WIMPlaton
dark matter from incomplete decay

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CAFPE

Inflation

- Horizon problem
- Flatness problem
- Relics
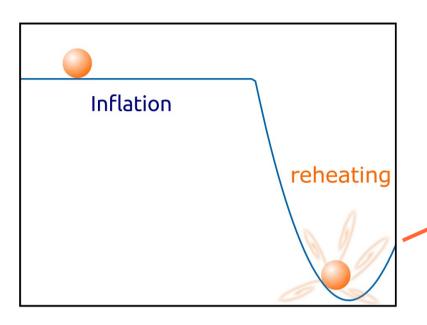- CMB anisotropies
- B-mode polarization

- Galaxy rotation curves
- Galaxy clusters
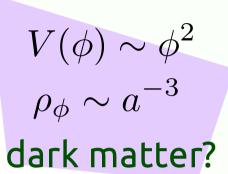- Gravitational lensing
- Structure formation

Dark Matter

Single description?

very different energy scales....

Inflation

reheating

[Turner'83; Kofman,Linde&Starobinsky'94]

$$V(\phi) \sim \phi^2$$

$$\rho_\phi \sim a^{-3}$$

dark matter?

Drastic but incomplete reduction

[Liddle&Ureña-Lopez'06]

Preheating

$$g^2\phi^2\chi^2$$

parametric resonance

not efficient
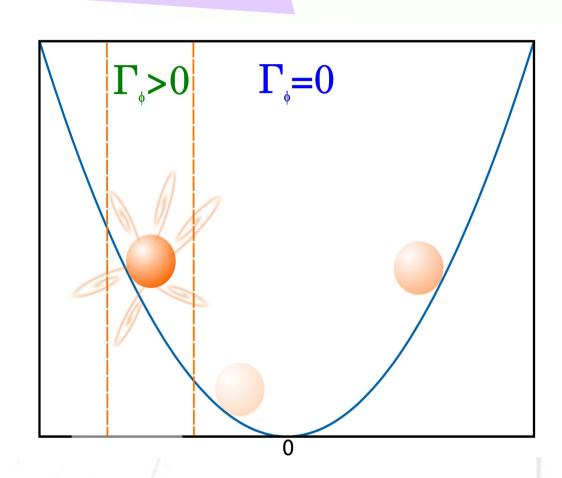
Reheating

$$gm\phi\chi^2$$

decay $\phi \to \chi\chi$

complete decay
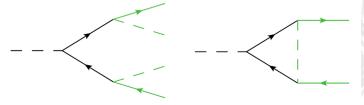
$$\mathcal{L}_{int} \sim -h\phi\bar{\psi}\psi - m_f\bar{\psi}\psi$$

$$m_\psi = |m_f + h\phi|$$

$$2m_f > m_\phi$$

$\phi \to \bar{\psi}\psi$

stops dynamically

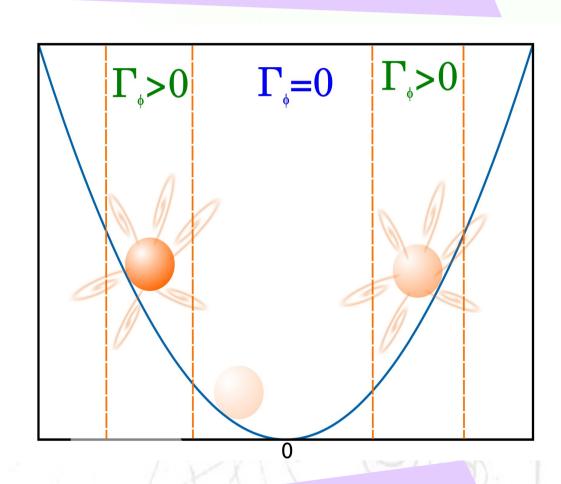$\Gamma_\phi > 0$ $\Gamma_\phi = 0$

0

ψ decay into SM $\longrightarrow$ ϕ induced decay

$$\mathcal{L}_{int} \sim -h\phi\bar{\psi}_+\psi_+ + h\phi\bar{\psi}_-\psi_- - m_f(\bar{\psi}_+\psi_+ + \bar{\psi}_-\psi_-)$$

