Predictions in multifield models of inflation

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arXiv:1303.3611

and current work in collaboration with
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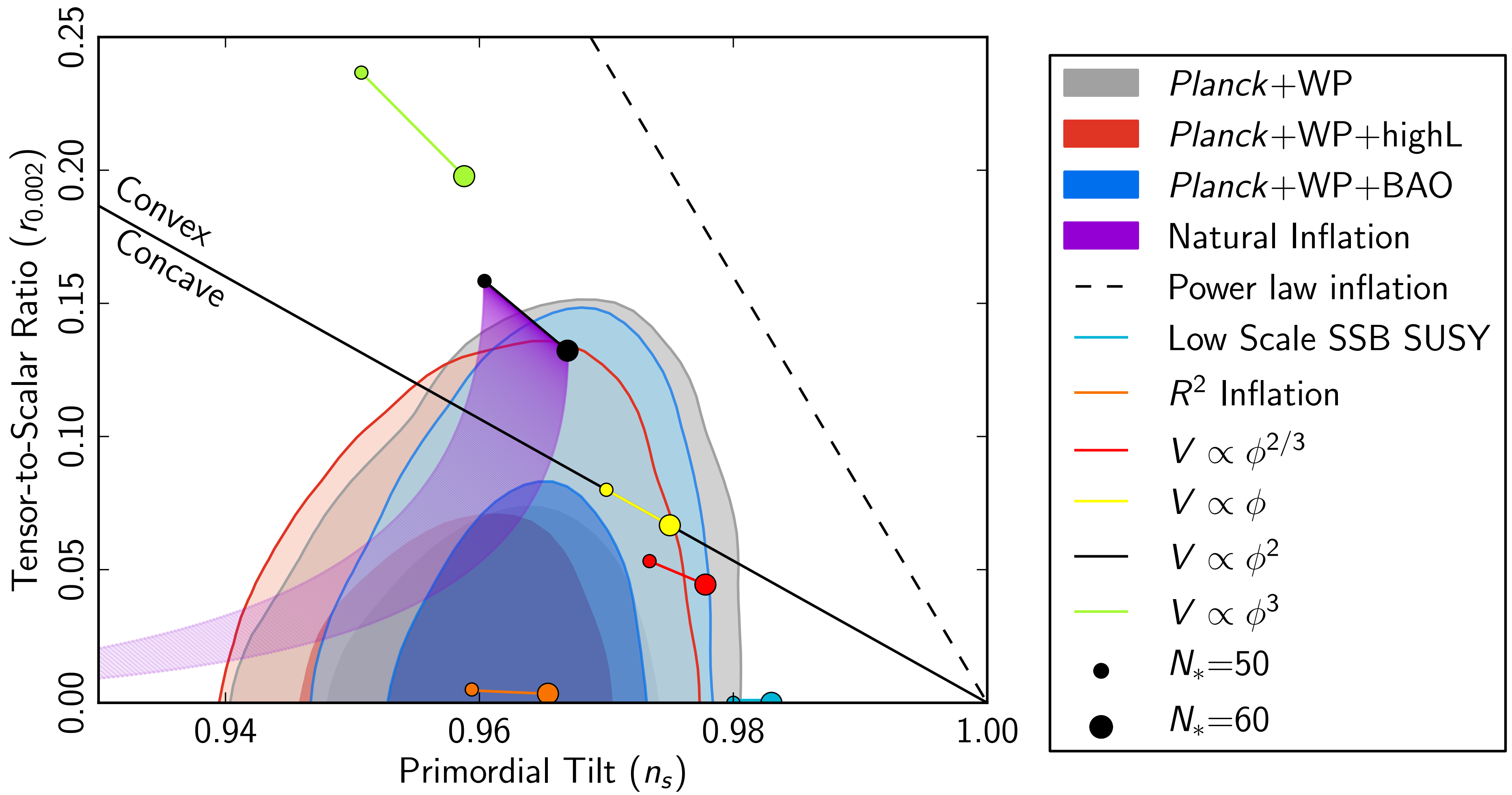
Overview

