HIGGS EVOLUTION IN Inflation

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Based On Hook, Kearney, Shakya, KZ 1404.5953 Kearney, Yoo, KZ 1503.05193 Kearney, Shakya, Yoo, KZ, in progress

HIGGS INSTASTABILITY LIICCC INCTA solid curve, the vacuum is absolutely stable. Between the two solid curves it is metastable with a lifetime exceeding inflation. We begin with a single Hubble patch, assuming h*h*i = 0 initially, and follow the Higgs field evolution as this region inflates. Our goal is to calculate the probability that the universe

Higgs-boson mass, the more unstable the potential and

In this section, we describe the formalism for studying the evolution of the Higgs field during

can undergo the necessary amount of inflation without quantum fluctuations knocking the Higgs

5

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bosonic ones at large P with the result that our vacuum is

 $\overline{}$

WELL-KNOWN THAT SM HIGGS HAS VACUUM INSTABILITY DRIVEN BY TOP **EXECUTE WARD CURVE CURVE LL-KNOWN THAT SM HIGGS HAS VACU puted at 2018 The corresponding to the current corresponding to the electronic to the potential to the potential**

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HIGGS METASTABILITY The Planck-scale stability bound (4) is also shown in Fig. 4) is also shown in Fig. 4 as a (somewhat broader)

Apparently No Cosmological Implications -- UNIVERSE IS "STABLE ENOUGH" I'V NO CORMOLOGICAL IMPLICATIONS

Figure 1: Vacuum structure of the SM as a function of the Higgs boson mass. Regions of stability/metastability/instability are denoted in blue/purple/red respectively. The solid lines indicate central values while the dotted lines indicate *±*2 error bars on the experimental mea-

iii) Unstable (ˆ*^H > H*). The vacuum is not the absolute minimum, and it decays within the

surement of the top quark mass.

Compute Lee-Weinberg bounce

[−] ².2 GeV !αS(M²

− 3.5 Gev 19

$$
p = \max_{h < \Lambda} [V_U h^4 \exp(-8\pi^2/3|\lambda(h)|)]
$$

Inflation **PUNCE ATION** the lifetime constraint is significantly different from that

shown for different choices of the cutoff scale A, whereas

the dependence of the dependence of the lower solid curve on curve on cutoff scales on curve

has been examined in Ref. 5. The lifetime has been computed in Ref. 5. The lifetime has been computed in Ref.

of Ref. 2, perhaps due to the use of more modern results

lutely stable and (b) when fermion masses are large enough that the contract of the contract of the contract of

for the effective potential.

QUANTUM FLUCTUATIONS DURING INFLATION Allow to Sample Unstable Vacuum

E HIGGS IN INFLATION: HOW DOES THIS EVOLVE?

INFLATION & HORIZONS

INFLATION CREATES e^{3N} CAUSALLY SEPARATED HORIZONS

EVEN STARTING IN STABLE VACUUM, Fluctuations Can Spawn Black Islands OUR UNIVERSE

 Ω

CAUSALLY SEPARATED HORIZONS

*e*³*^N*

INFLATION & HORIZONS

- **EVENTUALLY CAUSALLY SEPARATED HORIZONS** RE-ENTER HORIZON
- **HOW DOES THIS SYSTEM EVOLVE?**

 Ω

OUR UNIVERSE

CAUSALLY SEPARATED HORIZONS

*e*³*^N*

PROBABILITY

We now consider the evolution of the fluctuation of the fluctuations in the Hartree-Fock (Hartree-Fock (HF) or

G DOES THE UNIVERSE SURVIVE INFLATION? HOW BIG OF A TRANSITION PROB CAN ONE TOLERATE and Still Evolve Into a Universe Like Ours? SELF-EVOLVE INTO A UNIVERSE LINE

> Probabilities Taken with Super-Hubble MODES OUR UNIVERSE M ODES \overline{O} UR UNIVERSE)

$$
\langle \delta h^2(t) \rangle = \int_{k=1/L}^{k=eaH} \frac{d^3k}{(2\pi)^3} |\delta h_k(t)|^2
$$

including the interactions, and then inserting Eq. (5) into Eq. (4) gives the mode equation

Higgs EOM @ Inflation in finite time, and we discuss the implications of the implications of the increase for our Universe. The interest of the inte THE EQMETRELATION IN HIGGS FOM A INFI ATION For the slowling in a discussion with 11/2 in a discussion of the slow-roll is a discussion of the slowling superhorizon of the slowling superhorizon of the slowling superhorizon of the slowling superhorizon of the slowlin

given by

dt [|]hk(*t*)*[|]*

The solution of the solution to the solution of the solution of the solution of the solution of the solution of

model we show that the correlation function for the scalar field fluctuations, h*h*²(*t*)i, diverges