$$m_\psi = |m_f \pm h\phi|$$

$$2m_f > m_\phi$$

$$\phi \to \bar{\psi}_+\psi_+, \bar{\psi}_-\psi_-$$

stops dynamically

$\Gamma_\phi > 0$ $\Gamma_\phi = 0$ $\Gamma_\phi > 0$

0

ψ decay into SM $\longrightarrow$ ϕ induced decay

$$\mathbb{Z}_2 \times S_2$$
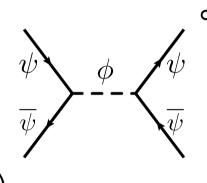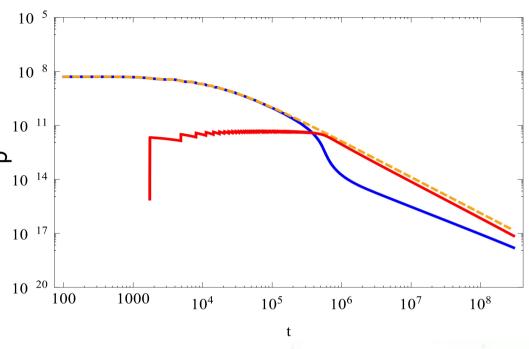
$$\phi \to -\phi \quad \psi_+ \leftrightarrow \psi_-$$

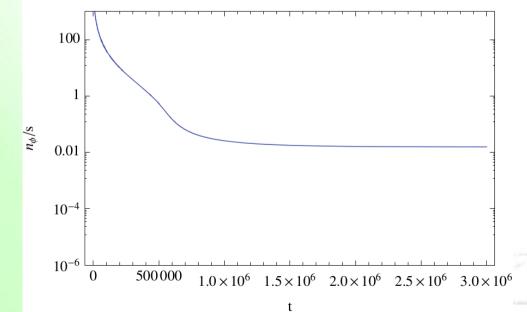$$V(\phi) = \frac{m^2}{2}\phi^2 + \cdots$$

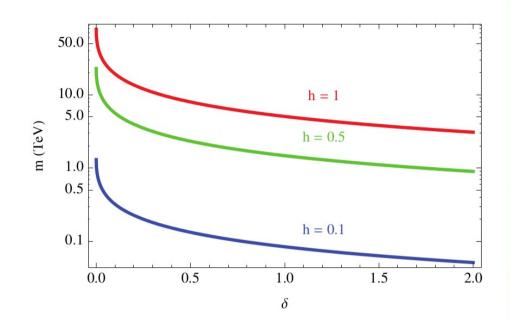Thermalization

$\downarrow$

annihilations
(same coupling)

Inflaton-to-entropy ratio

$$\frac{\Omega_{\phi 0}}{\Omega_{R0}} = \frac{4}{3}\frac{m}{T_0}\frac{n_\phi}{s}$$
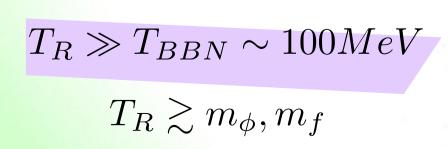
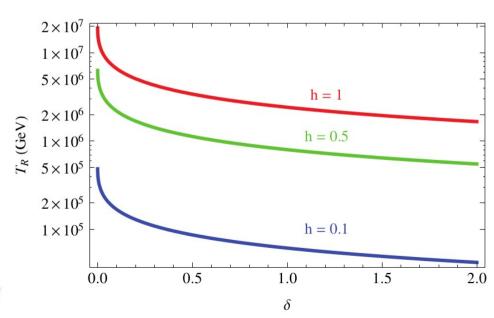$$m \simeq 72 \frac{h^{1.78} g_*^{0.12}}{f^{1.49}(\delta)} TeV$$

$$m_f = \frac{m}{2}(1+\delta)$$
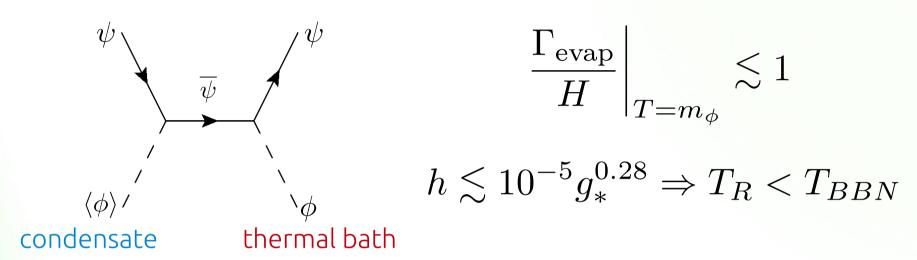
$$f(\delta) = 1 + 4.8\delta^{1/2} + 0.5\delta$$