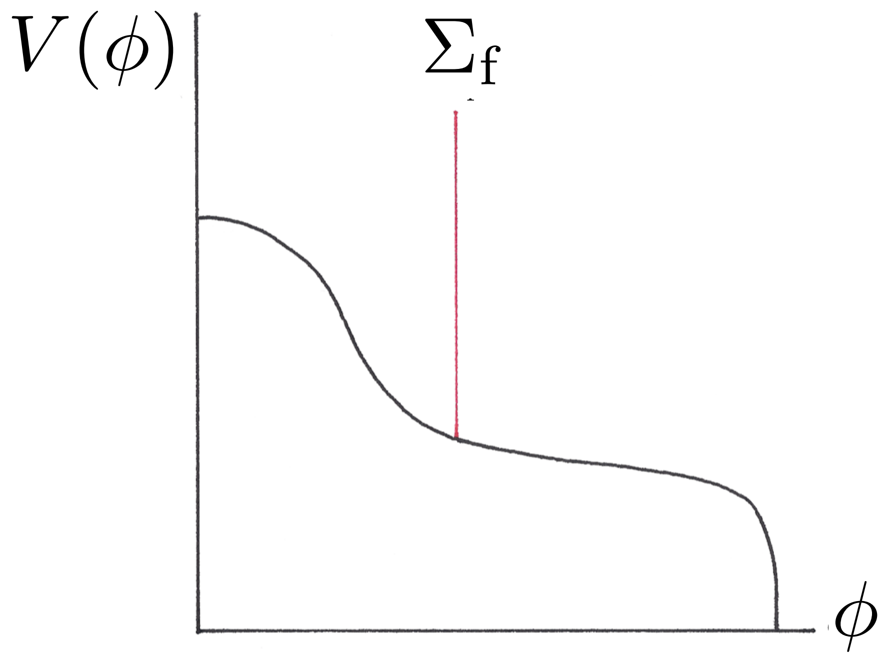
- The problem with predictions in multifield inflation
- A suggestion for a way forwards
- An analytic example
- Current numerical work

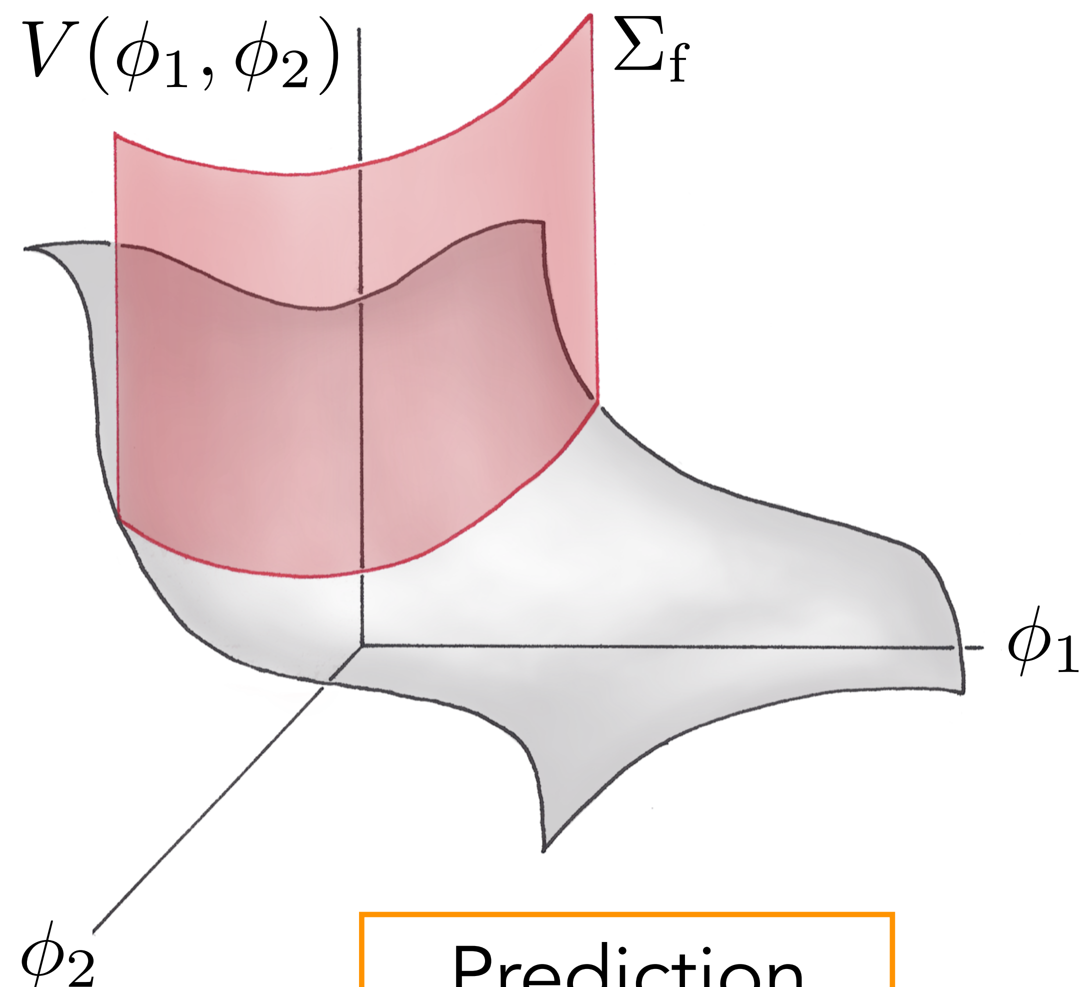
Problem: We don't know how to confront multifield models with observation.



