Cosmology Practice

For scalar inflation

Input Potential

In[1]:= `ClearAll["Global`*"]`

In[2]:= $V[\phi\_] := \frac{1}{2} m^2 \phi^2$

In[3]:= $\rho[\phi\_] := \frac{1}{2} (D[\phi[t], t])^2 + V[\phi]$

In[4]:= $H := \frac{1}{\sqrt{3} * M} \sqrt{\rho[\phi]}$

In[5]:= $\rho[\phi]$

Out[5]= $\frac{m^2 \phi^2}{2} + \frac{1}{2} \phi'[t]^2$

In[6]:= $D[H, t]$

Out[6]= $\frac{\phi'[t]\, \phi''[t]}{2 \sqrt{3}\, M \sqrt{\frac{m^2 \phi^2}{2} + \frac{1}{2} \phi'[t]^2}}$

Inflation constants (Not approximation)

Slow Role Parameters

Basic

In[10]:= $A[\phi\_] = \frac{M^2 * D[V[\phi], \phi]^2}{2 * V[\phi]^2}$

Out[10]= $\frac{2 M^2}{\phi^2}$

In[11]:= $B[\phi\_] = M^2 * \frac{D[D[V[\phi], \phi], \phi]}{V[\phi]}$

Out[11]= $\frac{2 M^2}{\phi^2}$

In[12]:= N_{SR} = Assuming$\left[M > 0 \,\&\&\, \phi_I > 0 \,\&\&\, \phi_E > 0,\ \text{Integrate}\left[\frac{1}{\sqrt{2 * A[\phi]} * M}, \{\phi, \phi_E, \phi_I\}\right]\right]$ /. $\phi_E \to 0$

Out[12]= $\frac{\phi_i^2}{4\, M^2}$

In[13]:= ϕ_{SR} := Simplify$\left[\text{Reduce}[N == N_{SR}, \phi_I], \text{Assumptions} \to M > 0 \,\&\&\, \phi_i > 0\right]$

In[14]:= RU = $\{\text{ToRules}[\phi_{SR}]\}$

Out[14]= $\left\{\left\{\phi_i \to -2\, M \sqrt{N}\right\}, \left\{2\, M \sqrt{N} \to \phi_i\right\}\right\}$

In[15]:= $A[\phi_I]$ /. RU

Out[15]= $\left\{\frac{1}{2\, N}, \frac{2\, M^2}{\phi_i^2}\right\}$

In[16]:= ϵ_v = Part[%, 1]

Out[16]= $\frac{1}{2\, N}$

In[17]:= $B[\phi_I]$ /. RU

Out[17]= $\left\{\frac{1}{2\, N}, \frac{2\, M^2}{\phi_i^2}\right\}$

In[18]:= η_v = Part[%, 1]

Out[18]= $\frac{1}{2\, N}$

Tilt of Scalar Spectrum

Data : 0.9666+- 0.0062

In[19]:= n[N_] = $1 - 2\, \epsilon_v - \eta_v$

Out[19]= $1 - \frac{3}{2\, N}$

In[20]:= Abs[n[60] - 0.9666]

Out[20]= 0.0084

In[21]:= Abs[n[50] - 0.9666]

Out[21]= 0.0034

Tensor to Scalar Ratio

Data : r<0.168 (Planck TT + Low P)

-Euler-Mascheroni Constant

In[22]:= γ_E := 0.5772

In[23]:= $C_E = 4\ (\text{Log}[2] + \gamma_E) - 5$

Out[23]= 0.0813887

-Tensor to Scalar Ratio

In[24]:= $r[N\_] = 16 * \epsilon_v * \frac{(1 - (C_E + 1)\ \epsilon_v)^2}{(1 - (3 * C_E + 1)\ \epsilon_v + C_E * \eta_v)^2}$

Out[24]= $\frac{8\left(1 - \frac{0.540694}{N}\right)^2}{\left(1 - \frac{0.581389}{N}\right)^2 N}$

In[25]:= r[60]

Out[25]= 0.133516

In[26]:= r[50]

Out[26]= 0.160264

Plot

In[27]:= P1 = ParametricPlot[{n[N], r[N]}, {N, 50, 60}, PlotRange → {{.92, 1}, {0, 0.2}}]

Out[27]=