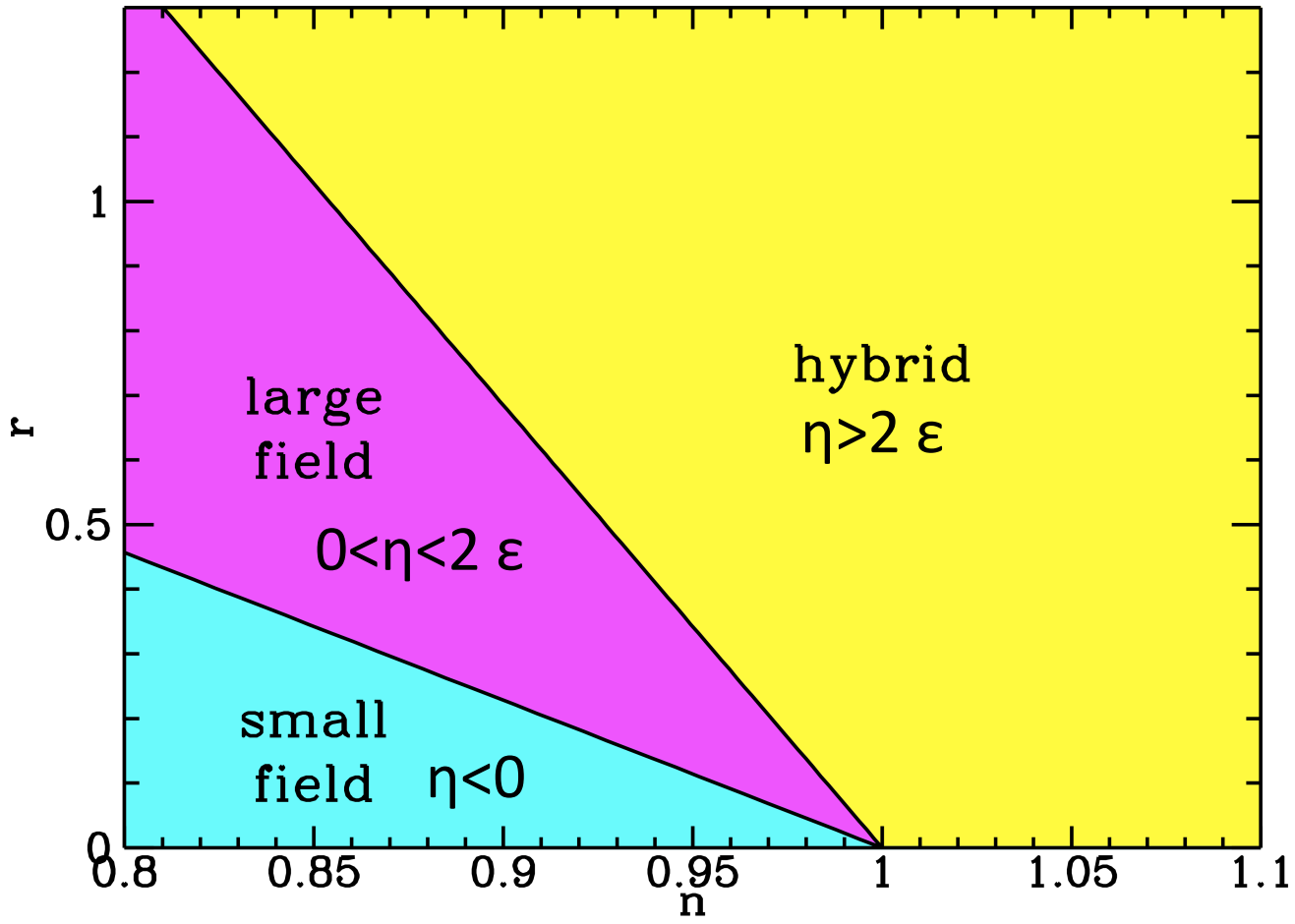
Zoology of inflationary models



$$r = \frac{8}{3}(1 - n_s) + \frac{2m_{Pl}^2}{3\pi}\frac{V_{,\phi\phi}}{V}$$

See,e.g., Kinney et al. astro-ph/0007375

Dai modelli di inflazione caotica si capisce che ~~ormai~~ il concetto di inflazione è ormai inteso come più generale di quello associato ad una rottura spontanea di simmetria. Una classificazione generale molto utile e attualmente molto usata divide i modelli in 3 tipi generali: modelli di campo grande, piccoli campi, e ibridi. Queste classi di modelli si differenziano a seconda dei valori della derivata seconda del potenziale, o, equivalentemente, a seconda della relazione tra i parametri di slow-roll ϵ e η. In genere $V(\varphi) = \Lambda^4 f\left(\frac{\varphi}{\mu}\right)$