Planck collaboration arXiv: 1303.5082

Multifield models are sensitive to initial conditions





Prediction is single valued

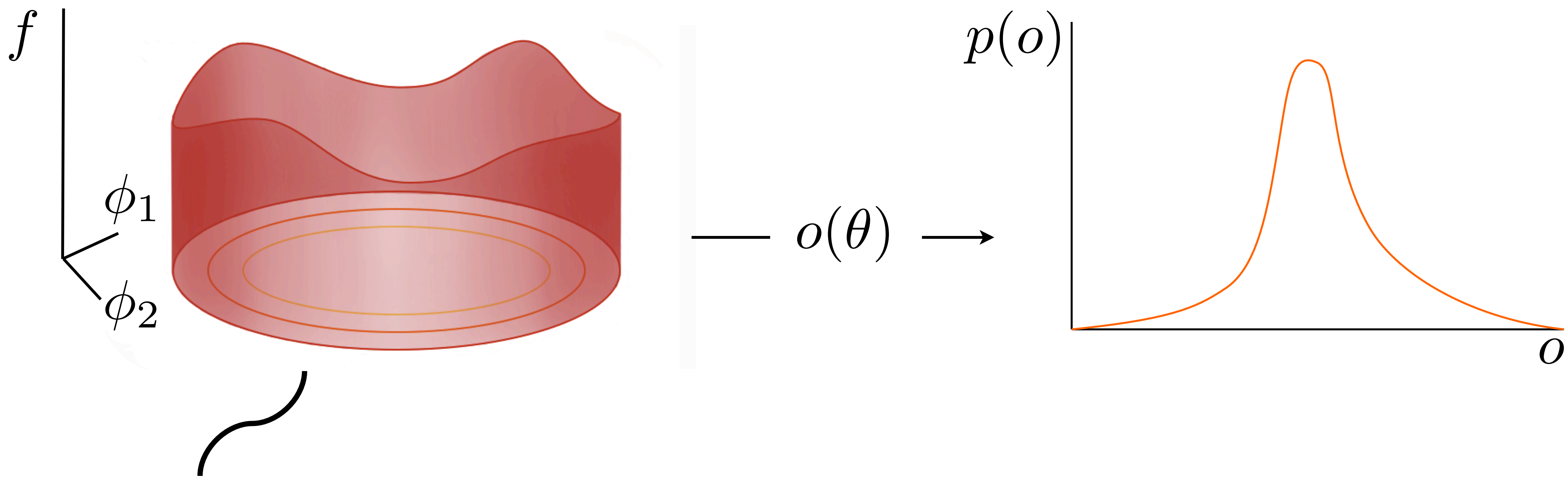
Prediction is a PDF

Split the problem into 2 parts:

1. Compute the PDF of initial conditions $f(\theta)$

2. Use PDF of initial conditions to compute PDF for observables $p(o)$ (a.k.a the prediction)

Strategy: Use conservation of probability to map PDF of initial conditions $f(\theta)$ to a PDF for observables $p(o)$.