(*t*)

✓

⌧ *^H*²

aH ◆

k

in finite time, and we discuss the implications of this divergence for our Universe.

model we show that the correlation function for the scalar field fluctuations, h*h*²(*t*)i, diverges

eⁱ ^k

h22 **h**22 **h**22 **h**22 **h**22

||

hk(*t*) = *^H*

approximation and neglect the gradient term such term such that gradient term such that gradient term such tha

$$
\ddot{h} + 3H\dot{h} - \left(\frac{\vec{\nabla}}{a}\right)^2 h + V'(h) = 0
$$

$$
\overline{h}(0) = 0, \bar{h}(t) = 0
$$

$$
3H\dot{\delta h}_k(t) + 3\lambda \left\langle \delta h^2(t) \right\rangle \delta h_k(t) = 0
$$

$$
\left\langle \delta h^2(t) \right\rangle = \int_{k=1/L}^{k=eaH} \frac{d^3k}{(2\pi)^3} |\delta h_k(t)|^2
$$

$$
\frac{d}{dt} \left\langle \delta h^2(t) \right\rangle = -\frac{2\lambda}{H} \left\langle \delta h^2(t) \right\rangle^2 + \frac{H^3}{4\pi^2}
$$

$$
\xrightarrow{\text{Kearney, YOO, KZ 1503.05193}}
$$

. (8)

aH . (9)

HIGGS EOM @ INFLATION horizon crossing. This derivation is one method by which the well-known result that we lead the well-known result *dt* ⌦ *h*² (*t*) ↵ $\overline{}$ *H* ⌦ *h*²

Second we observe that, for *>* 0, the interaction tends to reduce the size of the fluctuations

We pick up a stochastic or Brownian noise term as a result of the time-dependence of mode

 $\sqrt{-2\lambda}$

 2π

 $-2\lambda \frac{\mathcal{N}}{2\pi}$

de Sitter space behaves thermally. The equation governing the evolution of h*h*²(*t*)i is then

 2π

◆

⁴⇡² *.* (12)

2 *^N*

↵2

CAN HIGGS END INFLATION? *d dt* **TION**? \blacksquare CAN HIGGS END INFLATION ℓ

NOT AT LEAST UNTIL BLACK VACUA DOMINATE $\langle \delta h^2(t) \rangle =$ 1 H^2 $\tan \left(\sqrt{\right)$ as described in [26]. The more interesting case is when *<* 0, as for the SM Higgs with *H >* ⇤*^I* such that (*H*) *<* 0. In this case, we see that the superhorizon fluctuations grow even more $\langle \delta h^2(t) \rangle = \frac{1}{\sqrt{2\pi}} \tan \left(\sqrt{-2\lambda_{\overline{\Omega_{\pi}}}} \right)$ \overline{H} $\overline{$ $\langle \delta h^2(t) \rangle = \frac{1}{\sqrt{2\pi}} \tan \left(\sqrt{-2\lambda_{\overline{\Omega_{\pi}}}} \right)$

to a local fluctuation of the fluctuations in energy density, the fluctuations of the fluctuations and the fluctuations of the fluctuations of

Higgs EOM @ Inflation M or Brownian noise term as a result of the time-dependence of the time-dependence of the time-dependence of models \overline{M} horizon crossing. This derivation is one method by which to obtain the well-known result that \overline{z} \overline{a} where $\overline{}$ is the number of $\overline{}$ in $\overline{}$ and $\overline{}$ while we have written the result as for $\overline{}$

d

dt ✓Z

2 ◆

⁴⇡*k*²

de Sitter space behaves thermally. The equation governing the evolution of h*h*²(*t*)i is then

² *d*

dt(✏*aH*) = *^d*

⌦

*h*²

⁴⇡² *.* (12)

2

PICTURE -- SLOW DIFFUSION PROCESS UNTIL CLASSICAL RUN AWAY ⌦ ↵ *h*² $\overline{}$ ⌦ ↵2 *h*² *<* 0, it is equally valid for *>* 0 (with the tangent function replaced by a hyperbolic tangent).

Z *d*

WHAT IS THE RIGHT Calculation?

BE CAREFUL ABOUT REGIME OF VALIDITY OF Calculation!

HOW DOES H COMPARE TO HIGGS POTENTIAL?

