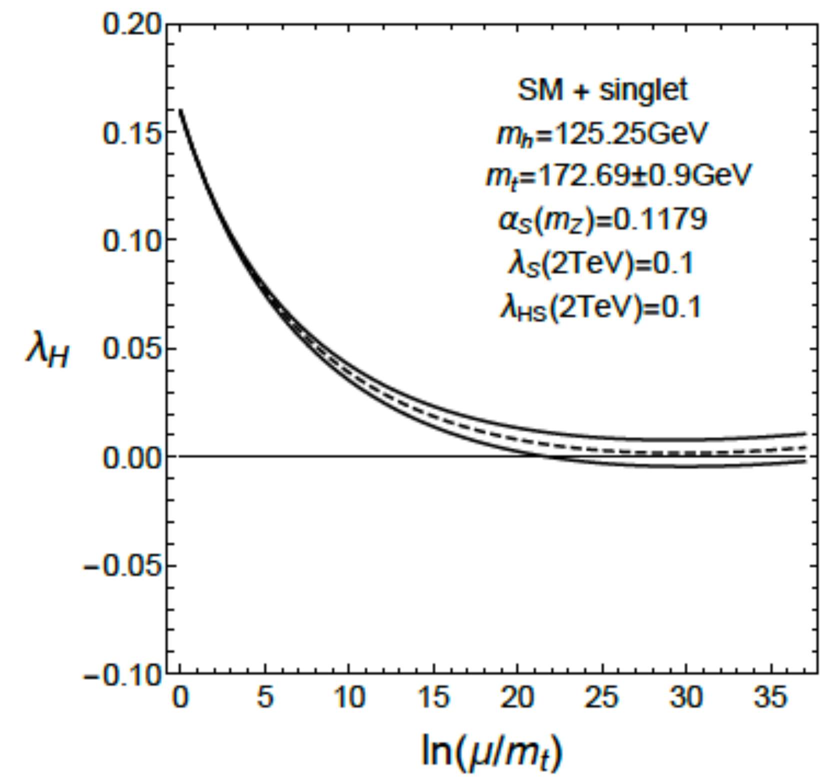
Red tilt needs “Larger N”(w>1/3) or loop corrections.

# Running inflaton potential



- Parametrize the loop corrections to the pole inflation.

$$\lambda_H(h) = \lambda_{H,e} + \underbrace{b_1 \left( \ln \frac{\mu(h)}{\mu(h_e)} \right)}_{\text{one-loop}} + \underbrace{b_2 \left( \ln \frac{\mu(h)}{\mu(h_e)} \right)^2}_{\text{two-loop}}$$




$$\xrightarrow[\text{inflaton}]{\text{canonical}} \quad \lambda_H(\phi) = 9\left( \lambda_{H,e} + \frac{b_1}{\sqrt{6}}(\phi - \phi_e) + \frac{b_2}{6}(\phi - \phi_e)^2 \right)$$

Running inflaton potential:

$$V_{E,\text{loops}} \simeq 9\left( \lambda_{H,e} + \underbrace{\frac{b_1}{\sqrt{6}}(\phi - \phi_e) + \frac{b_2}{6}(\phi - \phi_e)^2}_{\text{Power corrections in inflaton field}} \right) \left[ \tanh\left( \frac{\phi}{\sqrt{6}} \right) \right]^4$$

[J. Han, HML, J. Song(2025)]

# Symmetries for pole inflation



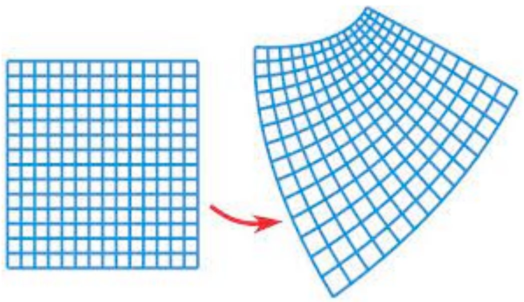
- Higgs potential almost vanishes at high energies.

Conformal or Weyl symmetry $x^\mu \to e^\alpha x^\mu : \ \alpha = \alpha(x),$

$$g_{\mu\nu} \to e^{2\alpha(x)} g_{\mu\nu}, \qquad \chi \to e^{-\alpha(x)}\chi, \quad \text{Dilaton}$$

$$\phi_i \to e^{-\alpha(x)}\phi_i, \qquad w_\mu \to w_\mu - \frac{1}{g_w}\partial_\mu \alpha(x).$$

Higgs Weyl photon



- Weyl gravity and isometry

[HML, PRL 2025]

$$\boxed{\chi^2 - \sigma^2 \to \chi'^2 - \sigma'^2}$$

SO(1,1)→SO(1,N)


Herman Weyl(1918)

$$\frac{\mathcal{L}_J}{\sqrt{-g_J}} = (1+a)\left[-\frac{1}{12}(\chi^2-\sigma^2)R - \frac{1}{2}(\partial_\mu\chi)^2 + \frac{1}{2}(\partial_\mu\sigma)^2\right]$$

$$+\frac{1}{2}a(D_\mu\chi)^2 - \frac{1}{2}a(D_\mu\sigma)^2 - \frac{1}{4}w_{\mu\nu}w^{\mu\nu} - V(\chi,\sigma)$$

# Higgs pole inflation and loop corrections

# Higgs pole inflation



- Consider the Higgs field near conformal coupling:

Jordan-frame: $$\frac{\mathcal{L}_J}{\sqrt{-g_J}} = -\frac{1}{2}M_P^2\,\underline{\Omega(H)}R(g_J) + |D_\mu H|^2 - \underline{V_J(H)}$$

$$\begin{cases} \Omega = 1 - \frac{1}{3M_P^2}|H|^2 : & \text{"conformal coupling" [S. Clery, HML, A. Menkara (2023)]} \\ V_J(H) = c_m \Lambda^{4-2m}|H|^{2m}\left(1 - \frac{1}{3M_P^2}|H|^2\right)^2 & \text{"Jordan-frame Higgs potential"} \end{cases}$$

Einstein-frame: $$\frac{\mathcal{L}_E}{\sqrt{-g_E}} = -\frac{1}{2}M_P^2 R(g_E) + \frac{|D_\mu H|^2}{\left(1-\frac{1}{3M_P^2}|H|^2\right)^2} - \frac{1}{3M_P^2}\left(|H|^2|D_\mu H|^2 - \frac{1}{4}\partial_\mu|H|^2\partial^\mu|H|^2\right) - \frac{V_J(H)}{\left(1-\frac{1}{3M_P^2}|H|^2\right)^2}$$

$$g_{J,\mu\nu} = g_{E,\mu\nu}/\Omega$$

Unitary gauge: $H^T = (0,h)/\sqrt{2} \longrightarrow |H|^2|D_\mu H|^2 - \frac{1}{4}\partial_\mu|H|^2\partial^\mu|H|^2 = 0$

$$\Rightarrow \frac{\mathcal{L}_E}{\sqrt{-g_E}} = -\frac{1}{2}M_P^2 R + \frac{1}{2}\underline{\frac{(\partial_\mu h)^2}{\left(1-\frac{1}{6M_P^2}h^2\right)^2}} - \frac{c_m}{2^m}\Lambda^{4-2m}h^{2m}$$ : Pole inflation type!

