rijksuniversiteit groningen
faculteit wiskunde en natuurwetenschappen

VRIJE UNIVERSITEIT BRUSSEL

Nilpotent inflation and gauge mediation of SUSY breaking

when cosmology meets particle physics

Dries Coone

Based on Arxiv:1705.06788
with Riccardo Argurio, Lucien Heurtier, Alberto Mariotti

Outline

- Nilpotent inflation, introduction
- Nilpotent inflation, our model
- Reheating constraints
- Conclusions

Inflation + Supergravity

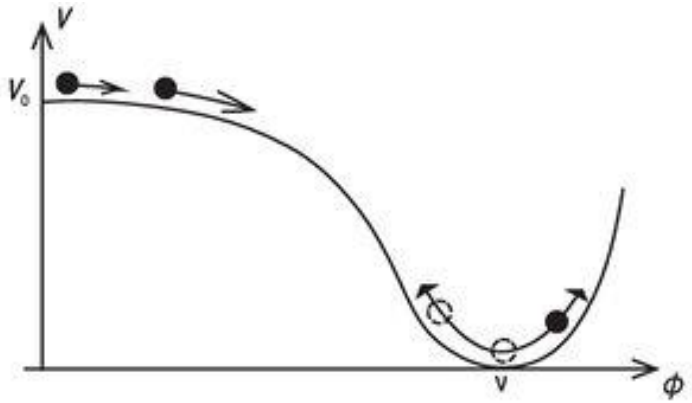
Inflation at high field values: requires Supergravity.

Potential as function of Kähler $K(\Phi, \bar{\Phi})$ and superpotential $W(\Phi)$

$$V = e^{K}(K_{i\bar{j}}\, D^{i}W\ \bar{D}^{\bar{j}}\bar{W} - 3|W|^{2})$$

η-problem

Unbounded from below



Nilpotent inflation

η-problem

$$K = \mathrm{K}(\Phi + \bar{\Phi}) + S\bar{S},$$

Unboundedness

$$W = h(\Phi) + Sf(\Phi)$$

$S^2 = 0$: constraint superfield

Inflaton mass

- $h(\Phi) = \frac{f_0}{\sqrt{3}} - m_h\Phi^2$
- $f(\Phi) = f_0 - m_f\Phi^2$

Mass scale during inflation

$f(0) \neq 0$: SUSY broken,
Propagate to MSSN with messengers

Nilpotent inflation

$$K = \mathrm{K}(\Phi + \bar{\Phi}) + S\bar{S} - \frac{(S\bar{S})^2}{(M+g\Phi)^2}, \qquad W = h(\Phi) + Sf(\Phi)$$