SMALLEST FLUCTUATIONS (Coleman-DeLuccia)

MODERATE FLUCTUATIONS (Hawking-Moss)

BIG FLUCTUATIONS (Fokker-Planck)

Rarest Transitions **• Code is the dominant contribution is the dominant contribution is the dominant contribution when the dominant contribution when** \mathbf{r} H^2 \sim \lesssim $V''_{\text{eff}}(\Lambda_{\text{max}})$ a
|-
|711 Λ *V* $\frac{1}{4}$ $\begin{pmatrix} w \\ w \end{pmatrix}$

PARE TRANSITIONS $V''_{\text{eff}}(\Lambda_{\text{max}}) \lesssim H^2 \lesssim (V_{\text{eff}}(\Lambda_{\text{max}}))^{1/2}$ **PARE TRANSITIONS** $\lesssim \left(V_{\rm eff}(\Lambda_{\rm max})\right)^{1/2}$

POT RARE TRANSITIONS $H \gtrsim \sqrt{|\lambda|} \Lambda_I$ **FRARE TRANSITIONS**

tion during inflation. However, with α is of the set α and α from BICEP2, this regime is of α

, such that the HM and stock and stockastic approaches are most relevant to Higgs evolutions

^e↵(⇤max)*[|] <* ⁴*H*² and likely *^H* ⇠

^e↵(⇤max)*[|] <* ⁴*H*² and likely *^H* ⇠

max*.*

Details: Hook, Kearney, Shakya, KZ 1404.5953 $\overline{201}$, such that the HM and stockastic approaches are most relevant to \mathbb{R}^n tion during inflation. However, even with first input from BICEP2, this regime is of far greater in

REGIMES OF VALIDITY

REGIMES OF VALIDITY WAI INITY previous results, notably the contribution in \mathcal{I}_1 , with \mathcal{I}_2 and \mathcal{I}_3 and \mathcal{I}_4 and \mathcal{I}_5 with \mathcal{I}_6 and \mathcal{I}_7 and \mathcal{I}_8 and \mathcal{I}_7 and \mathcal{I}_8 and \mathcal{I}_9 and \mathcal{I}_9 and \mathcal 3*H* ˙ *hk*(*t*)+3

top of the barrier, after which it classically rolls down to its true vacuum with unit probability. The barrier

The Fokker-Planck (FP) approach to studying the evolution of scalar field fluctuations in a

For the slowly-varying superhorizon modes with 1*/L k* ✏*aH*, we can employ the slow-roll

1 *i*

aH ◆

eⁱ ^k

aH . (9)

hk(*t*)=0*.* (10)

ds background was previously applied to the Higgs in Refs. [12, 17, 18]. Here we make use of the Higgs in Refs

p

hk(*t*) = *^H*

PROBABILITY require a fine-tuning of the initial conditions at the level of ⇤max*/M^P* . However, in light of the above picture in the Higgs field value of the Higgs field value of the Higgs field value of the order of the Higgs field value of the order order of the

on any value below *M^P* at the start of inflation and the Higgs must start within its shallow

potential well is the electron of the electroweak vacuum is to be realized in some regions of space, the space

Hubble scale and still realize the electroweak vacuum due to quantum fluctuations *into* the

CORRECT CALCULATION IN LIMIT $H > \Lambda_I$ is a STATISTICAL TREATMENT VIA FOKKER-PLANCK EQ false vacuum, relaxing the amount of tuning required to ⇠ *H/M^P* . Since the combination of LHC CORRECT CALCOLATIC

and the solution with ⇤*^c* = ⇤max from [12] (solid gray curve). As a comparison, we also show the HM

solving the FP: Espinosa et al 0712.2484 (red caroline black curve), the approximate analytic solution in Eq. (15) (solid black curve), \sim 150 (solid black curve), \sim 150 (solid black curve), \sim 150 (solid black curv

CONDITION TO TERMINATE prediction in the international district in the international district in the international district in the in $\overline{}$ *dt [|]hk*(*t*)*[|]* E RMINATI ² *d dt*(✏*aH*) = *^d*

FRACTION OF BLACK VACUA

FIG. 3. The proportion of surviving patches transitioning out of the slow-roll regime *f^N* (Eq. (43))

CONTRACTOR *h,*

N = 25)

We pick up a stochastic or Brownian noise term as a result of the time-dependence of models and the time-dependence of

