Parametric decay of the curvaton

Sami Nurmi

University of Helsinki

UniverseNet

Oxford, UK
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In collaboration with: Kari Enqvist, Gerasimos Rigopoulos

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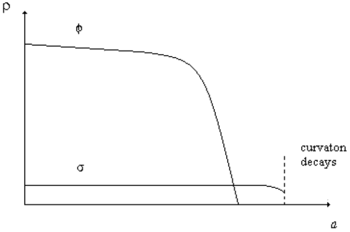
Curvaton model[1], standard picture

- Inflation driven by the inflaton field ϕ
- Perturbations generated by the curvaton field σ



- Perturbative decay: $\zeta \sim \frac{rH_*}{\sigma_*}$, $r \sim \frac{\rho_\sigma}{\rho} \sim \frac{\sigma_*^2}{M_P^2}\sqrt{\frac{m}{\Gamma}}$
- No gravity waves, large non-gaussianities if $r \ll 1$

[1] Enqvist,Sloth; Lyth,Wands; Moroi,Takahashi; Linde,Mukhanov; Mollerach

Non-perturbative decay

- If curvaton is coupled to other scalars, it can decay via a parametric resonance
- Consider a simple example:

$$V = \frac{1}{2}m^2\sigma^2 + \frac{1}{2}g^2\sigma^2\chi^2 + \frac{1}{4!}\lambda\chi^4$$

- Time dependent mass for the χ field, efficient parametric resonance for

$$q = \frac{g^2\sigma_*^2}{m^2} \gg 1$$

- $q \gg 1$ by construction since $g\sigma_* \gtrsim H_*$ (χ not a curvaton) and $m \ll H_*$ (curvaton massless)
- Analogous to inflationary preheating but **more generic**

Dynamics of the resonance

- The oscillating curvaton behaves as:

$$\begin{aligned} \sigma &= \frac{\sigma_*}{m_\sigma t}\sin(m_\sigma t) && \text{(dominant)} \\ \sigma &\simeq \frac{\sigma_*}{(m_\sigma t + \frac{\pi}{8})^{3/4}}\sin\left(m_\sigma t + \frac{\pi}{8}\right) && \text{(subdominant)} \end{aligned}$$

- Non-perturbative production of χ modes as $\sigma = 0$

$$\ddot{X}_k + \left(\frac{k^2}{a^2} + g^2\sigma^2\right) X_k = 0 \ , \qquad X_k = a^{3/2}\chi_k$$

- Modes with $k/a \lesssim mq^{1/4}$ exponentially amplified and

$$n \sim 10^{-3}\frac{m^3 q^{3/4}}{a^3\sqrt{\mu m t}}e^{2\mu m t}$$

Dynamics of the resonance

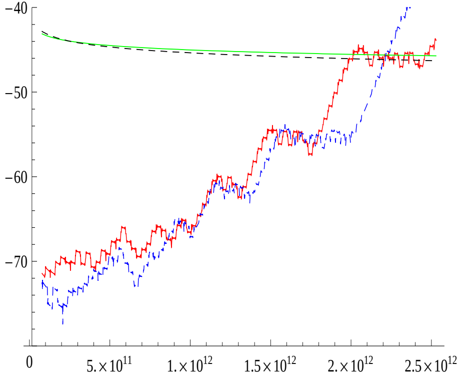


Figure: $\ln n_\chi(t)$ in the cases $r = 1$ (blue) and $r < 1$ (red).

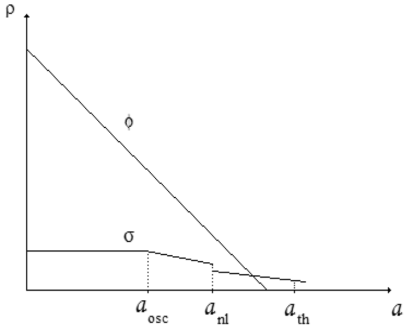
Non-perturbative decay, so what?

- Non-perturbative decay of the curvaton can have crucial consequences
- Stochastic gravity waves produced[2]

$$f_k \gtrsim \sqrt{\frac{H_*}{M_P}}\, 10^{10}\mathrm{Hz}\ , \qquad \Omega_{\mathrm{gw}} h^2 \lesssim 10^{-6}\frac{m}{H_*}$$

- Direct detection: $f \sim 10^{-4}\,\mathrm{Hz}$ (LISA) to $f \sim 10^{3}\,\mathrm{Hz}$ (LIGO), $\Omega_{\mathrm{gw}} h^2 \sim 10^{-18}$ (BBO)
- Non-gausssian perturbations like in inflationary preheating [3]?
- Non-thermal epoch after the resonant decay, constraints on the curvaton model itself?

[2] e.g. Dufaux, Bergman, Felder, Kofman, Uzan
[3] Rajantie, Chambers



ρ
ϕ
σ
a_{osc}
a_{nl}
a_{th}
a

Conclusions

- So far the curvaton decay has been mainly considered as a perturbative process
- However, non-perturbative decay quite generic feature of the model
- Mechanism analogous to preheating after inflation
- Can have important observable consequences: stochastic gravity waves, non-gaussianities, constraints on the model itself ...
- Must be studied in more detail!

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