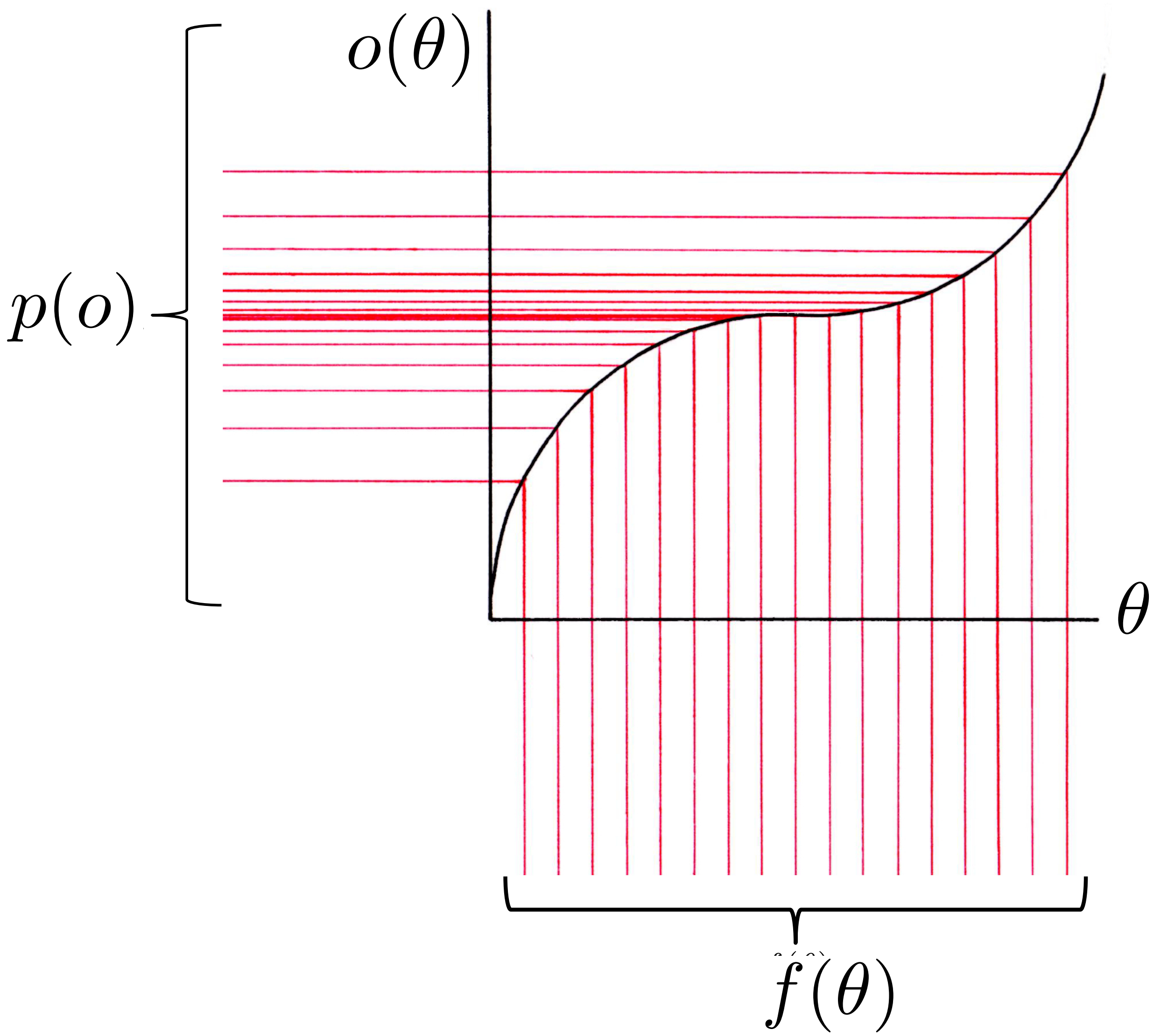


Parameterise Σ_{f} with variables θ.

$$p(o)|do| = f(\theta)|d\theta|$$

Strategy: Turning points in $o(\theta)$ enables robust predictions without detailed knowledge of initial conditions.

$$p(o)|do| = f(\theta)|d\theta|$$



Example: Double quadratic inflation $V = \frac{1}{2}m_1^2\phi_1^2 + \frac{1}{2}m_2^2\phi_2^2$

Since $N = \frac{1}{4}(\phi_1^2 + \phi_2^2)$, move to polar coordinates:

$$\phi_1 = 2\sqrt{N}\cos\theta \qquad \phi_2 = 2\sqrt{N}\sin\theta$$

Express observables as $o(\theta, N)$

-0.06

$n_{\mathrm{s}} - 1$

-0.40

0 θ 2π

0.15

α

-0.06

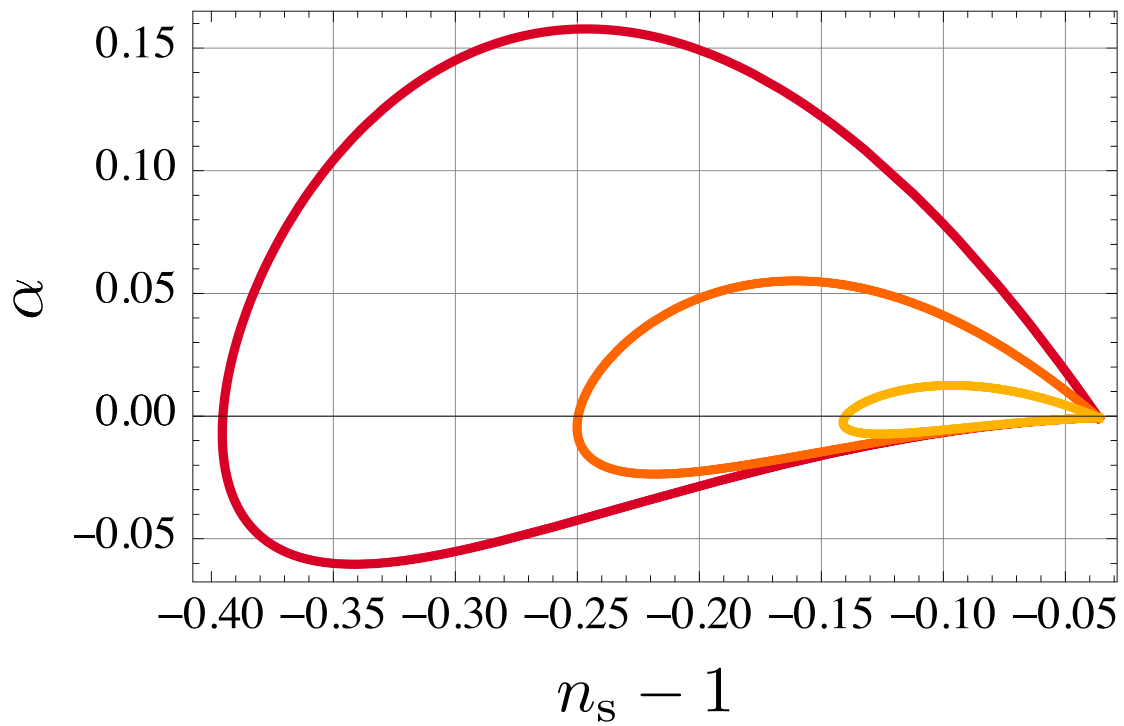
0 θ 2π

Example: Double quadratic inflation $V = \frac{1}{2}m_1^2\phi_1^2 + \frac{1}{2}m_2^2\phi_2^2$