The Fokker-Planck (FP) approach (FP) approach to study in a probability the evolution of scalar field fluctuations in a set of scalar field fluctuations in a set of scalar field fluctuations in a set of scalar field fluct

ds background was previously applied to the Higgs in Refs. [12, 17, 18]. Here we make use of the Higgs in Refs

The evolution equation for h*h*²(*t*)i can be found by multiplying by *h*⇤

◆

FIG. 2. Probability distribution of the Higgs, *P*(*h, t*), evaluated at *N* = 25 for the case of

(H) and shown is a gauge in the Hartree of the Hartree-Corresponding to the Hartree of the Hartree States of the

CONDITION TO TERMINATE

horizon crossing. This derivation is one method by which to obtain the well-known result that

Terminate Inflation The solution to this equation is the solution Second we observe that, for *DERWINATE INFLATION*

What does this divergence mean physically? As mentioned previously, h*h*²(*t*)i is the cor-

as h2(t)i, where it is the inflaton and inflaton and inflaton and inflaton and inflaton and the inflaton and t

= *H*²*N* 2 **2 SIGMA ON MT, MH**: 2SIGMA ON MT, MH:

▝▝▘▘▔▘▘▘▘▘▘▘▘▘▘▘▘▘▘▘▘▘▘▘▘▘

(13)

 $50 \lesssim \mathcal{N}_\mathrm{max} \lesssim 90$

SCALE OF QUARTIC? WHE OF CULARTIC present in Eq. (24).⁵ First, there are the IR logarithms of the form log(*a/a*0) = *N* , due to ⇢(*x, y*) = *i* ⌦⇥*h^I* (*x*)*, h^I* (*y*) ⇤↵ *, F*(*x, y*) = ¹ 2 ⌦*h^I* (*x*)*, h^I* we have at late time and hence do not contribute to the divergent part of h*h*²i—we elaborate on this \blacksquare \bigcap in \blacksquare modes are e \bigcap ↑*h***_k(***t*) **=**

 $\lambda_\text{eff}(h)$ is not a gauge invariant quantity the superhorizon modes, that give rise to the divergence of the correlator h*h*²i as observed $\lambda_{\text{eff}}(h)$ is not a gauge invariant quantity \mathbf{r} in Francisco term in \mathbf{r} $\mathsf{GAUGE}\;$ INVARIANT QUANTITY

E COMPUTE TWO-POINT CORRELATION IN IN-IN **FORMALISM** $F(x,y) = \frac{1}{2} \int \frac{d^3k}{(2-x)^3} h_k(t_x) h_k^*(t_y) e^{i\vec{k}\cdot(\vec{x}-\vec{r})}$ $F(x,y) = \frac{1}{2}$ 2 $\int d^3k$ (2π) $\frac{1}{3}h_k(t_x)h_k^*(t_y)e^{i\vec{k}\cdot(\vec{x}-\vec{y})} + \text{c.c.}$ 4⇡² ⇤*IRr H*² **4.** $\frac{1}{2}$ $\frac{1}{$ 3*H* ˙ *hk*(*t*)+3 ⌦ *h*² (*t*) ↵ *hk*(*t*)=0*.* (10) $2 \int (2\pi)^{3+\kappa}$ ² (κx) ³

^k (*tz*)*ei*[~]

(*t*)

. (8)

aH . (9)

^k(*t*) and integrating over

The two results agreements and the consistent with the the HF approach results that the HF approach results in

 $\sqrt{-2\lambda}$

 H^2

 2π

We see that perturbation theory breaks down (signal by the substitution by the substitution of the substitutio

 $\tan\left(\sqrt{-2\lambda}\frac{\mathcal{N}}{2\pi}\right)$

)

$$
3\lambda F(z,z) + \delta m^2 + \delta \xi R = \frac{3\lambda(\mu)H^2}{8\pi^2} \left(2\mathcal{N} + \ln\frac{\mu^2}{H^2}\right) \qquad \qquad \left(\delta h^2(t)\right)_{\text{HF}} \approx \frac{H^2}{4\pi^2} \mathcal{N} - \frac{\lambda H^2}{24\pi^4} \mathcal{N}^3
$$

The choice of renormalization scale resums the logarithms and ensures the theory remains perturbative control in the UV—specifical ly, the choice $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$ λ to be separated by less than one Hubble length during inflation and the gauge boson propagators, for $\sqrt{-2\lambda}/2\pi$ (REPRODUCES LEADING TERMS IN $\langle \delta h^2(t) \rangle = \frac{1}{\sqrt{-2\lambda}} \frac{H^2}{2\pi} \tan \left(\sqrt{-2\lambda} \frac{\mathcal{N}}{2\pi}\right)$)

logarithmic divergences. These terms are identical to terms that would be present in Minkowski

Defining

*m*²

END INFLATION

B ASSUME INFLATION ENDS BEFORE BLACK VACUA DOMINATE

B RE-HEATING STARTS AS USUAL

THEN WHAT?

