What do WMAP and SDSS really tell about inflation?

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24 September, 2007

based on:
astro-ph/0703625, Phys.Rev.D75:123519, 2007, Julien Lesgourgues, WV
work in progress, Alexei Starobinsky, Julien Lesgourgues, WV

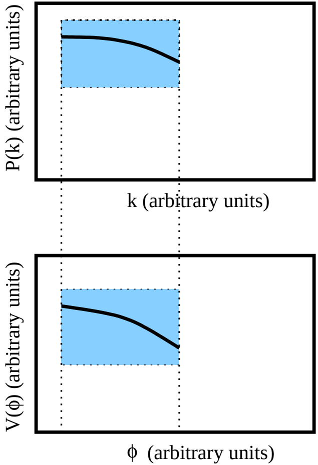
What's new?

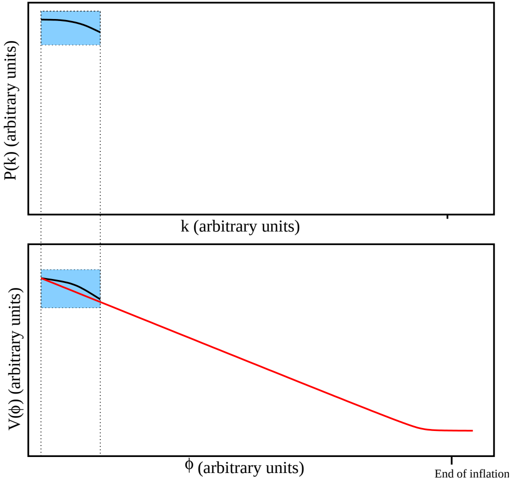
Other works

- use the slow-roll formalism
- and extrapolate far beyond the observable window.

We

- reconstruct only the observable window (no extrapolation)
- and numerically calculate the observables from a given $H(\phi)$ (or previously $V(\phi)$).
- make no approximation.

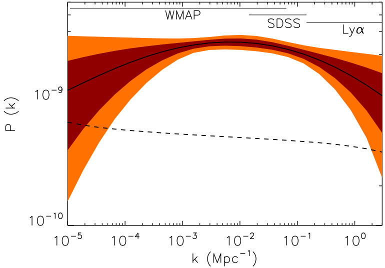

P(k) (arbitrary units)
k (arbitrary units)
V(ϕ) (arbitrary units)
ϕ (arbitrary units)


P(k) (arbitrary units)
k (arbitrary units)
V(ϕ) (arbitrary units)
ϕ (arbitrary units)
End of inflation

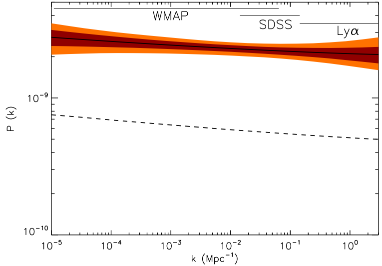
Different purposes:

SR - extrapolate	No extrapolation
Elegant / simple	Conservative about unobservable epoch
Very predictive / constraining	Relies on data only.

If you DID extrapolate:



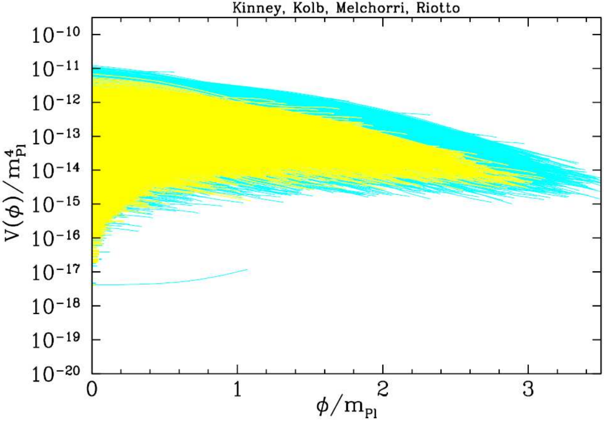
Fitting $P(k) = k^{(n_S - 1 + \dots)}$.



Fitting $P(k) = k^{(n_S - 1 + \dots)}$, selecting SR-inflationary models with $N > 30$. However: result heavily depends parametrisation (see e.g. Ballesteros et al. 2006 for large running and N$>$ 50)

Taken from Easther & Peiris, astro-ph/0609003.