Messenger loop term

$S^2 = 0$: constraint superfield

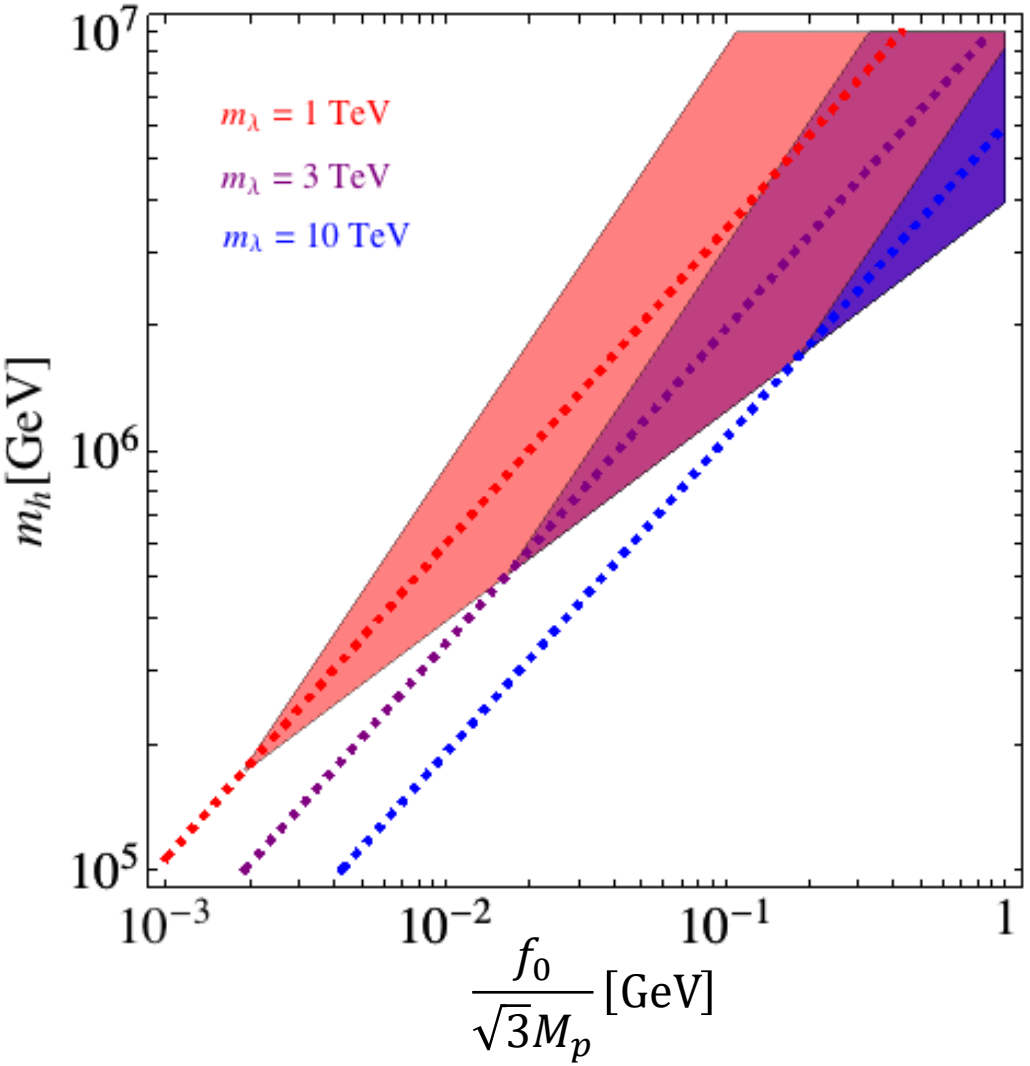
- $h(\Phi) = \frac{f_0}{\sqrt{3}} - m_h\Phi^2$
- $f(\Phi) = f_0 - m_f\Phi^2$

If $g = 0$, $M \approx 0.1\, M_{pl}$,
[Dudas,Heurtier, Wieck, Winkler ,16]