A. Modelli di campo grande: $0 < \eta_V \leq 2\epsilon_V$

Potenziali tipici dello scenario inflazionario caotico; sono potenziali del tipo $V(\varphi) = \Lambda^4 \left(\frac{\varphi}{\mu}\right)^p$ (polinomiali) o $V(\varphi) = \Lambda^4 \exp\left(\frac{\varphi}{\mu}\right)$

B. Modelli di piccolo campo: $\eta_V < 0$

Potenziali che emergono tipicamente da rottura spontanea della simmetria (come i modelli originali di "nuova inflazione"). φ va da una configurazione instabile a un minimo stabile. Tipici potenziali sono della forma $V(\varphi) = \Lambda^4 \left[1 - \left(\frac{\varphi}{\mu}\right)^p\right]$

Classifying inflationary models

- ***``Large-field'' models $0<\eta_V<2\varepsilon$:***

$V(\phi) \propto \phi^p$ typical of ``caothic inflation scenario'' (Linde `83)

$V(\phi) \propto \exp[\phi/\mu]$ ``power law inflation'' (Lucchin, Matarrese '85)

- ***``small-field models'': $\eta_V<0$***

$V(\phi) \propto \left[1-\left(\frac{\phi}{\mu}\right)^p\right]$ from spontaneous symmetry breaking or Goldstone, axion modes (Linde; Albrecht, Steinhardt `82; Freese et al '90)

- ***hybrid models $\eta_V>2\,\varepsilon$:***

$V(\phi) \propto \left[1+\left(\frac{\phi}{\mu}\right)^p\right]$ supersimmetry; typically involve a second field to end inflation (Linde '91; '94)

Classifying inflationary models

Two more interesting models (as an example):

- **Natural inflation**

$$V(\phi) = V_0 \left[1 - \cos\left(\frac{\phi}{\mu}\right)\right]$$

Related to a shift symmetry of the inflaton: φ → φ+c, where c is a constant. If exact this symmetry would imply that φ is massless (the potential would be exactly flat). Usually the symmetry gets broken → a small mass is generated → pseudo Nambu-Goldstone field (axion).

For $\mu > M_{Pl}$ it is a large field models (Freese et al. 1990)

For $\mu < M_{Pl}$ it is a small field models

- **R^2 inflation**

$$S = \int d^4x\sqrt{-g}\,\frac{M_{pl}^2}{2}\left(R + \frac{R^2}{6M^2}\right)$$

Predicts a tiny amount of gravity waves (Starobinsky 1980)

Motivation: a modified gravity theory arising from quantum corrections. The R^2 term corresponds to an additional scalar degree of freedom that plays the role of the inflaton. In fact via a conformal transformation $g_{\mu\nu} \to \mathrm{e}^{-2\omega} g_{\mu\nu}$ with $\sqrt{6}M_{\rm Pl}\omega = \varphi_1$ one can rewrite this action in the so called Einstein frame, where, besides the Ricci scalar R of the usual Hilbert-Einstein action, there is the action of a minimally coupled scalar field with standard kinetic term and a potential

$$M^2 M_{\rm Pl}^4 \left(1 - \mathrm{e}^{-2\varphi_1/\sqrt{6}M_{\rm Pl}}\right)^2$$