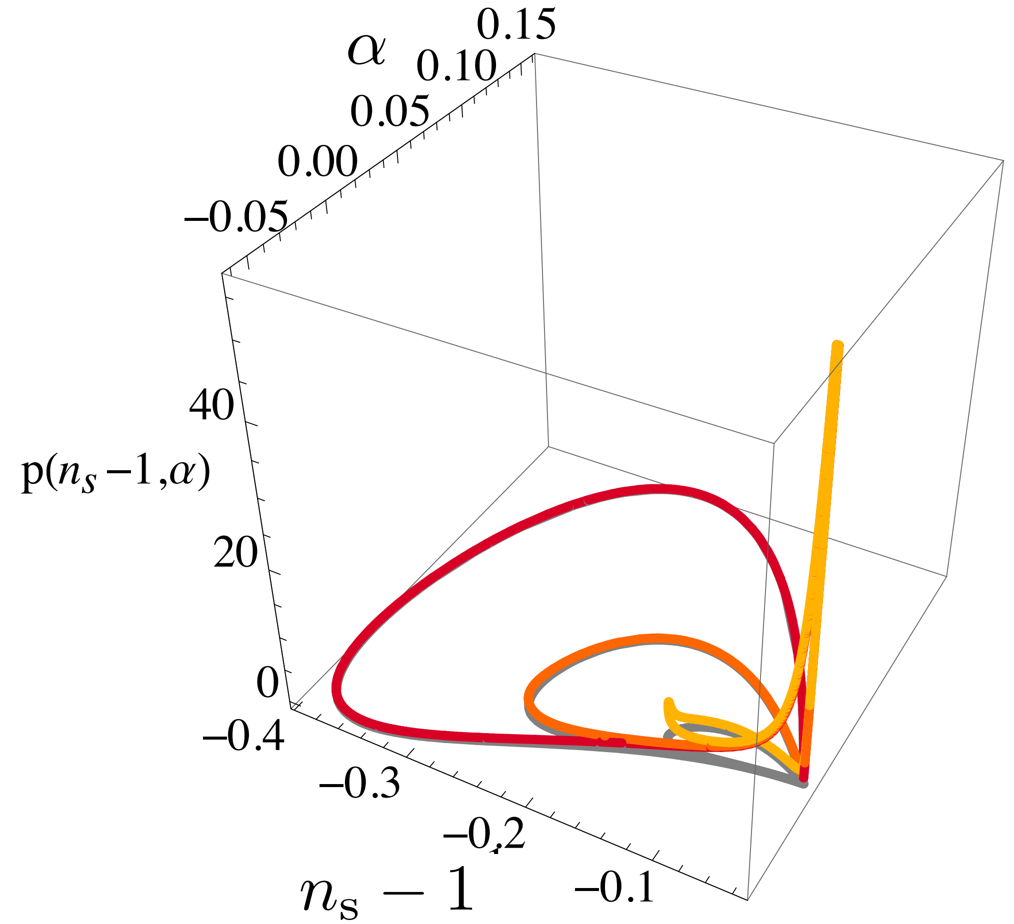
Try a flat distribution over the horizon crossing surface.

$$p(n_{\rm s}, \alpha) = \frac{2}{\pi}\frac{1}{\sqrt{\left(\frac{dn_{\rm s}}{d\theta}\right)^2 + \left(\frac{d\alpha}{d\theta}\right)^2}}$$

Result!