$f(0) \neq 0$: SUSY broken,
Propagate to MSSN with messengers

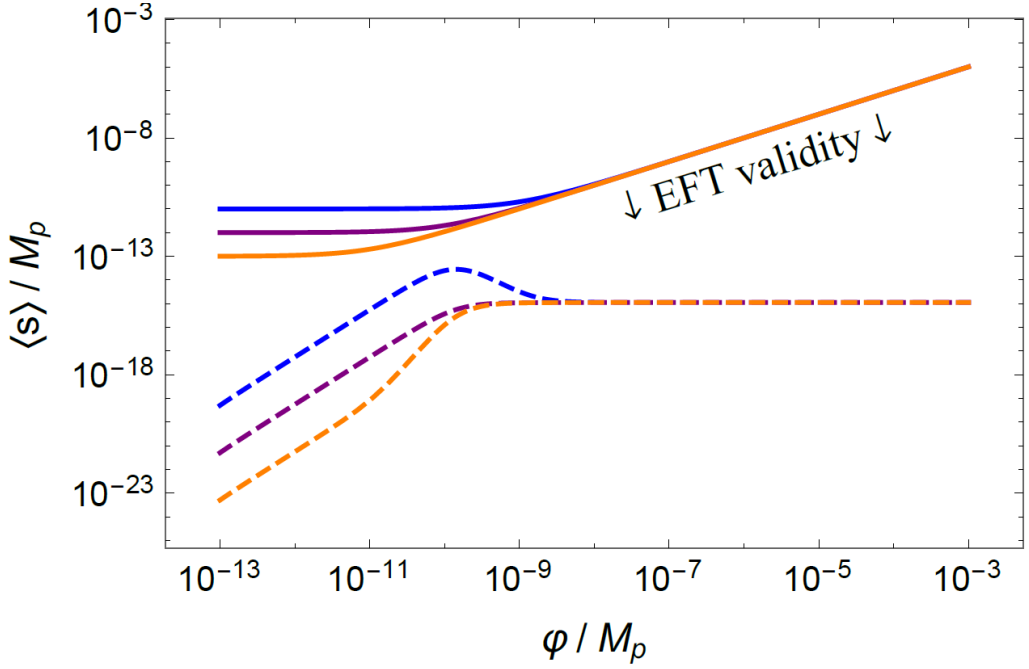
Validity of the model

- Tachyons
  1. Messenger masses large $M^2 > f_0$
  2. Inflaton mass small $\mathrm{m_h} < M$
  3. Inflaton mass large $m_h^2 > \frac{f_0 m_f}{2M_p}$



Validity of the model

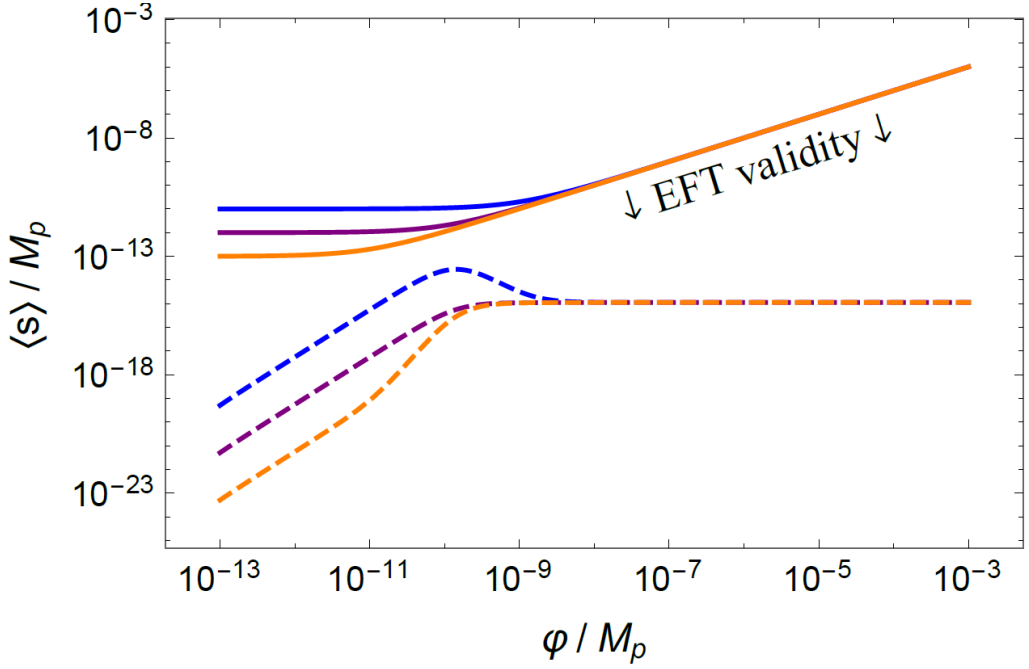
- Tachyons
  1. Messenger masses large $M^2 > f_0$
  2. Inflaton mass small $\mathrm{m_h} < M$
  3. Inflaton mass large $m_h^2 > \frac{f_0 m_f}{2M_p}$
- Validity of the effective theory
  4. Messenger mass small $\frac{M}{M_p} > \frac{m_h}{m_f}$