# Predictions from pole inflation



- Take the monomial Higgs potential in Einstein frame.

$$V_E(H) = \underline{c_m \Lambda^{4-2m} |H|^{2m}}$$

$\longleftrightarrow$ Jordan frame: $V_J(H) = \underline{c_m \Lambda^{4-2m} |H|^{2m} \left(1 - \frac{1}{3M_P^2}|H|^2\right)^2}$

Canonical inflaton: $h = \sqrt{6} M_P \tanh\left(\frac{\phi}{\sqrt{6}M_P}\right)$

$\longrightarrow$ $V_E(\phi) = 3^m c_m \Lambda^{4-2m} M_P^{2m} \left[\tanh\left(\frac{\phi}{\sqrt{6}M_P}\right)\right]^{2m}$ "Higgs pole inflation"

- Inflationary predictions:

Spectral index

$$n_s = 1 - \frac{4N+3}{2\left(N^2 - \frac{9}{16m^2}\right)}$$

Tensor-to-scalar ratio

$$r = \frac{12}{N^2 - \frac{9}{16m^2}}$$

CMB normalization

$$3^m c_m \left(\frac{\Lambda}{M_P}\right)^{4-2m} = (3.1 \times 10^{-8})\, r$$

$\boxed{n_s = 0.966,\ r = 0.0033}$ insensitive to m

Higgs quartic coupling

$$\lambda_H \lesssim 1.1 \times 10^{-11}$$

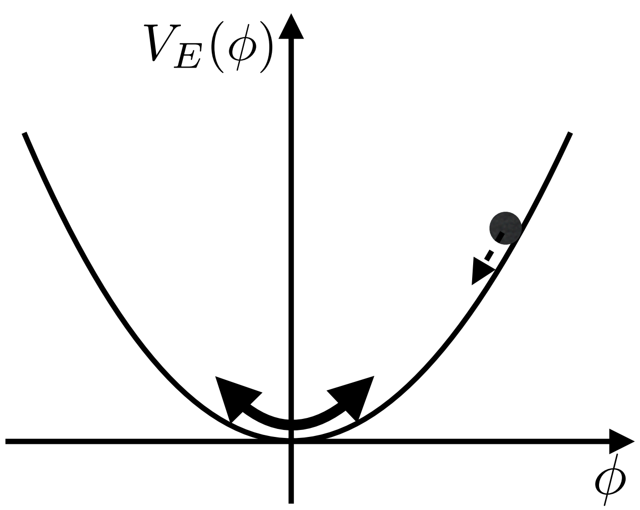
# Reheating from Higgs

- Perturbative reheating from inflaton decay/scattering. 

$$\dot{\rho}_\phi + 3(1+w_\phi)H\rho_\phi \simeq -\Gamma_\phi(1+w_\phi)\rho_\phi \,, \qquad \dot{\rho}_R + 4H\rho_R = \Gamma_\phi(1+w_\phi)\rho_\phi$$

$$\Gamma_\phi = \sum_f \Gamma_{\phi\to f\bar{f}} + \sum_{V=W,Z} \Gamma_{\phi\phi\to VV}$$ decays for heavy particles (t, W, Z) suppressed

[S. Clery, HML, A. Menkara (2023)]




$m \geq 2$

$$w_\phi = \frac{m-1}{m+1} \geq \frac{1}{3}$$

| $m$ | $T_{\rm RH}$ [GeV] |
|---|---|
| 1 | $5.1 \times 10^{13}$ |
| 2 | $2.6 \times 10^{9}$ |
| 3 | 260 |
| 4 | $9.4 \times 10^{5}$ |
| 5 | $2.1 \times 10^{7}$ |
| 6 | $1.1 \times 10^{8}$ |
| 7 | $2.8 \times 10^{8}$ |
| 8 | $4.9 \times 10^{8}$ |
| 9 | $8.4 \times 10^{8}$ |
| 10 | $1.2 \times 10^{9}$ |

$\Delta N_{\rm reh} > 0$ & low reheating

$\longrightarrow$ favored to explain ACT

But, Preheating might be also important!

[HML, A. Menkara, J.-H, Yoon, work in progress]

# Loops in Higgs pole inflation



- The loop corrections to the Higgs inflaton potential shift the inflationary predictions.

$$V_{\rm CW} = \sum_\alpha \frac{N_\alpha}{64\pi^2} M_\alpha^4 \left( \ln \frac{M_\alpha^2}{\mu^2} - C_\alpha \right)$$

[J. Han, HML, J. Song(2025)]

SM:

$$\begin{aligned} M_W^2 &= \frac{g^2 h^2}{4(1-\frac{1}{6}h^2)} = \frac{3}{2} g^2 M_P^2 \sinh^2\left(\frac{\phi}{\sqrt{6}M_P}\right), \\ M_Z^2 &= \frac{(g^2+g'^2)h^2}{4(1-\frac{1}{6}h^2)} = \frac{3}{2}(g^2+g'^2) M_P^2 \sinh^2\left(\frac{\phi}{\sqrt{6}M_P}\right) \end{aligned}$$

$$m_f = \frac{1}{\sqrt{2}} \frac{y_f h}{\sqrt{1-\frac{1}{6}h^2}} \qquad m_{G_i}^2 = \lambda_H h^2 \left(1 - \frac{1}{6}h^2\right),$$

Singlet scalar:

$$M_S^2 = m_S^2 + \frac{\lambda_{HS} h^2}{\sqrt{1-\frac{1}{6}h^2}}$$

$$\xrightarrow[\mu = c_* h/\sqrt{\Omega}]{} \quad V_E(h) \approx \frac{1}{4}\lambda_H(h) h^4 + \frac{1}{6}\lambda_6(h) h^6$$

"Running potential"

$$\begin{aligned} \frac{d\lambda_H}{d\ln\mu} &= \frac{1}{8\pi^2}\left(\frac{3}{16}(g^2+g'^2)^2 + \frac{3}{8}g^4 - 3y_t^4 + 12\lambda_H^2 + \lambda_{HS}^2\right) - 4\gamma_h \lambda_H, \\ \frac{d\lambda_6}{d\ln\mu} &= \frac{3}{16\pi^2}\left(\frac{1}{16}(g^2+g'^2)^2 + \frac{1}{8}g^4 - y_t^4 - 9\lambda_H^2 + \frac{1}{3}\lambda_{HS}^2\right) - 6\gamma_h \lambda_6 \end{aligned}$$

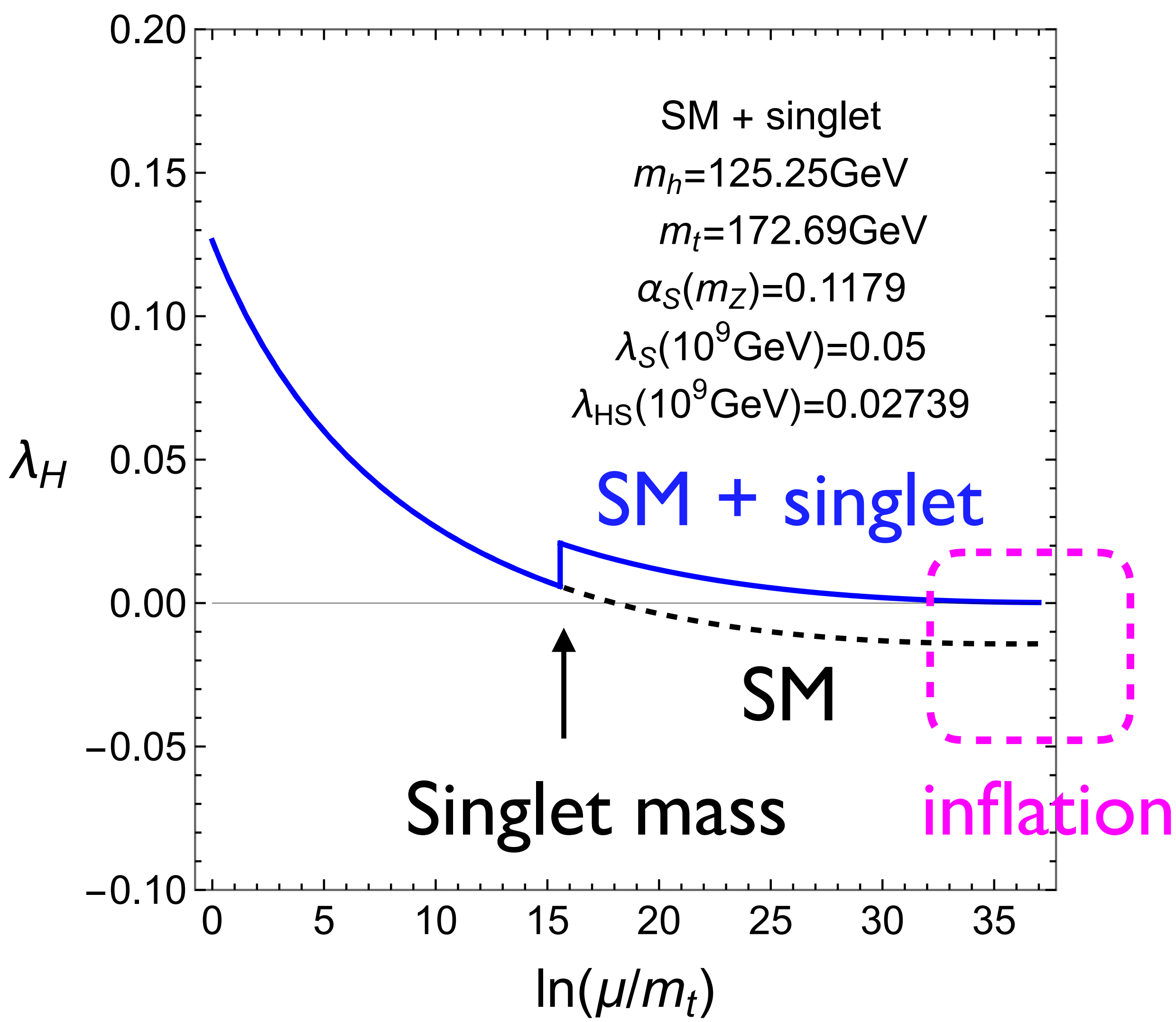
Higgs quartic coupling can be small at high scale due to singlet coupling.