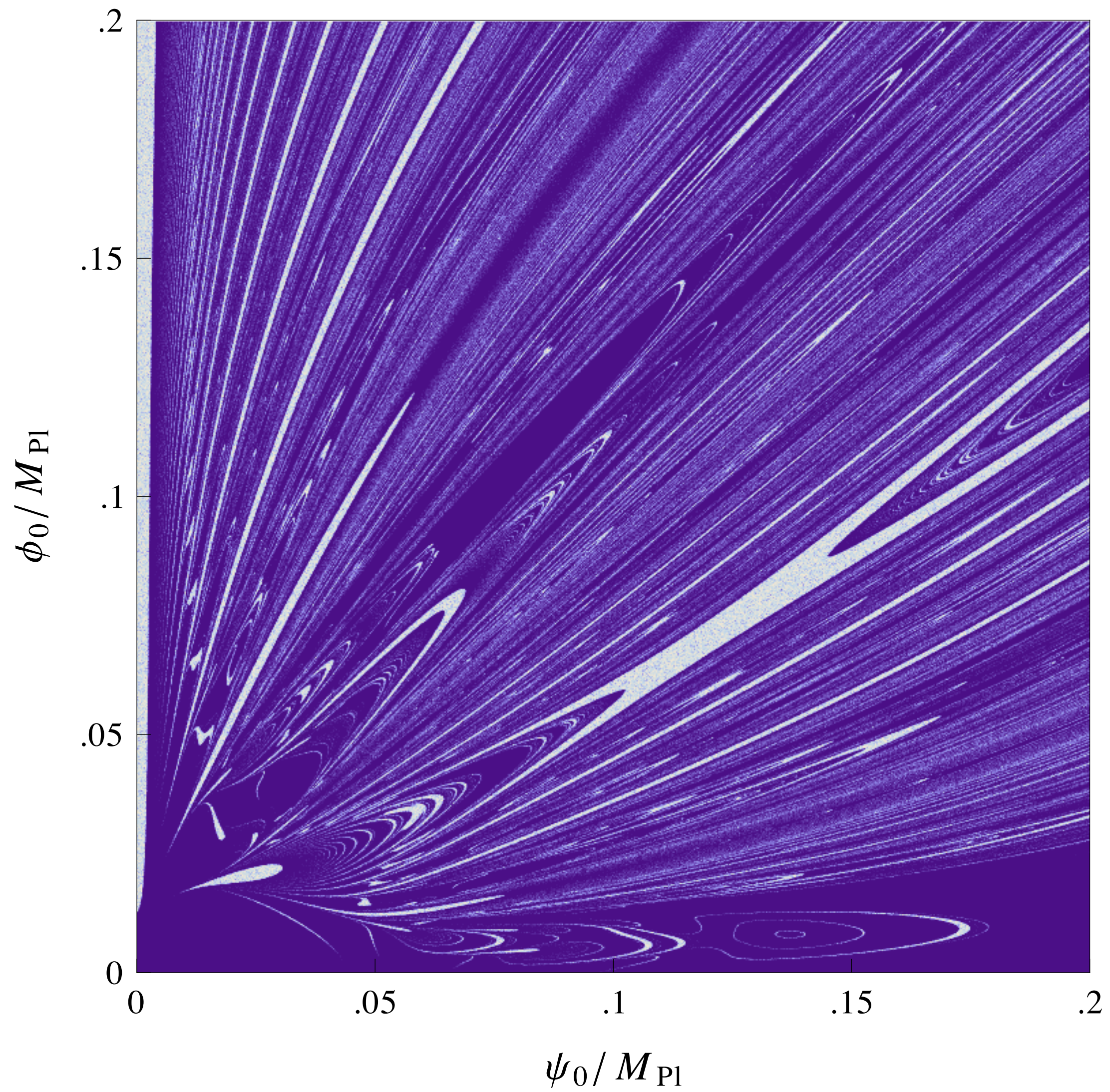
0.15
0.10
0.05
0.00
−0.05
α
−0.40 −0.35 −0.30 −0.25 −0.20 −0.15 −0.10 −0.05
$n_s - 1$



α
0.15
0.10
0.05
0.00
−0.05
40
$p(n_s - 1, \alpha)$
20
0
−0.4
−0.3
−0.2
−0.1
$n_s - 1$

Is there something misleading about the use of iso e-fold slicing?