Validity of the model

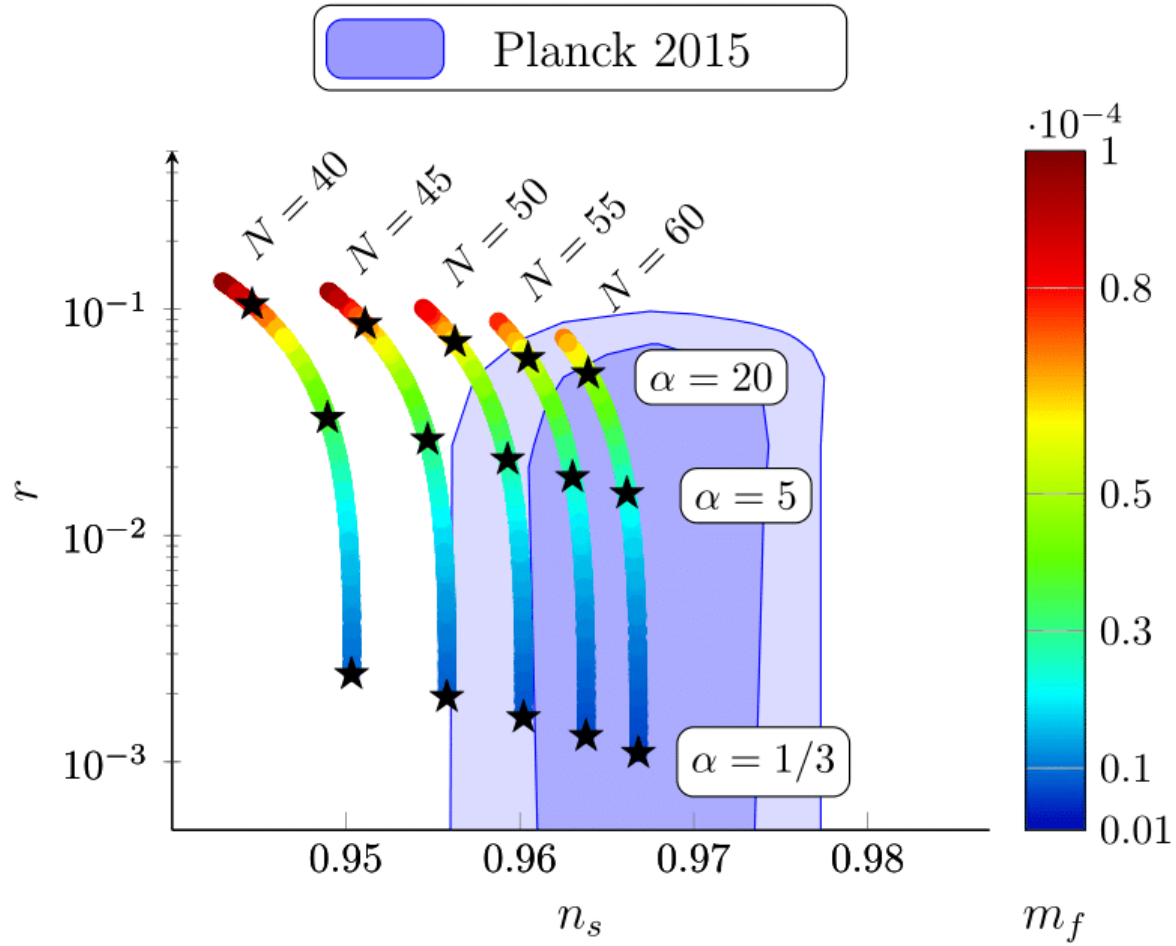
- Tachyons
  1. Messenger masses large $M^2 > f_0$
  2. Inflaton mass small $\mathrm{m_h} < M$
  3. Inflaton mass large $m_h^2 > \frac{f_0 m_f}{2M_p}$
- Validity of the effective theory
  4. Messenger mass small $\frac{M}{M_p} > \frac{m_h}{m_f}$