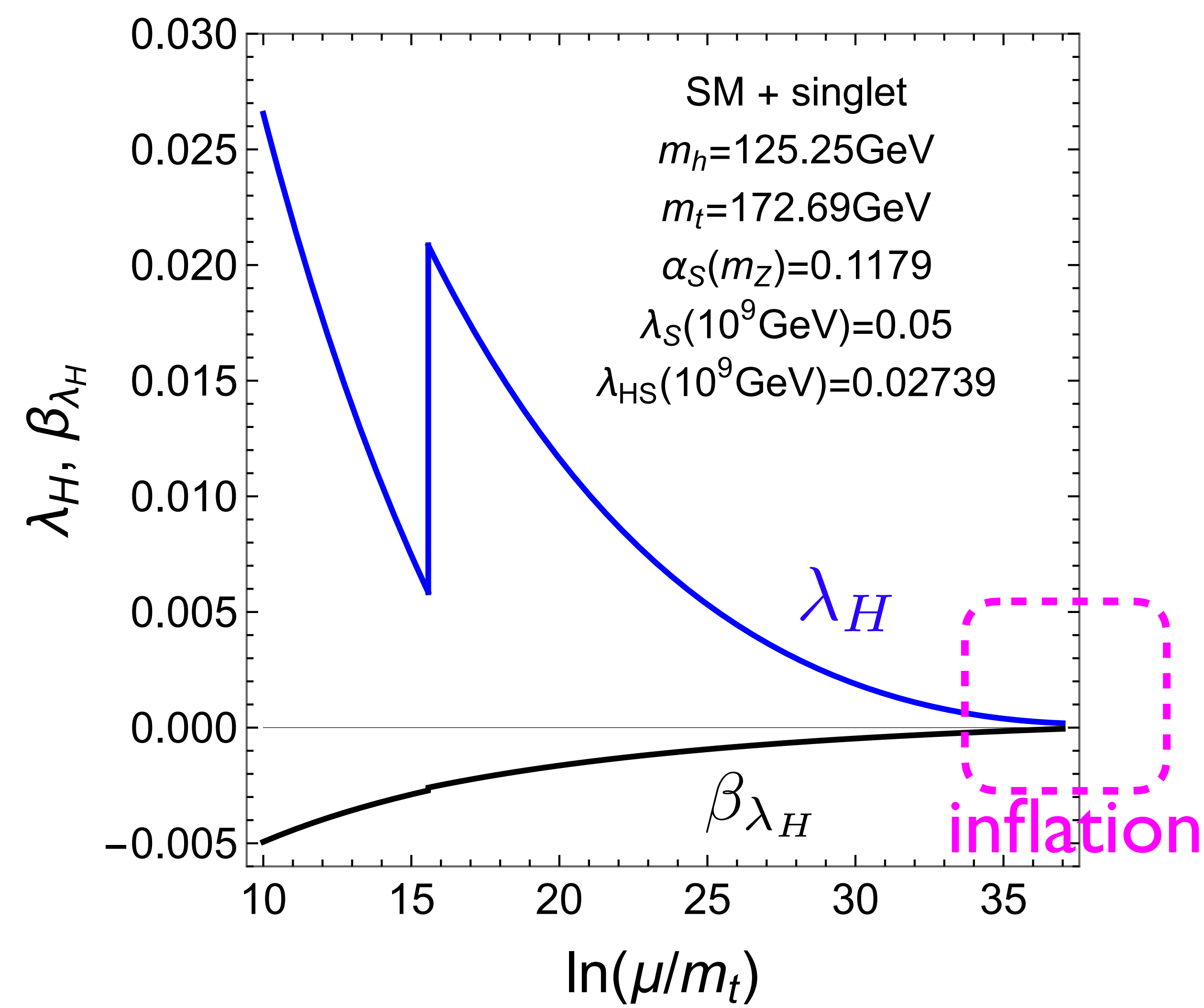
# SM-like loops



- Singlet scalar below the instability scale in SM:

  Higgs quartic coupling is subject to tree-level shift + two-loop effects. [J. Han, HML, J. Song(2025)]