Iso velocity



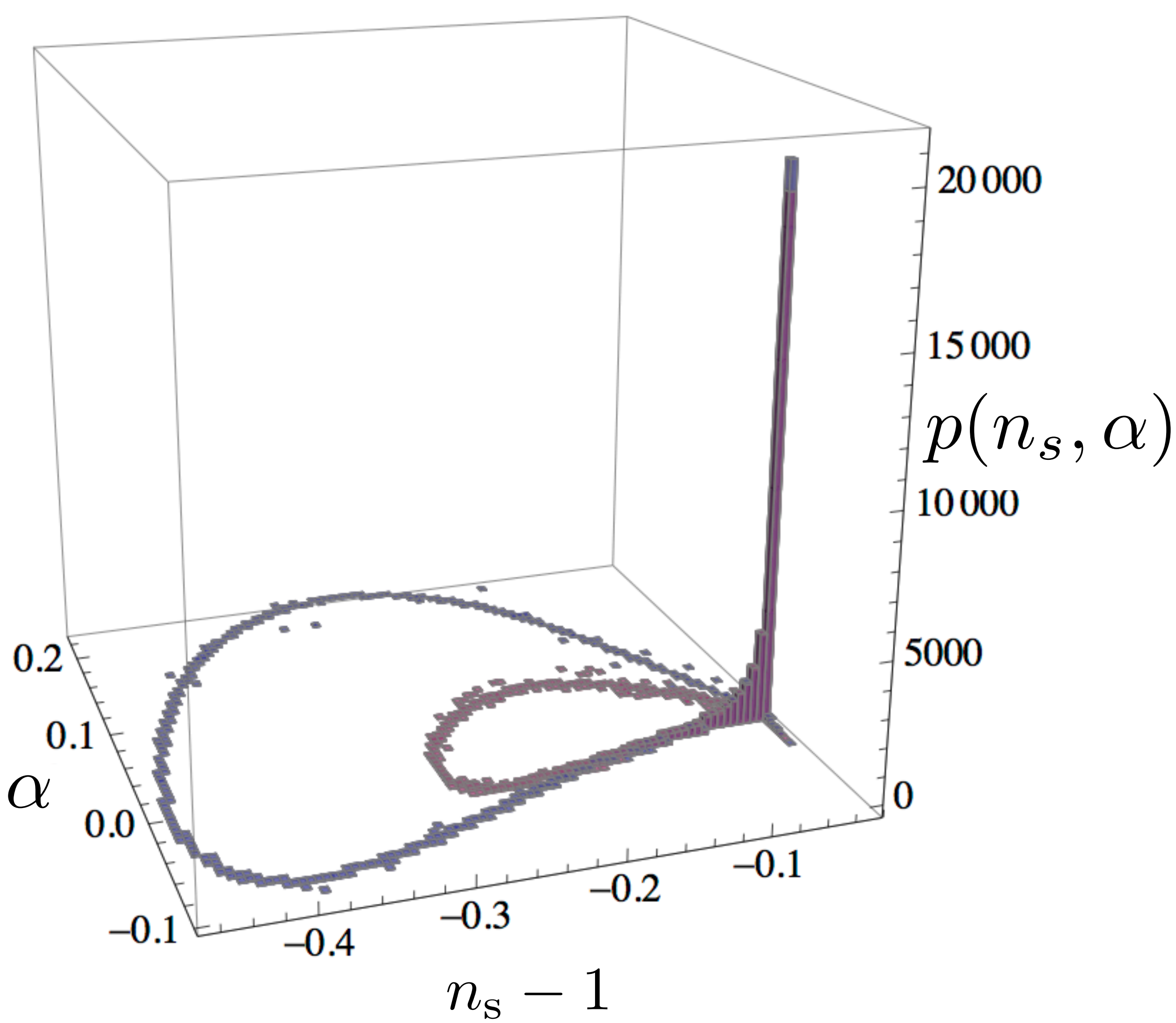
Iso energy

Plots taken from Easther and Price arXiv: 1304.4244

See also Clesse, Ringeval, Rocher arXiv: 0909.0402

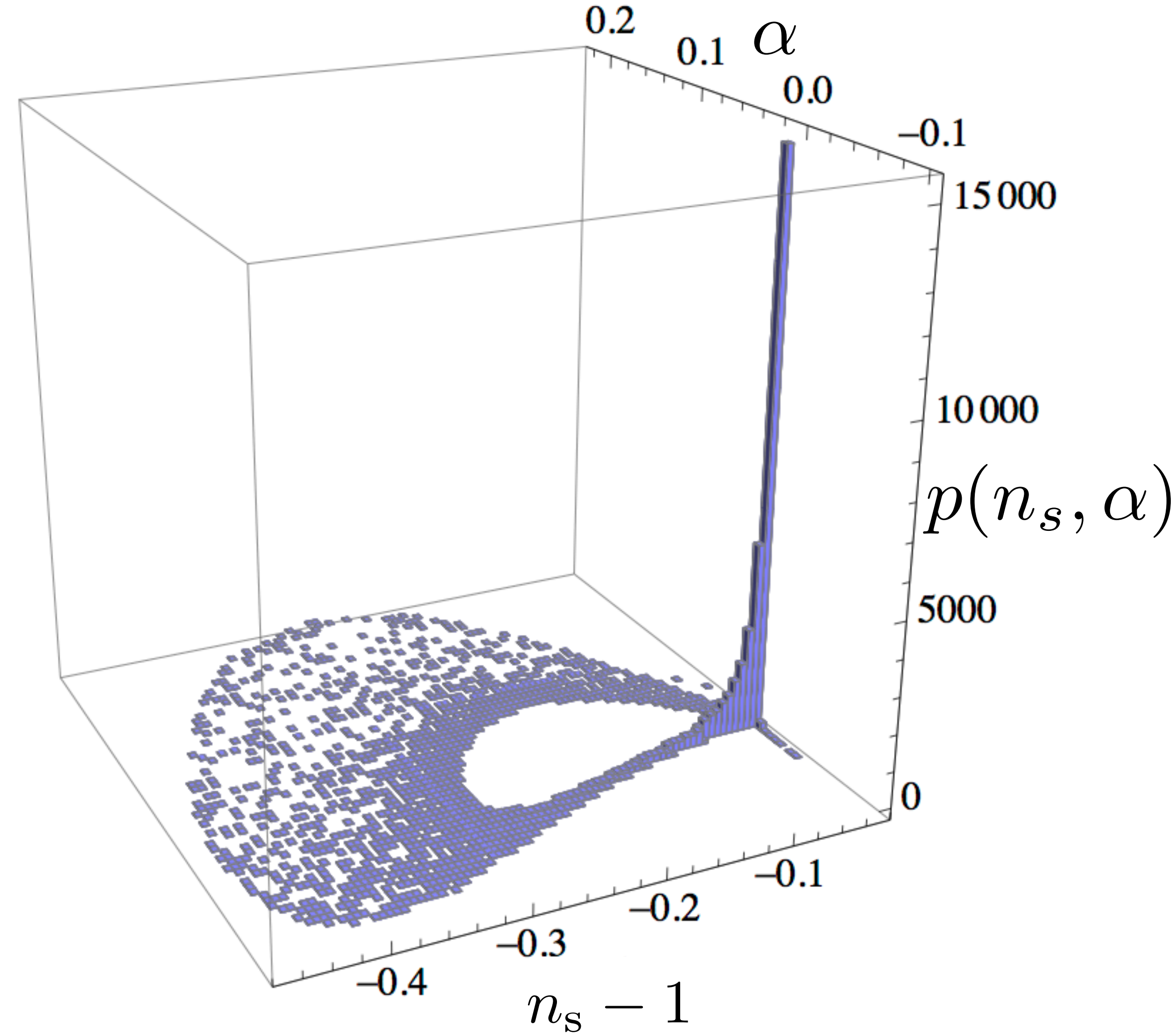
PDFs of observables for N_f-quadratic inflation