RE-HEATING homogeneous Universe such as ours would not be consistent with the existence of a scalar field such as *h* exhibiting an instability in its potential. We will return to this point in Sec. IV. *< ^No*, where *^N^o* ⇡ ⁵⁰ 60 is the number Δ inflation (inflating regions would fracture or Δ). The inflation Δ

analysis of [36] suggests that the inflating regions could not percolate and undergo the necessary

of *e*-folds needed to satisfy observational bounds on flatness and homogeneity, then a relatively

prevent collapse of the entire spacetime. Finite temperature electrical positive mass-

field is rapidly thermalized and driven to h*h*²i = 0. This is easily satisfied, since the maximum

In deriving the several approximation several approximations. First, we have a proximations. First, we have a

|**|**
|*|*hh2(1) The fluctuations are evolutions are evolutions and the evolutions are evolutions and the evolution

superhorizon modes can be considered in the slow-roll approximation. If *<* 0, modes become

*> H*², leading to their rapid growth. This coupled with the rapid (*i.e.*,

becomes unstable, and inflation ends. Thus if *^N*max ⇠

IF HIGH ENOUGH RE-HEAT TEMP, FINITE TEMP EFFECTS FORCE HIGGS BACK TO EW VACUUM **CONSEQUENTLY IS NET ANAD IS NET A PART IS NOT SUCH A PART IS NECESSARY, AND IS NECESSARY, IS NET A PART IS NE** prevent collapse of the entire spacetime. Finite temperature e 4 ects generate a positive mass-and positive ma **EXPLAND IN VIRGOUGH RE-H** such as *h* exhibiting an instability in its potential. We will return to this point in Sec. IV. Consequently, having *N^o N*max is necessary, but not sucient, to guarantee the existence $h = h = h + h + h = h + h + h + h$ such as *h* exhibiting an instability in its potential. We will return to this point in Sec. IV.

tachyonic once **|**
|*|***|**hh

of *e*-folds needed to satisfy observational bounds on flatness and homogeneity, then a relatively

< ^No, where *^N^o* ⇡ ⁵⁰ 60 is the number

[34] and Planck [35]. In addition, if the proportion of non-inflating patches becomes *O*(1), the

analysis of $[36]$ suggests that the inflating regions could not percolate and undergo the necessary \mathcal{S}

of *e*-folds needed to satisfy observational bounds on flatness and homogeneity, then a relatively

Consequently, having *N^o N*max is necessary, but not sucient, to guarantee the existence

prevent collapse of the entire spacetime. Finite temperature elects generate a positive mass-a positive mass-a

field is rapidly thermalized and driven to h*h*²i = 0. This is easily satisfied, since the maximum

In deriving these results, we have employed several approximations. First, we have assumed

*||*h*h*²(*t*)i ⌧ *H*², such that the fluctuations are e↵ectively massless and the evolution of the

superhorizon modes can be considered in the slow-roll approximation. If *<* 0, modes become

*> H*², leading to their rapid growth. This coupled with the rapid (*i.e.*,

^R, where *T^R* is the re-heat temperature. As long as *m*²

^R ⇠ ^p*HM^P* , while ^h*h*²ⁱ is typically of size *^H*2*^N*

*||*h*h*²(*t*)i ⌧ *H*², such that the fluctuations are e↵ectively massless and the evolution of the

superhorizon modes can be considered in the slow-roll approximation. If *<* 0, modes become

*> H*², leading to their rapid growth. This coupled with the rapid (*i.e.*,

FINITE TEMPERATURE EFFECTS: $m_{eff}^2 \sim T_R^2$ *^R*, where *T^R* is the re-heat temperature. As long as *m*²

> **REQUIRE:** $m_{eff}^2 \gtrsim \lambda \langle \delta h \rangle^2$ field is rapidly thermalized and driven to h*h*²i = 0. This is easily satisfied, since the maximum

> Easily Satisfied because **EXECTED SECAUSE** $T_R^{\text{max}} \sim \sqrt{H M_P}$ FIED BECAUSE T_R^{\max} $\frac{M_{max}}{R} \sim \sqrt{HM_P}$

