Testability of Inflection Inflation in Colliders

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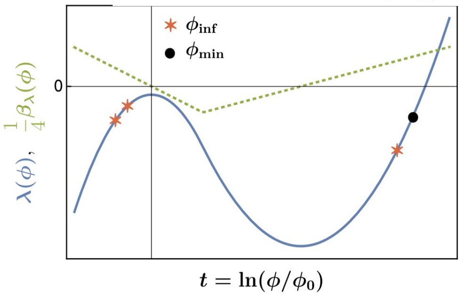
What is Dynamical Inflection Point Inflation?

- Coleman Weinberg (CW) potential predicts a lower scalar spectral index (n_s) than observed, Planckian fields too
- Modify CW by including quartic Renormalization Group (RG) flow
- For small fields, n_s goes with η => minimize V''
  - Target potentials with inflection points
- Multiple β=0 => slow rolling from boundary ensured

$$\epsilon_v = \frac{1}{2}\left(\frac{V'(\phi)}{V(\phi)}\right)^2\Bigg|_{\phi=\phi_i} ,$$

$$\eta_v = \frac{V''(\phi)}{V(\phi)}\Bigg|_{\phi=\phi_i} ,$$

$$\xi_v^2 = \frac{V'''(\phi)V'(\phi)}{V(\phi)^2}\Bigg|_{\phi=\phi_i} ,$$



$$V(\phi) = \frac{1}{4}\lambda(\phi)\,\phi^4 + V_0 ,$$

$$V'(\phi) = \left(\lambda + \frac{1}{4}\beta_\lambda\right)\phi^3 ,$$

$$V''(\phi) = \frac{1}{4}\left(12\lambda + 7\beta_\lambda + \beta'_\lambda\right)\phi^2$$

Source: Y. Bai et al.
arxiv: 2008.09639

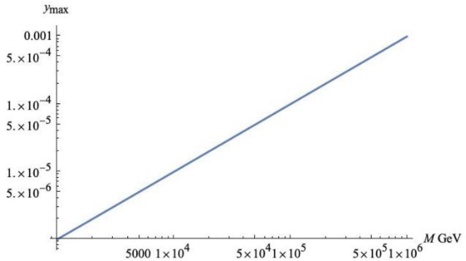
Model and Particle Content:

- Key Concept: SU(N) fermions have two β=0 points
    - small field inflation satisfying slow roll conditions
    - N = Number of Generations
- Our model: SU(2) fermions

$$
\begin{aligned}
\mathcal{L} \supset\ & y_R^t \epsilon^{ab} \hat{U}_a^s \Phi_b \hat{\hat{t}} + y_R^c \delta^{ab} \hat{U}_a^s \Phi_b \hat{\hat{c}} + y_L^{q_3} \delta^{\alpha\beta} \epsilon^{ab} \hat{q}_{3\alpha} \Phi_a \hat{\hat{Q}}_{b\beta}^d \\
& + y_R^b \epsilon^{ab} \hat{D}_a^s \Phi_b \hat{\hat{b}} + y_R^s \delta^{ab} \hat{D}_a^s \Phi_b \hat{\hat{s}} + y_L^{q_2} \delta^{\alpha\beta} \delta^{ab} \hat{q}_{2\alpha} \Phi_a \hat{\hat{Q}}_{b\beta}^d \\
& + y_R^\tau \epsilon^{ab} \hat{E}_a^s \Phi_b \hat{\hat{\tau}} + y_R^\mu \delta^{ab} \hat{E}_a^s \Phi_b \hat{\hat{\mu}} + y_L^{l_3} \delta^{\alpha\beta} \epsilon^{ab} \hat{l}_{3\alpha} \Phi_a \hat{\hat{L}}_{b\beta}^d \\
& + y_R^{\nu_\tau} \epsilon^{ab} \hat{N}_a^s \Phi_b \hat{\hat{\nu}}_\tau + y_R^{\nu_\mu} \delta^{ab} \hat{N}_a^s \Phi_b \hat{\hat{\nu}}_\mu + y_L^{l_2} \delta^{\alpha\beta} \delta^{ab} \hat{l}_{2\alpha} \Phi_a \hat{\hat{L}}_{b\beta}^d \\
& + M \left(\hat{\hat{U}}_s \hat{U}_s + \bar{D}_s \hat{D}_s + \bar{Q}_d \hat{Q}_d + \bar{E}_s \hat{E}_s + \bar{L}_d \hat{L}_d \right) \\
& + \delta_{ab} N_a^s \Phi_b \bar{\chi} + \delta_{ab} \bar{N}_a^s \Phi_b \chi
\end{aligned}
$$