$m_f \gg m_h$: Quartic inflation



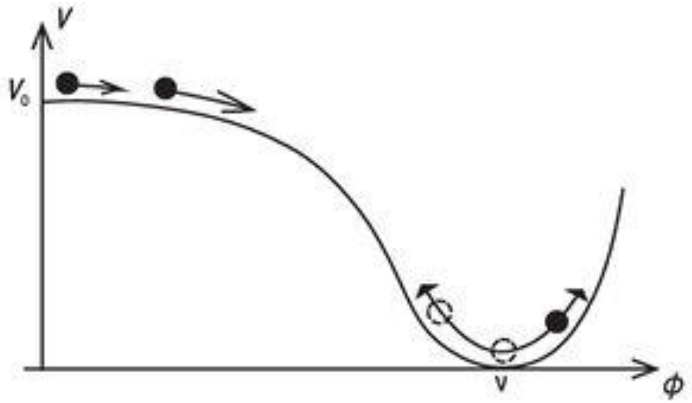
Our model

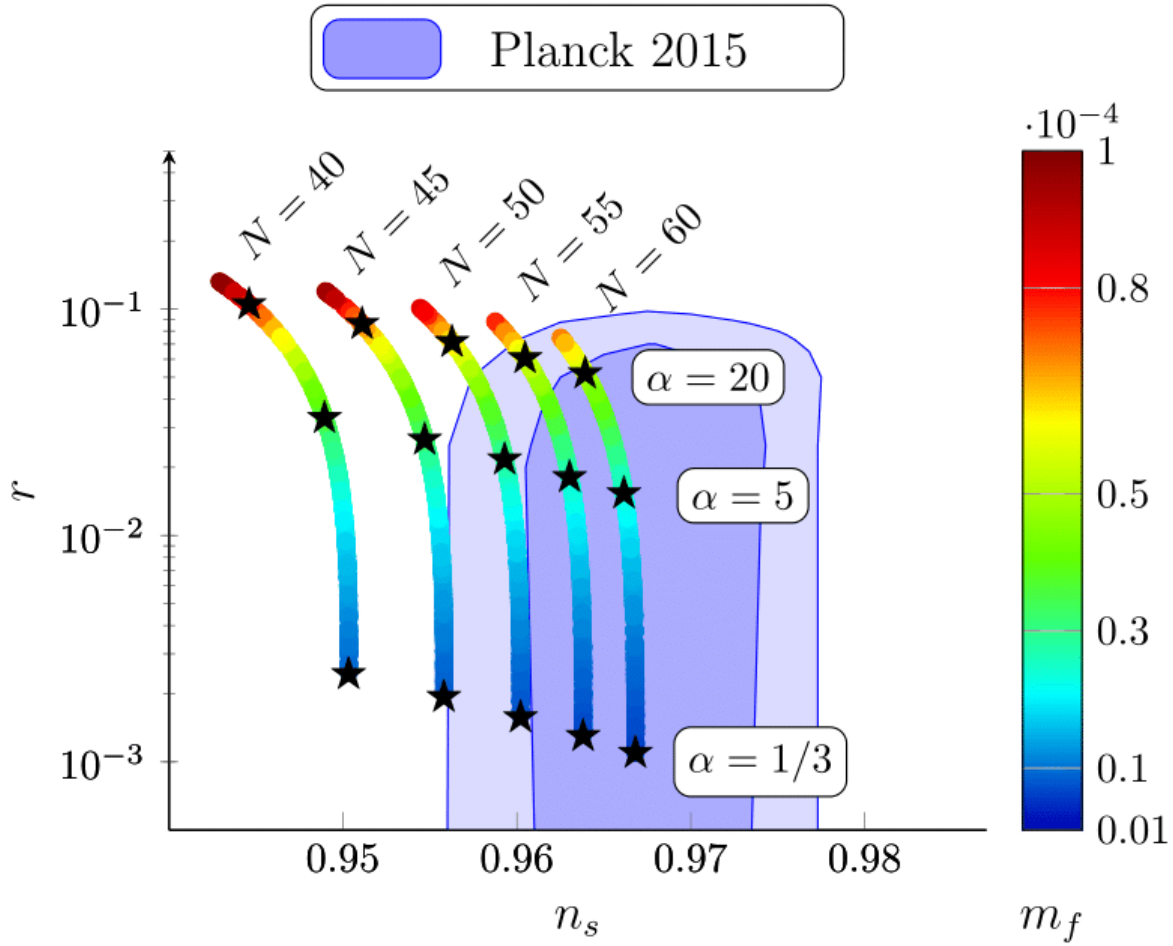
- We define a UV model containing:
  - SUSY breaking in the vacuum
  - Gauge mediation to the MSSM
  - Nilpotent α-attractor inflation