$$T_R \simeq 4 \times 10^7 \ \frac{h^{1.59} g_*^{-0.16}}{f^{1.12}(\delta)} \ \text{GeV}$$

$$T_R \gg T_{BBN} \sim 100 MeV$$

$$T_R \gtrsim m_\phi, m_f$$

Condensate evaporation

condensate   thermal bath

$$\frac{\Gamma_{\text{evap}}}{H}\bigg|_{T=m_\phi} \lesssim 1$$

$$h \lesssim 10^{-5} g_*^{0.28} \Rightarrow T_R < T_{BBN}$$

evaporation is (most likely) **inevitable**

WIMPlaton

$$m_\phi \simeq 464 h^2 \left(\frac{\Omega_{\phi 0} h_0^2}{0.1}\right)^2 \left(\frac{g_{*F}}{10}\right)^{1/4} \left(\frac{x_F}{25}\right)^{-3/4} \text{GeV}$$

$$T_R^{\max} \simeq 8.5 \times 10^{10} g_*^{-1/4} \left(\frac{m_\phi}{1\text{TeV}}\right)^{1/2} \text{GeV}$$
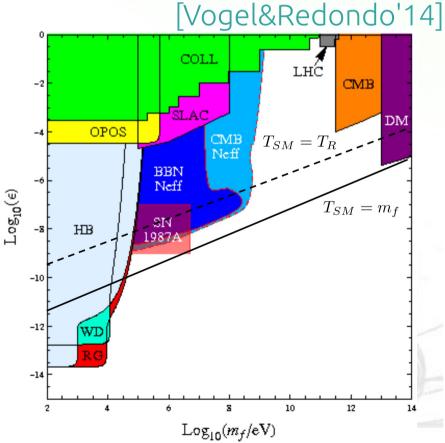
→ SUSY hybrid inflation

- **Decay**

ψ decay into SM $\longrightarrow$ ϕ induced decay

$$h_f \gtrsim 8 \times 10^{-8} g_{*f}^{1/4} \left(\frac{m_f}{1\text{TeV}} \right)^{1/2}$$

- **Annihilation**

[Vogel&Redondo'14]

hidden $U(1)$ $\quad \psi_j \psi_j \rightarrow \gamma \rightarrow qq$

milicharge ϵ

$$\epsilon \gtrsim 5 \times 10^{-7} g_{*f}^{1/4} \left(\frac{\alpha^{-1}}{128} \right) \left(\frac{N_{ch}}{20/3} \right)^{-1/2} \left(\frac{m_f}{1\text{TeV}} \right)^{1/2}$$
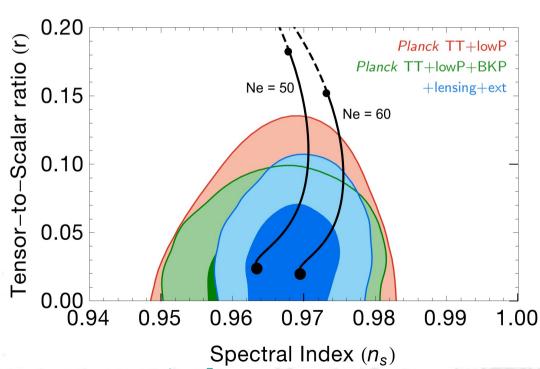
tension with Planck results:

$$V(\phi) = \frac{\lambda}{4!}\phi^4 + \frac{1}{2}m^2\phi^2 \qquad h \gtrsim 3 \times 10^{-8}\frac{m_f}{m_\phi}$$

- **Non-minimal coupling**

$$h > (10^{-19} - 10^{-16})\sqrt{\xi}$$

- **Warm inflation**

[Bartrum,Bastero-Gil, Berera, RC, Ramos, Rosa'13]

Incomplete decay mechanism:

- WIMPlaton vs ~~condensate~~

- consistent with DM abundance

- consistent with BBN

- interesting phenomenology

- consistent with inflationary observables

- complatible with different models of inflation

Thank you!