Finite Temperature Effects in Warm Hybrid Inflation

Tom Metcalf
University of Edinburgh

International School of Subnuclear Physics
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Inflationary Cosmology - Two Dynamical Realizations

There are two dynamical realizations of Inflation.

- Cold Inflation
  - The inflaton is treated as an isolated system.
  - Other initial components of energy density are redshifted away.
  - A separate reheating phase after inflation brings the universe to a radiation dominated regime.

- Warm Inflation
  - Interactions leading to dissipation of inflaton energy to other degrees of freedom.
  - Inflationary expansion occurs concurrently with particle production.
  - Radiation can eventually dominate the energy density without a separate reheating phase.

Warm Inflation

- A dissipative term, Υ, appears as a friction term in the slow-roll evolution equation for the inflaton

$$\begin{array}{ccc} \text{Cold Inflation} & & \text{Warm Inflation} \\ 3H\dot{\phi}(t) + V_\phi \simeq 0 & \rightarrow & (3H + \Upsilon)\dot{\phi}(t) + V_\phi \simeq 0 \end{array}$$

- Energy lost by the inflaton field is gained by some other fluid ρ_α
- If $\rho_\alpha = \rho_R$ then the evolution equation for the radiation energy density becomes

$$\dot{\rho_R} + 4H\rho_R = \Upsilon\dot{\phi}^2$$

- Radiation is not necessarily redshifted.

Warm SUSY Hybrid Inflation

- Supersymmetry protects the potential from radiative corrections
- Warm inflation models have a two stage mechanism
  - Inflaton is coupled to very heavy χ fields
  - Heavy fields are in turn coupled to light y fields
- The two stage mechanism can be realised with the superpotential

$$W = \frac{m}{2}\Phi^2 + g\Phi(X^2 - M^2) + hXY^2$$

- The masses of the χ fields come from the interaction with the inflaton field

$$m^2_{\chi I} = 2g^2(\phi^2 + M^2)$$
$$m^2_{\chi R} = 2g^2(\phi^2 - M^2)$$
$$m^2_{\bar{\chi}} = 2g^2\phi^2$$

- When $\phi = \phi_c$, $m^2_{\chi R}$ becomes negative
- Tachyonic instability in the χ field drives the system to the global minimum of the potential at $\phi = 0$ and $\langle\chi\rangle \neq 0$
- This is the hybrid transition and will happen when $\phi = \phi_c = M$

Warm SUSY Hybrid Inflation

- Tree level inflationary potential is given by

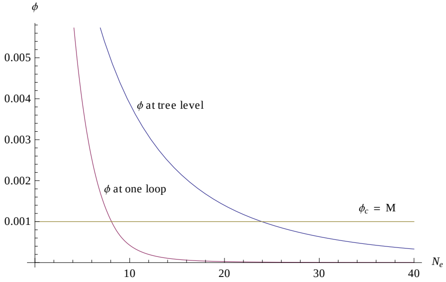
$$V = V_0 \left(1 + \frac{\gamma}{2}\left(\frac{\phi}{m_p}\right)^2\right)$$

- The one loop correction to the χ fields is given by the well known Coleman-Weinberg expression

$$V_{1-loop} = \frac{1}{32\pi^2}\left[m_{\chi R}^4 \log\left(\frac{m_{\chi R}^2}{\mu^2}\right) + m_{\chi I}^4 \log\left(\frac{m_{\chi I}^2}{\mu^2}\right) - 2\left(m_{\tilde{\chi}}\right)^4 \log\left(\frac{m_{\tilde{\chi}}^2}{\mu^2}\right)\right]$$

Inflation without temperature effects

Plot of the evolution of ϕ at both tree level and one loop where temperature effects have not been included.



At one loop the height of the potential has been increased, so more dissipation will be required to achieve the same number of e-folds as the tree level potential.

Effect of Finite Temperature Corrections

- Finite temperature corrections are made by adding a thermal mass to the χ multiplets caused by the interactions with the light y fields.

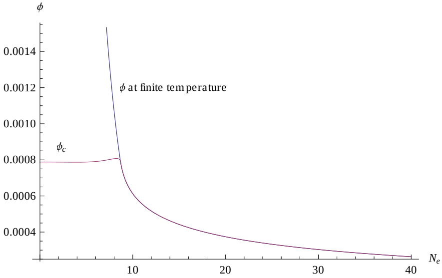
$$m^2_{\chi I} = 2g^2(\phi^2 + M^2) + \alpha T^2$$
$$m^2_{\chi R} = 2g^2(\phi^2 - M^2) + \alpha T^2$$
$$m^2_{\bar{\chi}} = 2g^2\phi^2 + \alpha T^2$$

- The χ mass multiplets are now temperature dependent
- The critical value of ϕ_c is now also temperature dependent

$$\phi_c = M^2 - \frac{\alpha}{2g^2} T^2$$

Effect of Finite Temperature Corrections

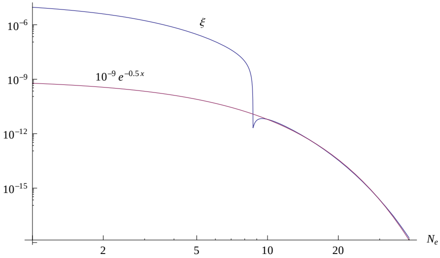
Plot for the evolution of ϕ and ϕ_c throughout inflation.



As the system starts to speed up and so T increases and the critical value of ϕ, ϕ_c reduces, preventing the hybrid transition.

Effect of Finite Temperature Corrections

The evolution of the function $\xi = \phi^2 - \phi_c^2$, plotted below, appears to fit very well with an exponential



- As ξ starts to fall rapidly to 0 dissipation increases causing αT^2 to become comparable to $g^2\phi^2$
- Numerics suggest ϕ never reaches ϕ_c

THANKYOU FOR LISTENING