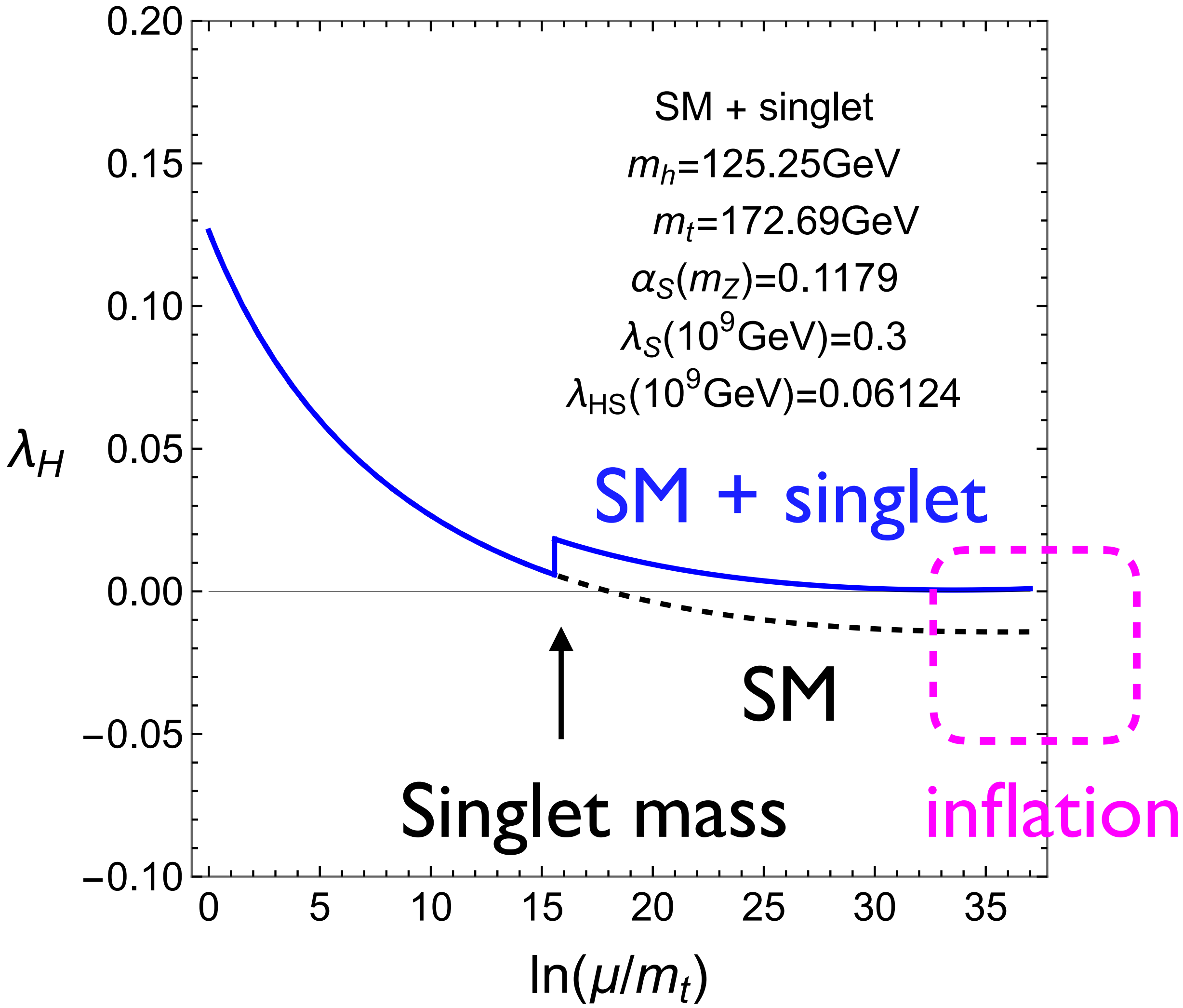

Higgs-portal increases beta function but small & "negative".

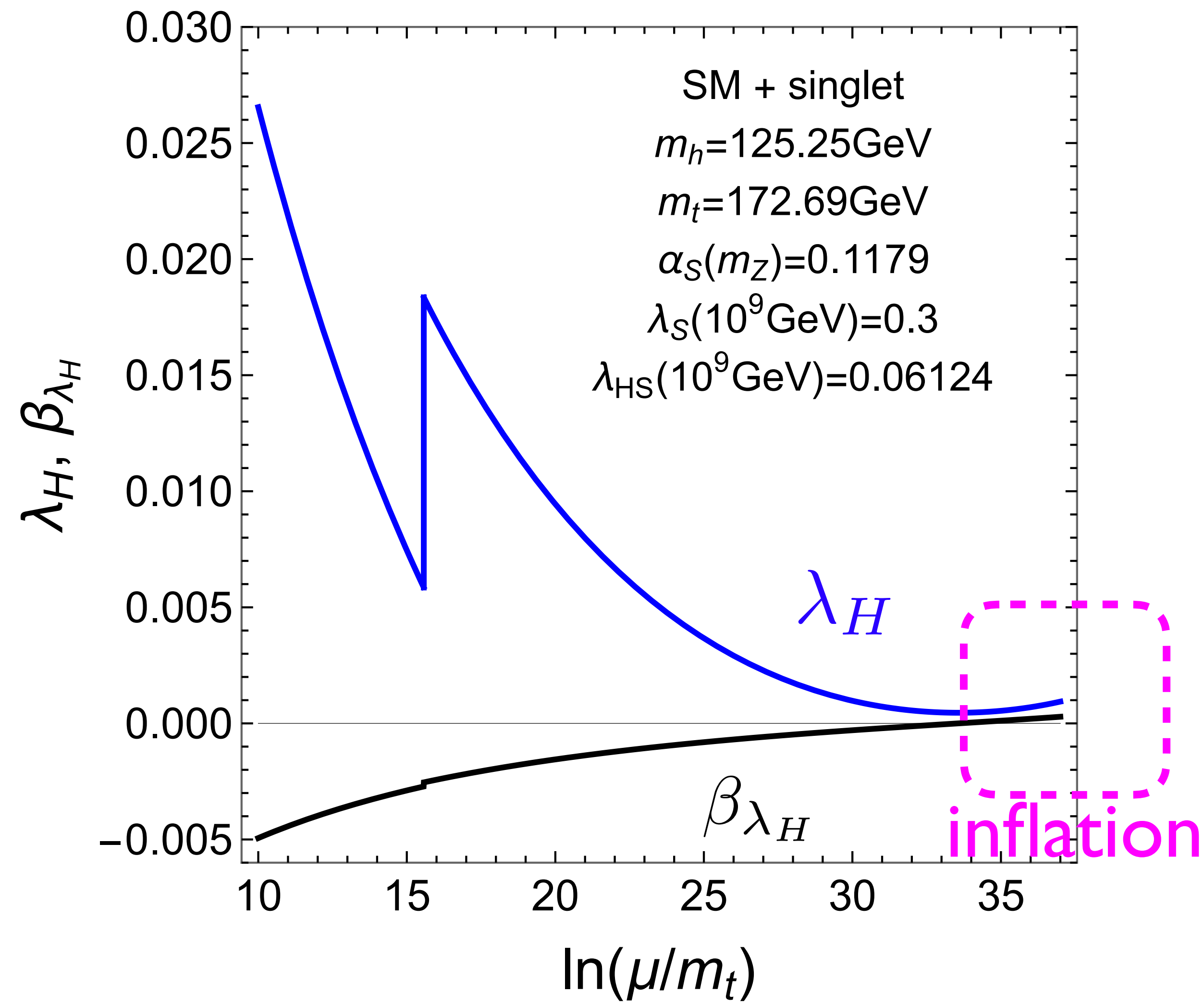
# Singlet scalar dominated



- Singlet scalar below the instability scale in SM:

Higgs quartic coupling is subject to tree-level shift + two-loop effects. [J. Han, HML, J. Song(2025)]




Stronger Higgs-portal drives beta function small and positive.

# Running pole potential



- Parametrize the loop corrections to the pole inflation.

$$\lambda_H(h) = \lambda_{H,e} \underbrace{+\, b_1}_{\text{one-loop}} \left( \ln \frac{\mu(h)}{\mu(h_e)} \right) \underbrace{+\, b_2}_{\text{two-loop}} \left( \ln \frac{\mu(h)}{\mu(h_e)} \right)^2$$

$\longrightarrow$ canonical inflaton: $\lambda_H(\phi) = \; 9\Big( \lambda_{H,e} + \frac{b_1}{\sqrt{6}}(\phi-\phi_e) + \frac{b_2}{6}(\phi-\phi_e)^2 \Big)$

Running inflaton potential:

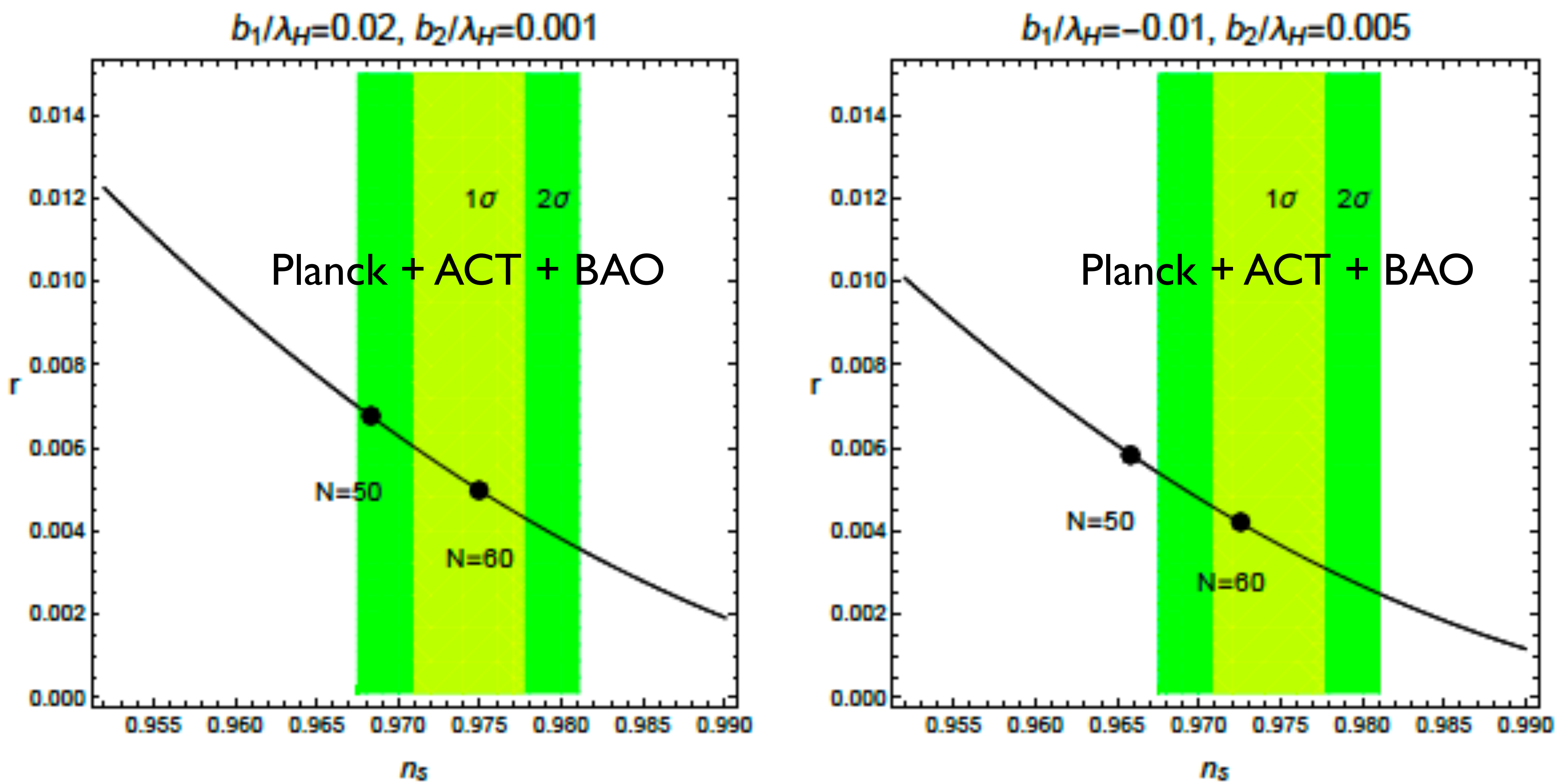
$$V_{E,\mathrm{loops}} \simeq 9\Big( \lambda_{H,e} + \underline{\frac{b_1}{\sqrt{6}}(\phi-\phi_e) + \frac{b_2}{6}(\phi-\phi_e)^2} \Big) \left[ \tanh\left( \frac{\phi}{\sqrt{6}} \right) \right]^4$$

[J. Han, HML, J.-Song(2025)]

Loops => Power corrections to inflaton potential

# Loops and spectral tilt






[J. Han, HML, J. Song(2025)]

| | |
|---|---|
| Planck + ACT + BAO | $n_s = 0.9743 \pm 0.0034$ |
| Planck + Keck | $r < 0.036$ at 95% CL |

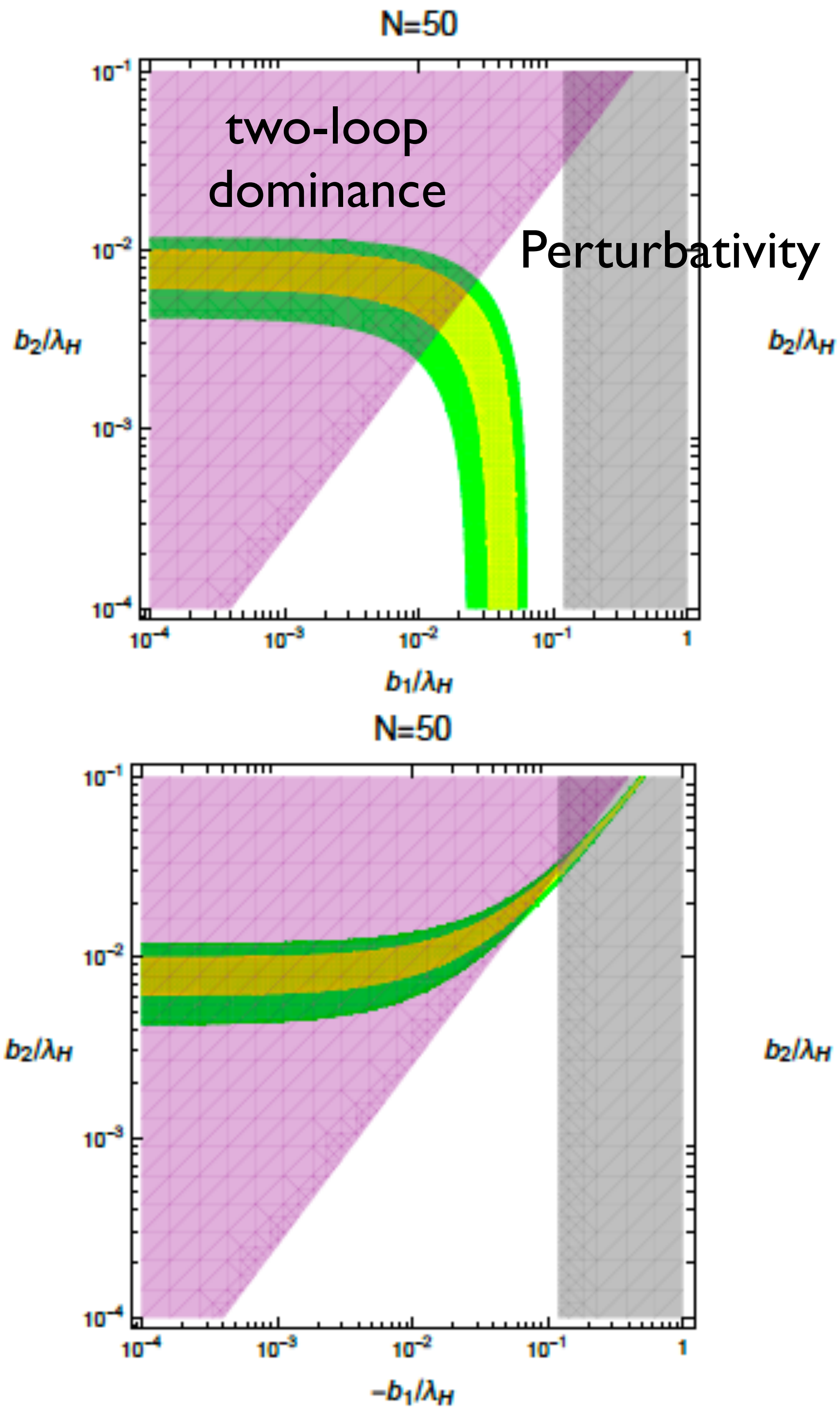
$$n_s = 1 - \frac{2}{N} + \underline{\frac{6b_1 + 9b_2 + 2\sqrt{6}b_2(\phi_* - \phi_e)}{18\lambda_{H,*}} - \frac{6b_1 + 3b_2 + 2\sqrt{6}b_2(\phi_* - \phi_e)}{12\lambda_{H,*}N}},$$

$$r = \frac{12}{N^2} + \underline{\frac{2(6b_1 + 3b_2 + 2\sqrt{6}b_2(\phi_* - \phi_e))}{3\lambda_{H,*}N}}$$

Loops!

# Beta functions in light of ACT






Planck + ACT + BAO

$n_s = 0.9743 \pm 0.0034$

$b_1 > 0$

One-loops are sufficient!