> > tachyonic once *[|]|*h*h*²(*t*)i⇠

POST INFLATION

- **BUT, SOME BLACK VACUA WERE CREATED DURING** Inflation. What Happens to Them Post Inflation?
- **HERE, MOST TRICKY. CALCULATE** EVOLUTION OF BUBBLES IN RADIATION DOMINATED, MINKOWSKI BACKGROUND
- **BLACK VACUA CRUNCH? -- CREATE DEFECTS**

BOR, THEY EXPAND

IF THEY EXPAND ◆⁴

 $\Delta \sigma^2$ mentioned previously in Eq. (8), the HM probability for a single HM probability for a single patch to fluctuate σ^2

THEN A SINGLE BLACK VACUA IS ENOUGH TO DESTROY UNIVERSE FOR PURSE A SINGLE BLACK **Probability of the probability of the probability of no Hubble patches transitioning parameters transitioning o**

$$
P_{\text{nodas}} \sim \prod_{N_e=1}^{N_o} (e^{-p})^{e^{3N_e}}
$$

$$
\bullet \text{ so } p < e^{-3\mathcal{N}}
$$

SO, MUST STABILIZE **POTENTIAL IF** $H \gtrsim \Lambda_{max}$ FIG. 5. *B*HM and *P*noAdS as a function of *H/*⇤max for the central values *m^h* = 125*.*7 GeV, *m^t* =

Hook, Kearney, Shakya, KZ 1404.5953

The survival of our universe either requires *H/*⇤max ⇠

¹⁷³*.*34 GeV (left) and as a function of *^m^t* for *^m^h* = 125*.*7 GeV and *^H*BICEP2 ⇡ ¹⁰¹⁴ GeV (right).

STABILIZE POTENTIAL patches in the past light cone) happens when the past light cone, this term is cone, the past light cone, the p
The past light cone, this term is contributed in past light cone, the past light cone is contributed in the pa the evolution of the Ni of the Higgs potential for ↵² *>* 0, leading to a true minimum at *^h* ⇠

ENERGY DE PLANCK SUPPRESSED CORRECTIONS ARE SUFFICIENT

$$
V(h) = \frac{c}{2}H^2h^2 + \frac{\lambda_{\text{eff}}(h)}{4}h^4
$$

vacuum patches crunch or dominate) is realized.¹⁰

10 One might have the dimension eight that the dimension eight that the dimension eight operator operator that

for the large *H* favored by BICEP2, *V^I* ()*/M*⁴

probable to an improbable universe (with the requirement that there be no unstable Hubble

^P ⇠ *^H*²*/M*² Hook, Kearney, Shakya, KZ 1404.5953

Hig potential is at large energies in the son that the south correction is interesting to a large energies in the south for reasonable values of the south for reasonable values of the south for reasonable values of the so

SO WHAT?

- **IF WE CAN ALWAYS STABILIZE POTENTIAL** SUFFICIENTLY WITH PLANCK SLOP, WHY STUDY THIS?
- **SM HIGGS + INFLATION BOTH APPEAR TO BE** REAL; WORTH UNDERSTANDING THE DYNAMICS
- ONE TANTALIZING FACT:

DURING INFLATION

Higgs is Stable Enough to Allow Us to Inflate Long Enough to Give Rise to A Universe Like Ours **B** HIGGS IS STABLE ENOUGH TO ALLOW US TO **EXECRIBED IN CONGENOUGH IO GIVE RISE IO A**
IN INTEREST LIKE QUIDE

BUT NOT MUCH LONGER rapidly than for a massless field, and in fact diverge after a finite number of *e*-folds,

 $50 \leq \mathcal{N}_{\text{max}} \leq 90$

averaged over a Hubble-sized patch). It is analogous to more familiar correlations such a Hubble-sized patch).

such that (*H*) *<* 0. In this case, we see that the superhorizon fluctuations grow even more

High Scale Quartic Needed to Be Small for THAT TO HAPPEN What does this divergence mean physically? As mentioned previously, h*h*²(*t*)i is the cor-

SUMMARY

FOLLOWING HIGGS EVOLUTION DURING INFLATION Requires Application of Correct Probability **EVOLUTION**

POST-INFLATION EVOLUTION DEPENDS ON HOW AdS Bubbles Evolve -- if They Expand, REQUIRE NONE IN PAST LIGHTCONE

E CAN STABILIZE POTENTIAL SUFFICIENTLY WITH Planck Suppressed Corrections

HIGGS INSTABILITY: TANTALIZING HINT OR Coincidence?