Our model, Reheating

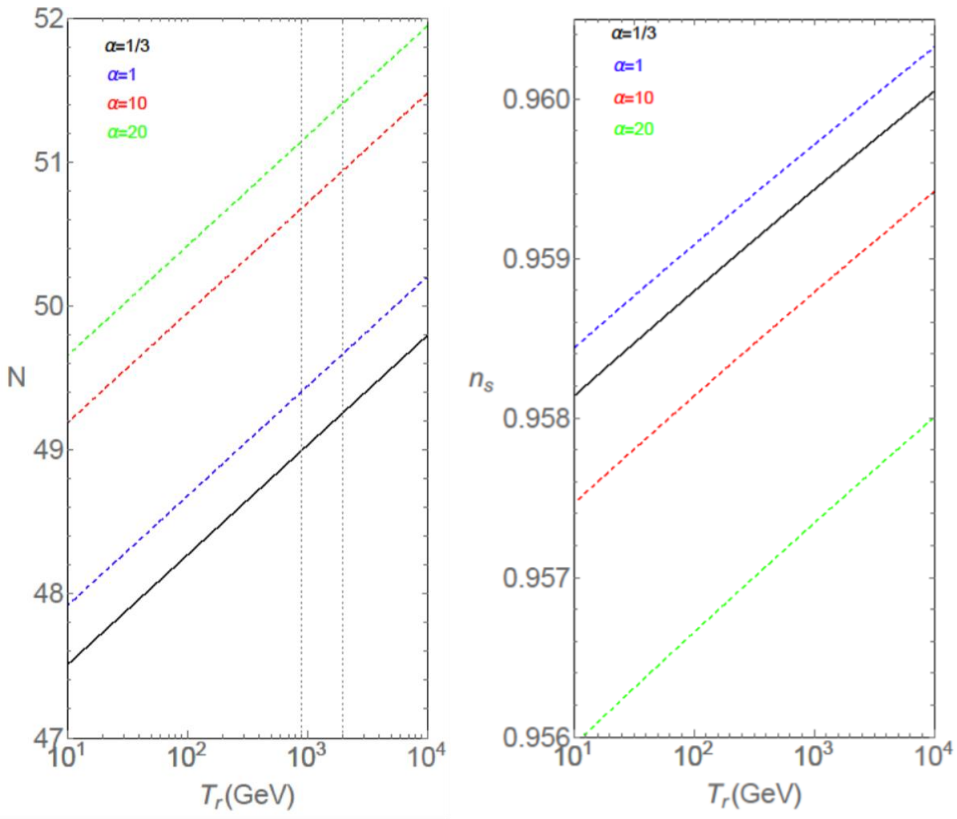
- We define a UV model containing:
  - SUSY breaking in the vacuum
  - Gauge mediation to the MSSM
  - Nilpotent α-attractor inflation
- We can define:
  - SUSY spectrum
  - Reheating temperature



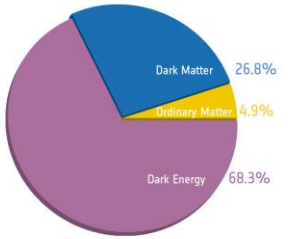


Our model, Reheating

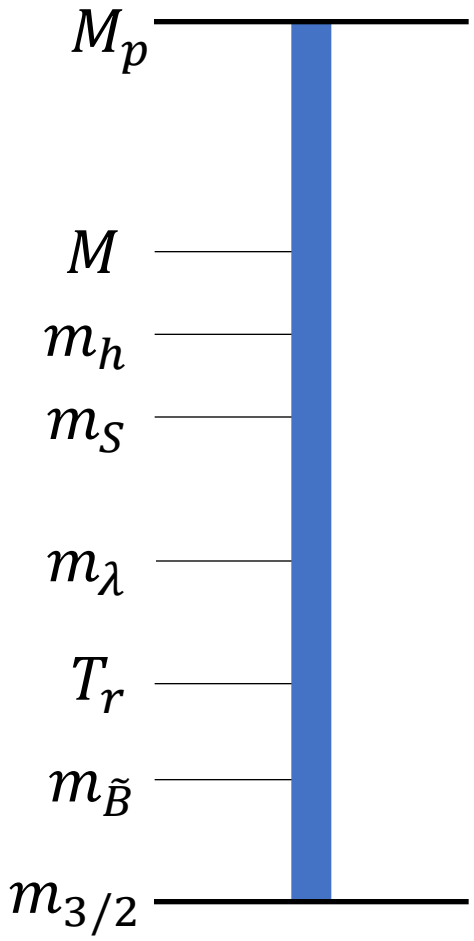
- We define a UV model containing:
  - SUSY breaking in the vacuum
  - Gauge mediation to the MSSM
  - Nilpotent α-attractor inflation
- We can define:
  - SUSY spectrum
  - Reheating temperature
    - Number of efolds
    - Inflation parameters



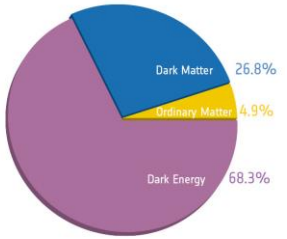
Gravitino LSP: dark matter?