[J. Han, HML, J. Song(2025)]

$b_1 < 0$

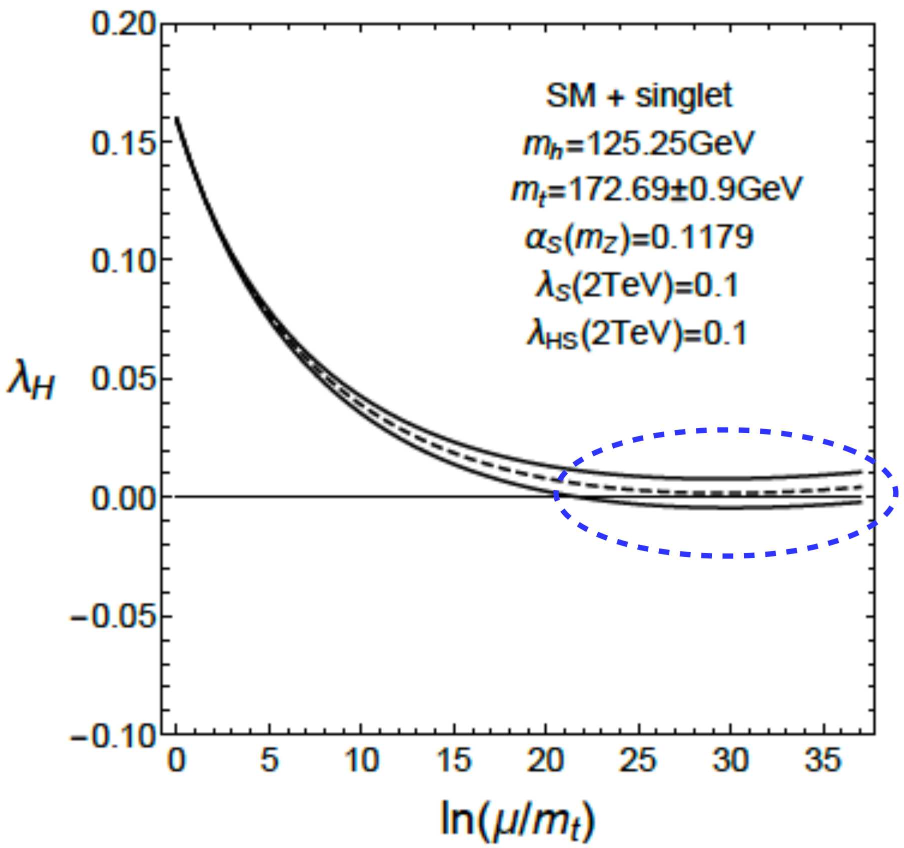
Two-loops are necessary!

# UV-complete pole inflation

# Higgs and Wely symmetry

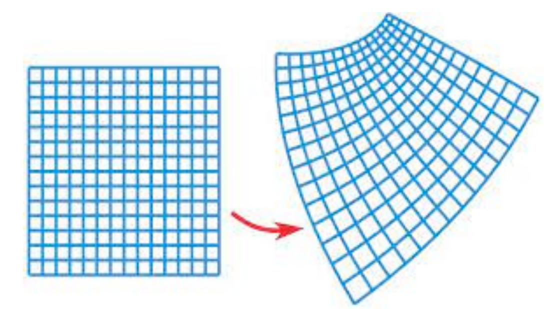


- Higgs potential almost vanishes at high energies.




Conformal or Weyl symmetry

$$x^\mu \to e^\alpha \, x^\mu \; : \;\; \alpha = \alpha(x),$$



=> Local transformations

$$g_{\mu\nu} \to e^{2\alpha(x)} g_{\mu\nu}, \qquad \chi \to e^{-\alpha(x)}\chi,$$ Dilaton

$$\phi_i \to e^{-\alpha(x)}\phi_i, \qquad w_\mu \to w_\mu - \frac{1}{g_w}\partial_\mu \alpha(x),$$

Higgs Weyl photon

- Weyl gravity and Higgs [HML, PRL 2025]

$$\frac{\mathcal{L}_J}{\sqrt{-g_J}} = (1+a)\Big[-\frac{1}{12}(\chi^2-\sigma^2)R - \frac{1}{2}(\partial_\mu\chi)^2 + \frac{1}{2}(\partial_\mu\sigma)^2\Big]$$

Dilaton Higgs

$$+\frac{1}{2}a(D_\mu\chi)^2 - \frac{1}{2}a(D_\mu\sigma)^2 - \frac{1}{4}w_{\mu\nu}w^{\mu\nu} - V(\chi,\sigma)$$

Herman Weyl(1918)

# UV-complete pole inflation



- Impose the global SO(1,1) in Weyl gravity:

$$\boxed{\chi^2 - \sigma^2 \to \chi'^2 - \sigma'^2}$$

[HML, PRL 2025]

$$\frac{\mathcal{L}_J}{\sqrt{-g_J}} = (1+a)\Big[-\frac{1}{12}\underline{(\chi^2-\sigma^2)}R \underline{-\frac{1}{2}(\partial_\mu\chi)^2+\frac{1}{2}(\partial_\mu\sigma)^2}\Big]$$
$$\underline{+\frac{1}{2}a(D_\mu\chi)^2-\frac{1}{2}a(D_\mu\sigma)^2}-\frac{1}{4}w_{\mu\nu}w^{\mu\nu}-V(\chi,\sigma),$$

Weyl covariant derivatives: $D_\mu\chi = (\partial_\mu - g_w w_\mu)\chi, \quad D_\mu\phi_i = (\partial_\mu - g_w w_\mu)\phi_i,$

Weyl covariant potential: $V(\chi,\sigma) = \underline{F(\sigma^2/\chi^2)}(\chi^2-\sigma^2)^2$

SO(1,1) breaking

Gauge fixing ⟶ Newton constant: $G_N = \frac{1}{8\pi M_P^2} = \frac{6}{(1+a)\langle\chi\rangle^2}$