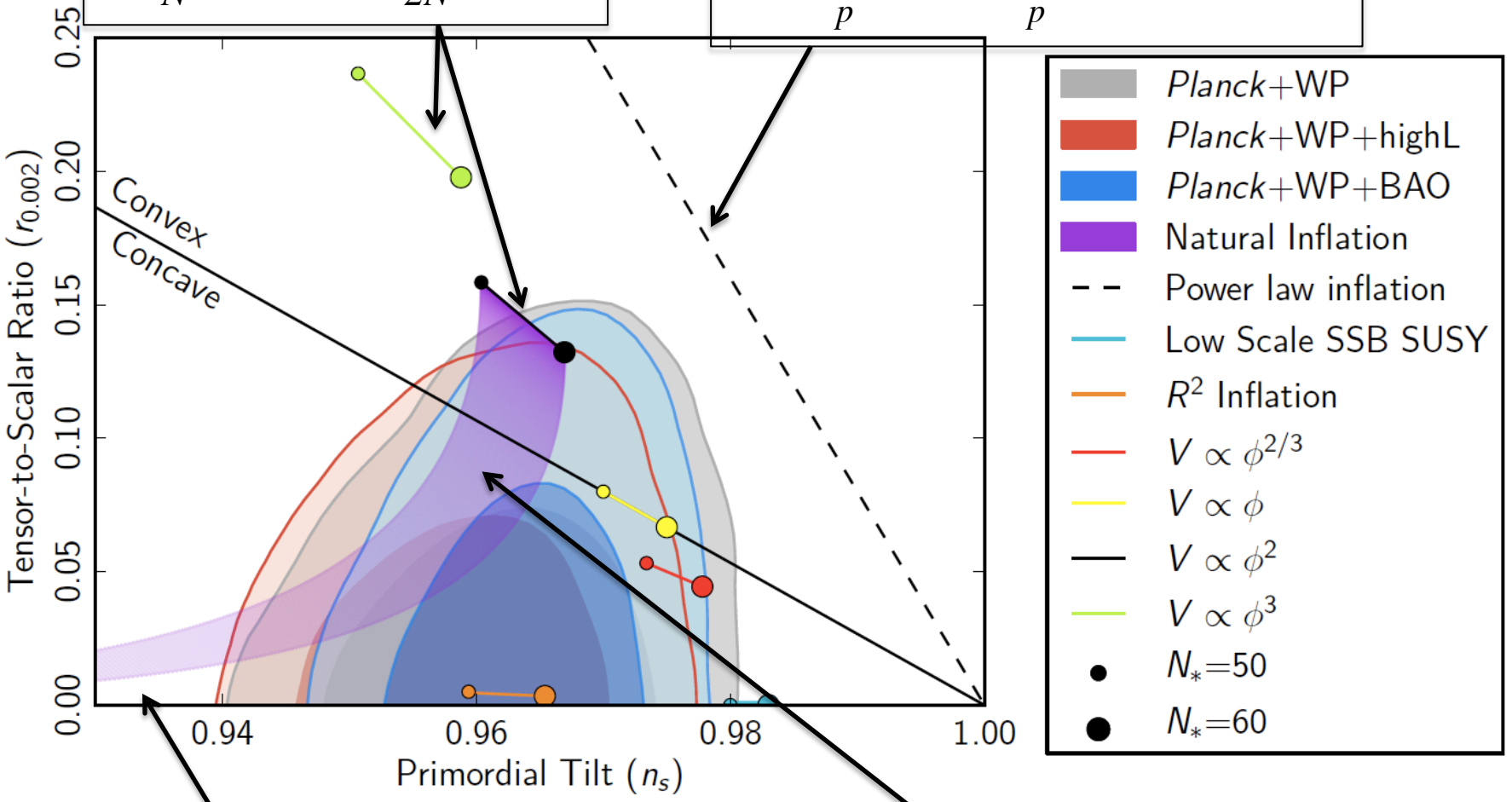
Large field models $V(\phi) \propto \phi^{\alpha}$

$$r = \frac{4\alpha}{N} \qquad 1 - n = \frac{\alpha + 2}{2N}$$

Exponential models

$V(\phi) \propto \exp[-\sqrt{2/p}\ \phi / M_{Pl}] \rightarrow a(t) \propto t^{p}$

$$r = \frac{16}{p} \qquad 1 - n = \frac{2}{p}$$



Small field models $V(\phi) \propto 1 - (\phi^{p} / \mu^{p}),\ p \geq 3$

$$r \sim 0 \quad 1 - n = \frac{2}{N}\frac{(p-1)}{(p-2)}$$

for example p = 3 out of 95% CL

Natural inflation $V(\phi) \propto 1 + \cos(\phi / f)$

consistent for $f \geq 5 M_{Pl}$

Planck 2013 Results. XXII. Constraints on inflation