If you DID extrapolate:



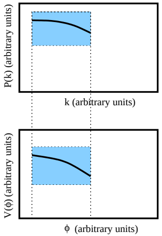
Taken from Kinney et al., astro-ph/0605338.

Directly fit the inflaton potential, numerically, using COSMOMC[I] and our own freely available module[II].

CBM + LSS

$\updownarrow$

$H(\phi) \rightarrow V(\phi)$



[I]Lewis & Bridle, 2002

[II]see astro-ph/0703625

$$\text{CBM} + \text{LSS}$$
$$\updownarrow$$
$$H(\phi) \rightarrow V(\phi)$$

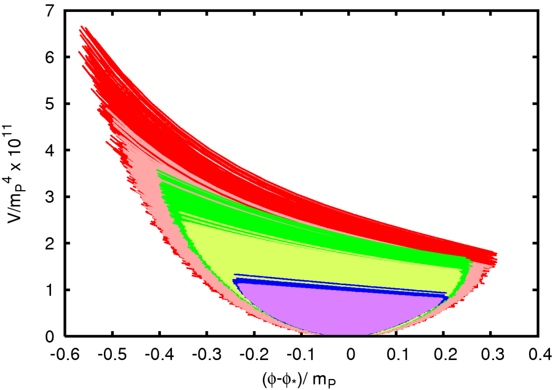
$$\dot{\phi} = -\frac{m_P^2}{4\pi} H'(\phi)$$
$$-\frac{32\pi^2}{m_P^4} V(\phi) = \left[H'(\phi)\right]^2 - \frac{12\pi}{m_P^2} H^2(\phi).$$

Result applies to any theory of inflation which, during the observable window, has effectively one scalar degree of freedom.

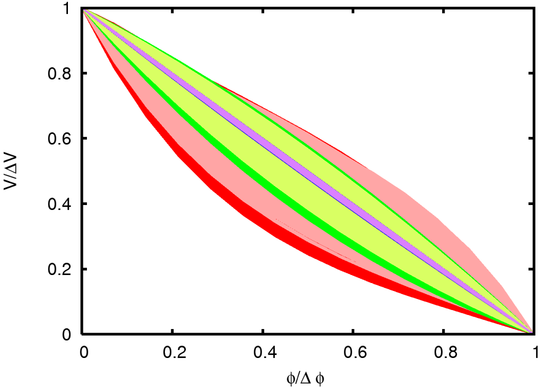
Directly fit the inflaton potential, numerically

Slow Roll	Numerical potential fit
$\Omega_b h^2$	$\Omega_b h^2$
$\Omega_{cdm} h^2$	$\Omega_{cdm} h^2$
θ	θ
τ	τ
$\ln[10^{10}\mathcal{P}_{\mathcal{R}}^{k_*}]$	$\ln\left[\frac{128\pi 10^{10} H_*^3}{3 H_*'^2 m_P^6}\right]$
r	$\left(\frac{H_*'}{H_*}\right)^2 m_P^2$
n_S	$\frac{H_*''}{H_*} m_P^2$
α_S	$\frac{H_*'''}{H_*}\frac{H_*'}{H_*} m_P^4$
β_S	$\frac{H_*''''}{H_*}\left(\frac{H_*'}{H_*}\right)^2 m_P^6$

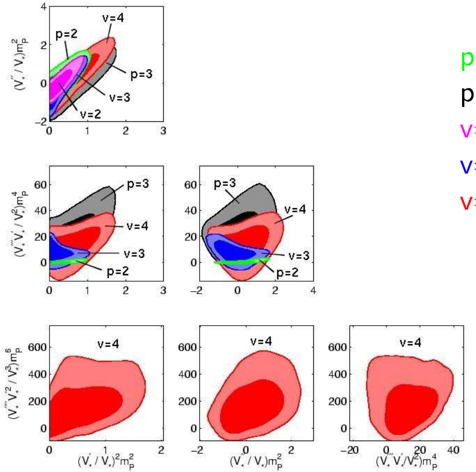
\+ self-consistent tensor parameters:
$n_\mathrm{T} = -r/8$,
$\alpha_\mathrm{T} = n_\mathrm{T}[n_\mathrm{T} - n_\mathrm{S} + 1]$