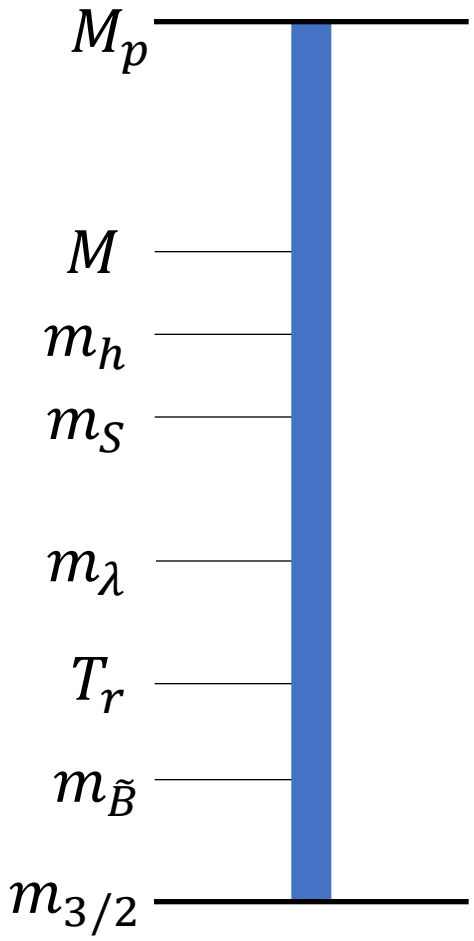
- overclose the universe?



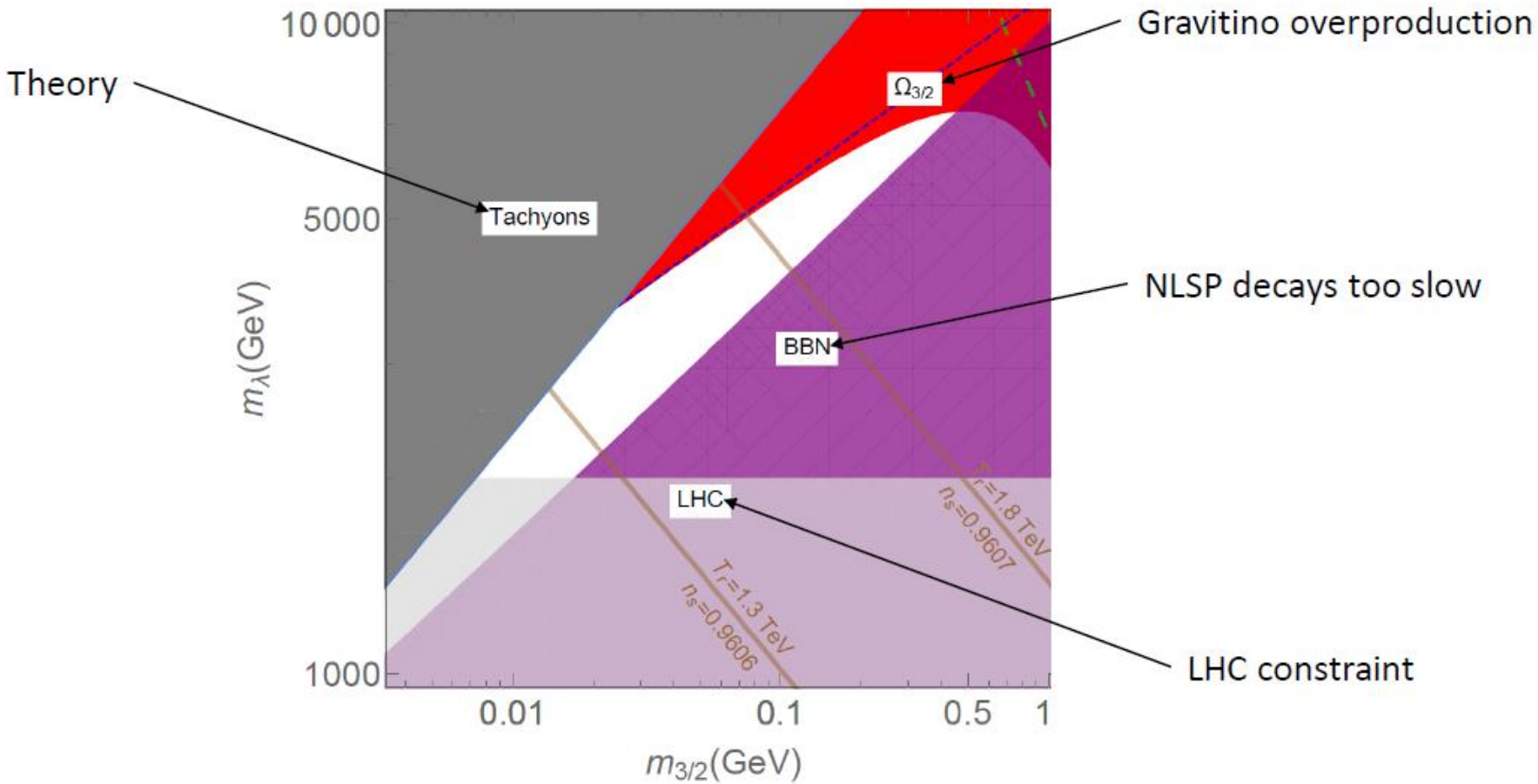
Gravitino LSP: dark matter?