	n_f	$SU(3)_c \times SU(2)_D \times SU(2)_L \times U(1)_Y$
$\hat{U}_s = \begin{pmatrix} \hat{T}_s \\ \hat{C}_s \end{pmatrix}$	1	(3,2,1,2/3)
$\hat{\hat{U}}_s = \begin{pmatrix} \hat{\hat{T}}_s \\ \hat{\hat{C}}_s \end{pmatrix}$	1	($\bar{3}$,2,1,-2/3)
$\hat{D}_s = \begin{pmatrix} \hat{B}_s \\ \hat{S}_s \end{pmatrix}$	1	(3,2,1,-1/3)
$\hat{\hat{D}}_s = \begin{pmatrix} \hat{\hat{B}}_s \\ \hat{\hat{S}}_s \end{pmatrix}$	1	($\bar{3}$,2,1,1/3)
$\hat{E}_s = \begin{pmatrix} \hat{E}_{\tau s} \\ \hat{E}_{\mu s} \end{pmatrix}$	1	(1,2,1,-1)
$\hat{\hat{E}}_s = \begin{pmatrix} \hat{\hat{E}}_{\tau s} \\ \hat{\hat{E}}_{\mu s} \end{pmatrix}$	1	(1,2,1,1)
$\hat{N}_s = \begin{pmatrix} \hat{N}_{\tau s} \\ \hat{N}_{\mu s} \end{pmatrix}$	1	(1,2,1,0)
$\hat{\hat{N}}_s = \begin{pmatrix} \hat{\hat{N}}_{\tau s} \\ \hat{\hat{N}}_{\mu s} \end{pmatrix}$	1	(1,2,1,0)
$\hat{Q}_d = \begin{pmatrix} \hat{T}_d & \hat{B}_d \\ \hat{C}_d & \hat{S}_d \end{pmatrix}$	1	(3,2,2,1/6)
$\hat{\hat{Q}}_d = \begin{pmatrix} \hat{\hat{T}}_d & \hat{\hat{B}}_d \\ \hat{\hat{C}}_d & \hat{\hat{S}}_d \end{pmatrix}$	1	($\bar{3}$,2,2,-1/6)
$\hat{L}_d = \begin{pmatrix} \hat{N}_{\tau d} & \hat{E}_{\tau d} \\ \hat{N}_{\mu d} & \hat{E}_{\mu d} \end{pmatrix}$	1	(1,2,2,-1/2)
$\hat{\hat{L}}_d = \begin{pmatrix} \hat{\hat{N}}_{\tau d} & \hat{\hat{E}}_{\tau d} \\ \hat{\hat{N}}_{\mu d} & \hat{\hat{E}}_{\mu d} \end{pmatrix}$	1	(1,2,2,1/2)
χ	1	(1,1,1,0)
$\bar{\chi}$	1	(1,1,1,0)
Φ	1	(1,2,1,0)

$$\mathcal{M} = \begin{pmatrix} m_t & 0 & \epsilon_f \\ \epsilon_f & M & 0 \\ 0 & 0 & M \end{pmatrix}$$

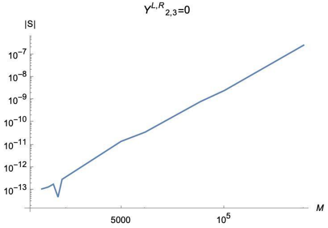


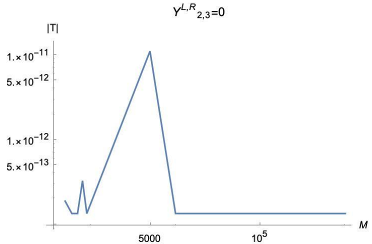
Constraints on the Collider Search:

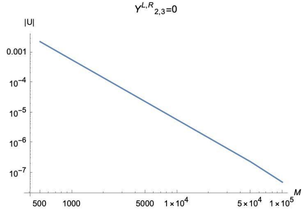
- Mass mixing with Standard Model fermions
  - Assume eigenvalues within 1% of SM masses
  - Compute maximum yukawa coupling to new fields

- Electroweak Oblique Parameters
  - Assume no mixing with SM fermions for now
  - Use SPheno to scan over mass range
  - Parameters fall within allowed bounds

- Lower Bound From Reheating
  - Inflaton decay width corresponds to reheating temperature
  - Use reheating temperature to set a lower bound on allowed masses







Conclusions and Next Steps:

- Heavy fermions coupling to an inflation field facilitate dynamical inflection point inflation
- Oblique parameters from new fields mixing with SM fields currently underway
- Will use constraints to conduct a full collider search

Thank you for your attention!