$\langle\chi\rangle = \sqrt{\frac{6}{1+a}}$

Weyl photon mass: $m_w^2 = \frac{6ag_w^2}{1+a}M_P^2$

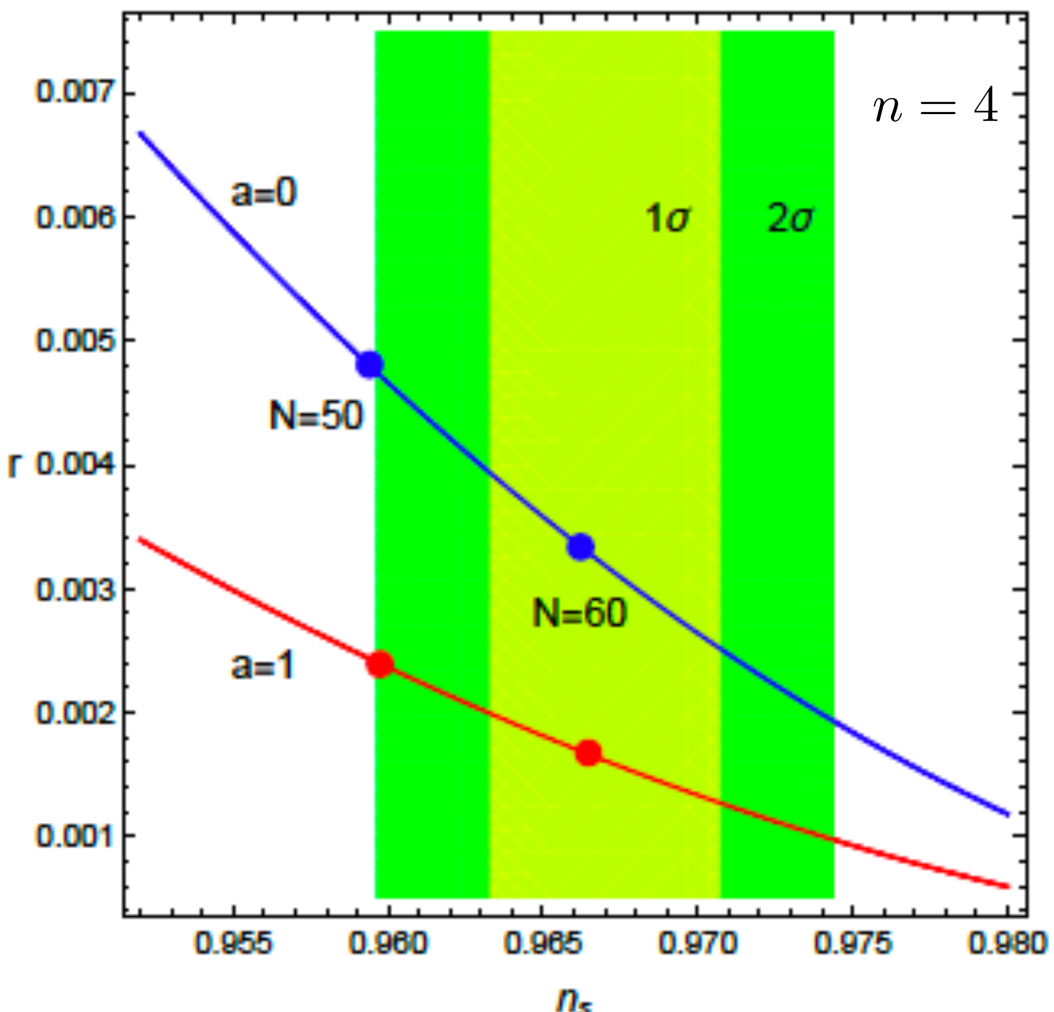
# Pole inflation and Weyl photon



- Gauge-fixed Lagrangian in Einstein frame:

$$\frac{\mathcal{L}_E}{\sqrt{-g_E}} = -\frac{1}{2}R + \frac{1}{2}\frac{(\partial_\mu\sigma)^2}{\left(1-\frac{1}{6}(1+a)\sigma^2\right)^2} - V_E(\sigma) - \underbrace{\frac{1}{4}\widetilde{w}_{\mu\nu}\widetilde{w}^{\mu\nu} + \frac{1}{2}m_w^2\widetilde{w}_\mu\widetilde{w}^\mu}_{\text{minimally coupled}},$$

SO(1,1) breaking: $V_E(\sigma) = F(\sigma^2/\langle\chi^2\rangle) = \beta_n\sigma^n, \quad \beta_n = \frac{\alpha_n}{\langle\chi^n\rangle}$




[HML, PRL 2025]

=> pole inflation with "shifted" pole:

$$\boxed{n_s \simeq 1 - \frac{2}{N}, \quad r \simeq \frac{12}{(1+a)N^2}, \quad m_w^2 = \frac{6ag_w^2}{1+a}M_P^2}$$

$$\sigma \longrightarrow \phi_i, \; i = 1, 2, \cdots, N,$$

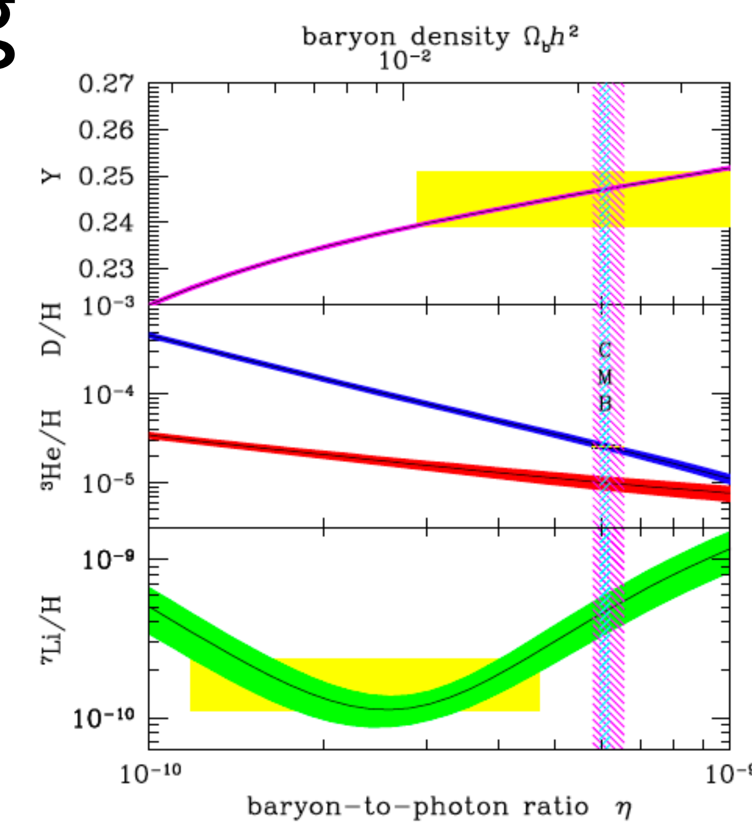
SO(1,N)→SO(N):

$\left\{ \begin{array}{l} \text{N=4: Higgs pole inflation,} \\ \text{N=2: PQ pole inflation.} \end{array} \right.$

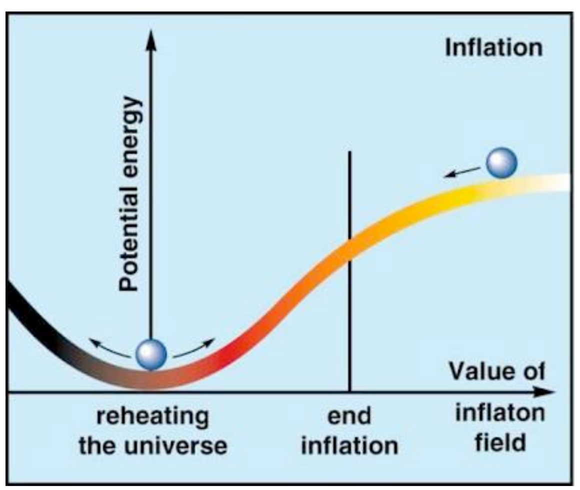
# Conformal reheating



- Reheating is necessary for Big Bang Nucleosynthesis.




SO(1,4)→SO(4): $V_E = \lambda_H |H|^4 - m_H^2 |H|^2$




$$V_E \simeq \lambda_H |H|^4 = \frac{1}{4}\lambda_H \psi^4$$

$$\longrightarrow \quad w_\psi = \frac{1}{3}$$

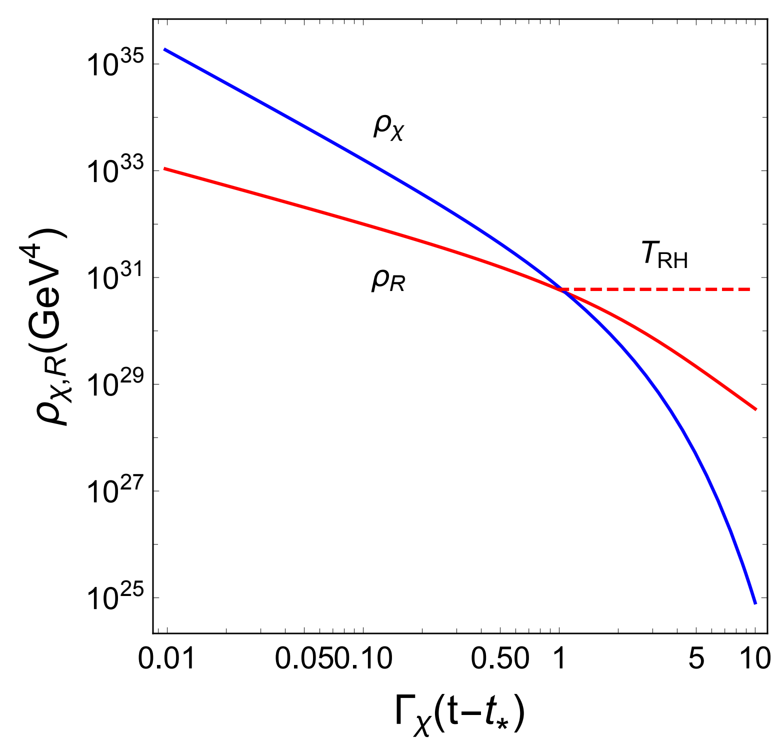
"radiation-like"