- overclose the universe?
- Production via:
  - Inflaton decays into gravitinos
  - Thermal production [*Moroi, Murayama, Yamaguchi '93*]
  - Freeze-in *[Cheung, Elor, Hall '11]*
  - NLSP decay



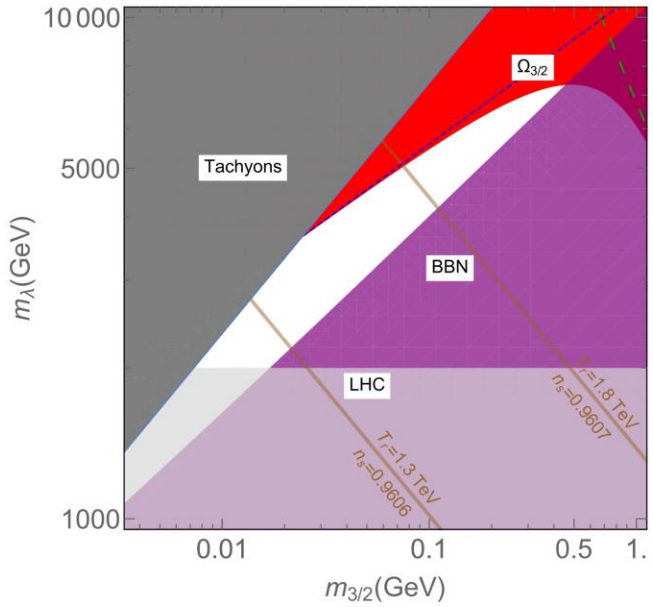
All constraints combined



[Argurio, D.C., Heurtier, Mariotti, '17]

Conclusions

- We can combine gauge mediation and nilpotent inflation
- We can compute reheating parameters
- Reheating constraints strongly our parameter space



Back-up

Full model

- $K = -\frac{3\alpha}{2} M_p^2 \log\left(\frac{\left(M_p^2 - \Phi\bar{\Phi}\right)^2}{\left(M_p^2+\Phi^2\right)\left(M_p^2+\bar{\Phi}^2\right)}\right) + S\bar{S} + \cdots$
- $W = h(\Phi) + S\, f(\Phi) + \lambda S X \tilde{X} + (M + g\Phi)\left(X\tilde{Y} + Y\tilde{X}\right) + m_y Y\tilde{Y}$
- $h(\Phi) = \frac{f_0}{\sqrt{3}} - m_h \Phi^2$
- $f(\Phi) = f_0 - m_f \Phi^2$