The inflaton potential at 68% and 95% confidence level



The inflaton potential at 68% and 95% confidence level



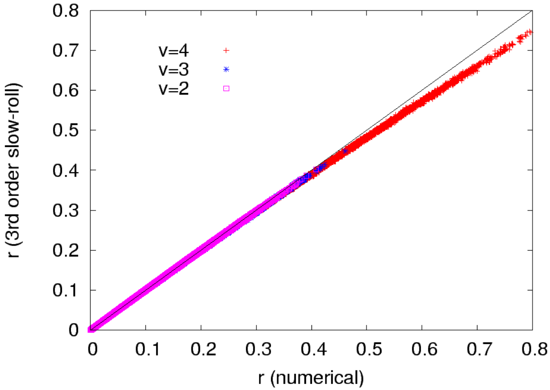
p=2 - A_S, n_S

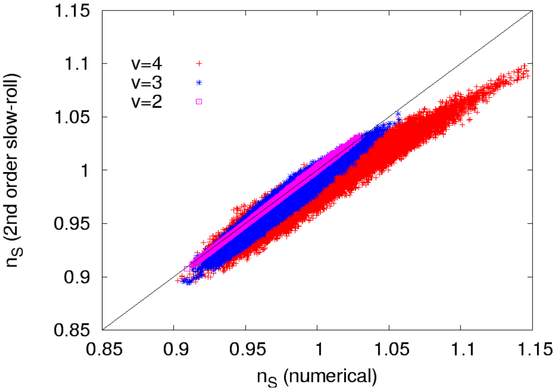
p=3 - A_S, n_S, α_S

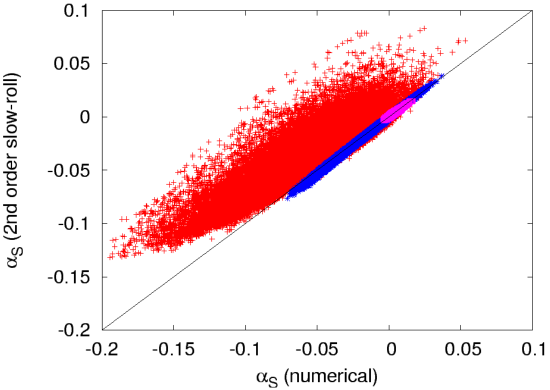
v=2 - V'_*, V''_*

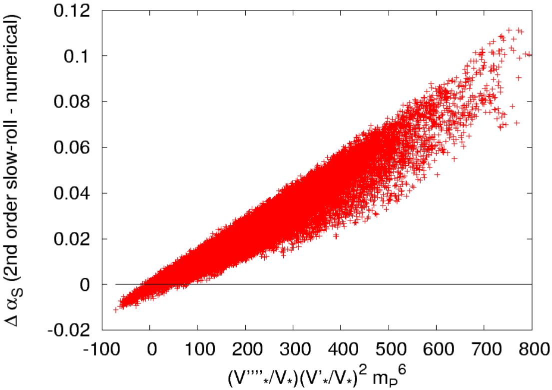
v=3 - V'_*, V''_*, V'''_*

v=4 - V'_*, V''_*, V'''_*, V''''_*

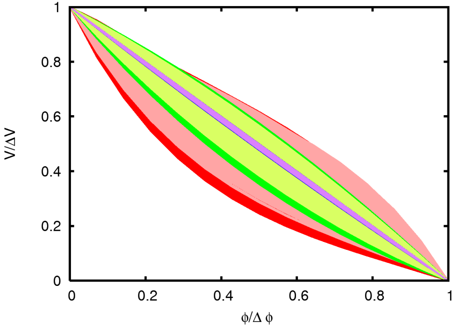

v=4
v=3
v=2
r (3rd order slow-roll)
r (numerical)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8


1.15
1.1
1.05
1
0.95
0.9
0.85
0.85
0.9
0.95
1
1.05
1.1
1.15
v=4
v=3
v=2
n_S (2nd order slow-roll)
n_S (numerical)


0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.2
-0.15
-0.1
-0.05
0
0.05
0.1
α_S (2nd order slow-roll)
α_S (numerical)


0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-100
0
100
200
300
400
500
600
700
800
Δ α_S (2nd order slow-roll - numerical)
(V''''*/V*)(V'*/V*)^2 m_P^6

Conclusion



- Previously obtained info on $V(\phi)$
  - depends parametrisation.
  - depends on strong assumptions
- Hint to go to one order higher in SR
- Conservative analysis of data constrains $H(\phi)$ up to H''' and thereby $V(\phi)$.