Reheating as in Higgs/PQ pole inflation:

$$\dot\rho_\psi + 3(1+w_\psi) H \rho_\psi = -(1+w_\psi)\Gamma_\psi \rho_\psi,$$

$$\dot\rho_R + 4 H \rho_R = (1+w_\psi)\Gamma_\psi \rho_\psi$$

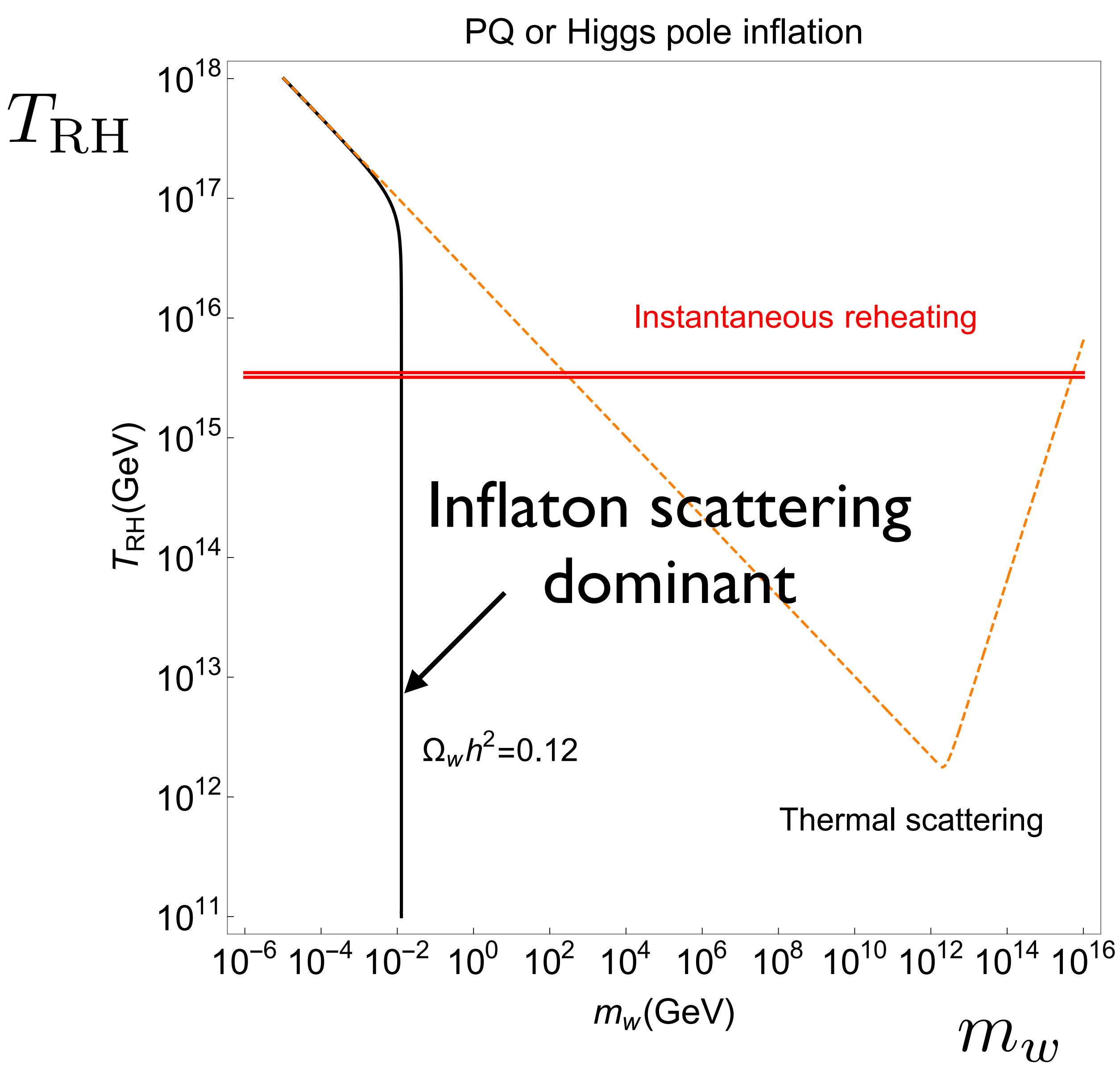
$$\longrightarrow \quad \rho_R(a) \simeq \frac{8 M_P \Gamma_\psi \sqrt{\rho_{\psi,\rm end}}}{\sqrt{3}(5-3w_\psi)} \left(\frac{a}{a_{\rm end}}\right)^{-\frac{3}{2}(1+w_\psi)} \left(1 - \left(\frac{a}{a_{\rm end}}\right)^{-\frac{1}{2}(5-3w_\psi)}\right)$$

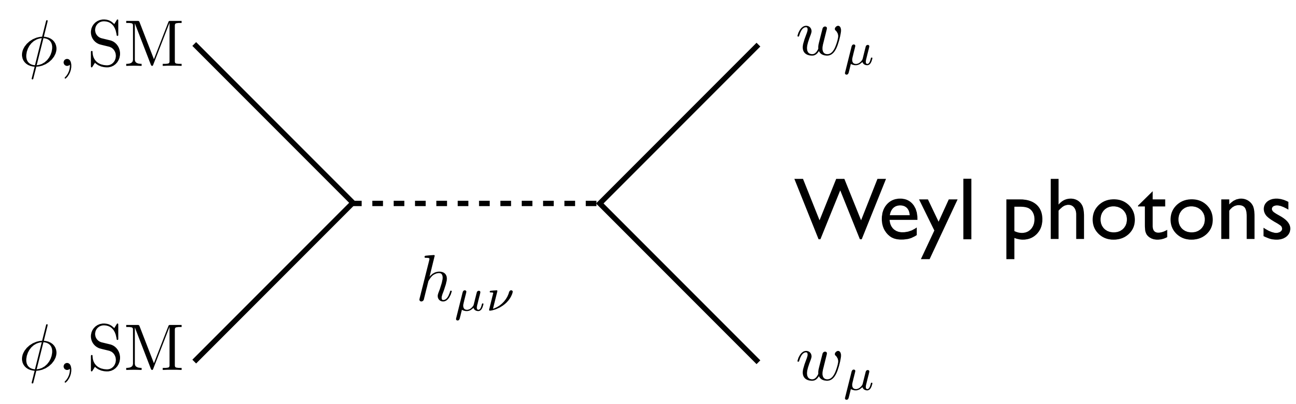


# Weyl photon dark matter



- Weyl photon dark matter is produced by freeze-in during or after reheating.




DM abundance:

$$\Omega_w h^2 = 1.6\times 10^8\, m_w \left(\frac{g_{*,0}}{g_{\rm RH}}\right)\left(Y_{w,{\rm inflaton}} + Y_{w,{\rm thermal}} + Y_{w,{\rm reheating}}\right)$$

$$\left.\begin{aligned} Y_{w,{\rm inflaton}} &\simeq \frac{2.53 g_{RH}^{3/4}\lambda_\phi^{3/4}\psi_{\rm end}^3}{M_P^3}, \\ Y_{w,{\rm thermal}} &\simeq \frac{56469 T_{\rm RH}^3}{128\pi^6\sqrt{10 g_{\rm RH}} M_P^3}, \end{aligned}\right\}\ \text{during reheating}$$

$$Y_{w,{\rm reheating}} \simeq \begin{cases} Y_{w,{\rm thermal}}, & \text{PQ inflation}, \\ \frac{18759}{18823}\, Y_{w,{\rm thermal}}, & \text{Higgs inflation}. \end{cases}$$

after reheating

[HML, PRL 2025]

=> DM mass: $m_w \simeq 10\,{\rm MeV}$

# Conclusions

- The pole inflation relies on a conformal coupling to gravity and a small quartic coupling of the inflaton, leading to successful & testable predictions.

- SM Higgs/PQ fields can be realized when the running quartic coupling for the inflaton remains small during inflation; loops from BSM couplings make small deviations in favor of ACT.

- Weyl gravity with broken SO(1,N) isometry realizes successful pole inflation models and contains a dark matter candidate (Weyl photon).