2-field



$$\frac{m_1}{m_2} = 7, 9$$

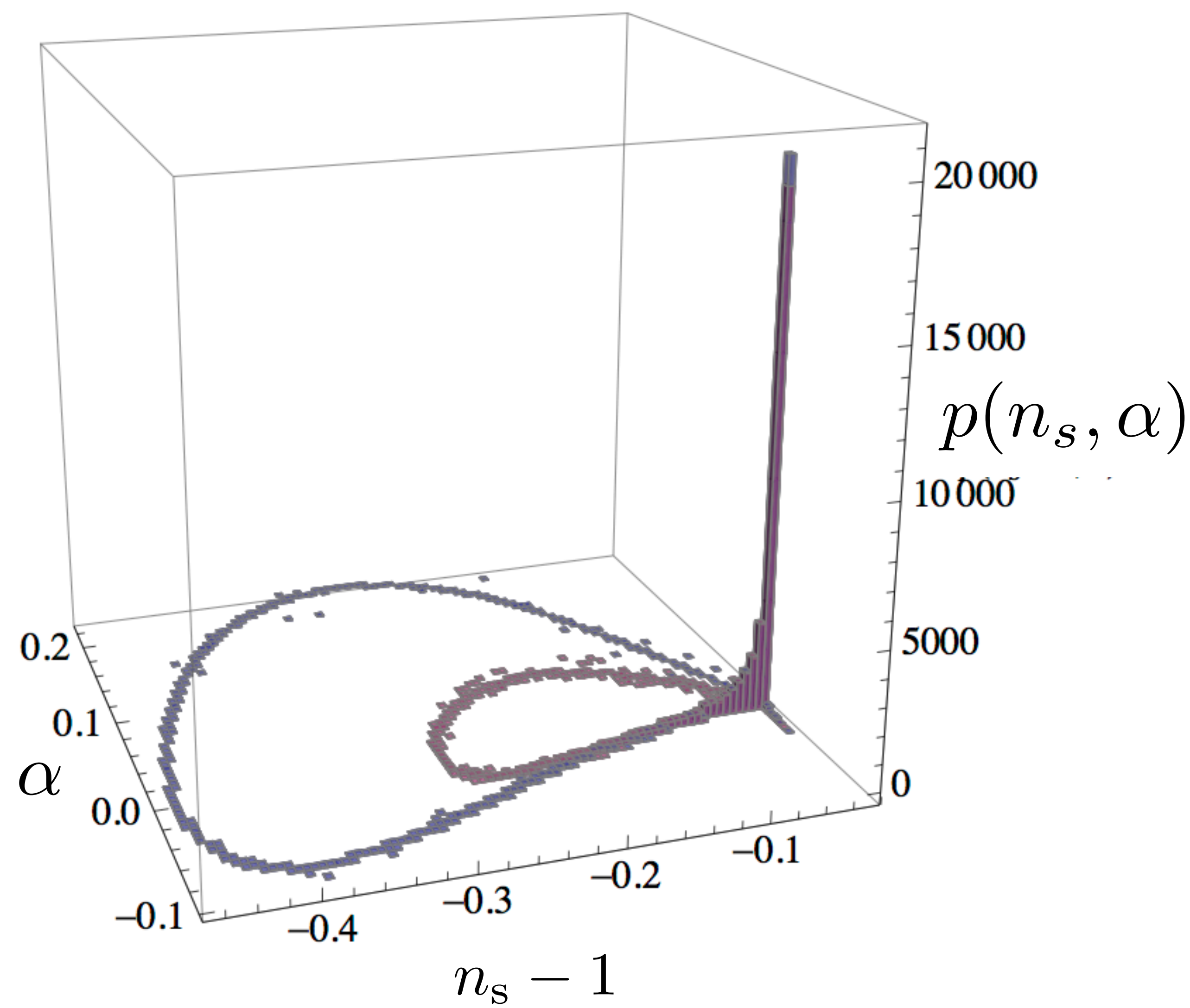
3-field



$$\frac{m_1}{m_2} = 7 \qquad \frac{m_1}{m_3} = 9$$

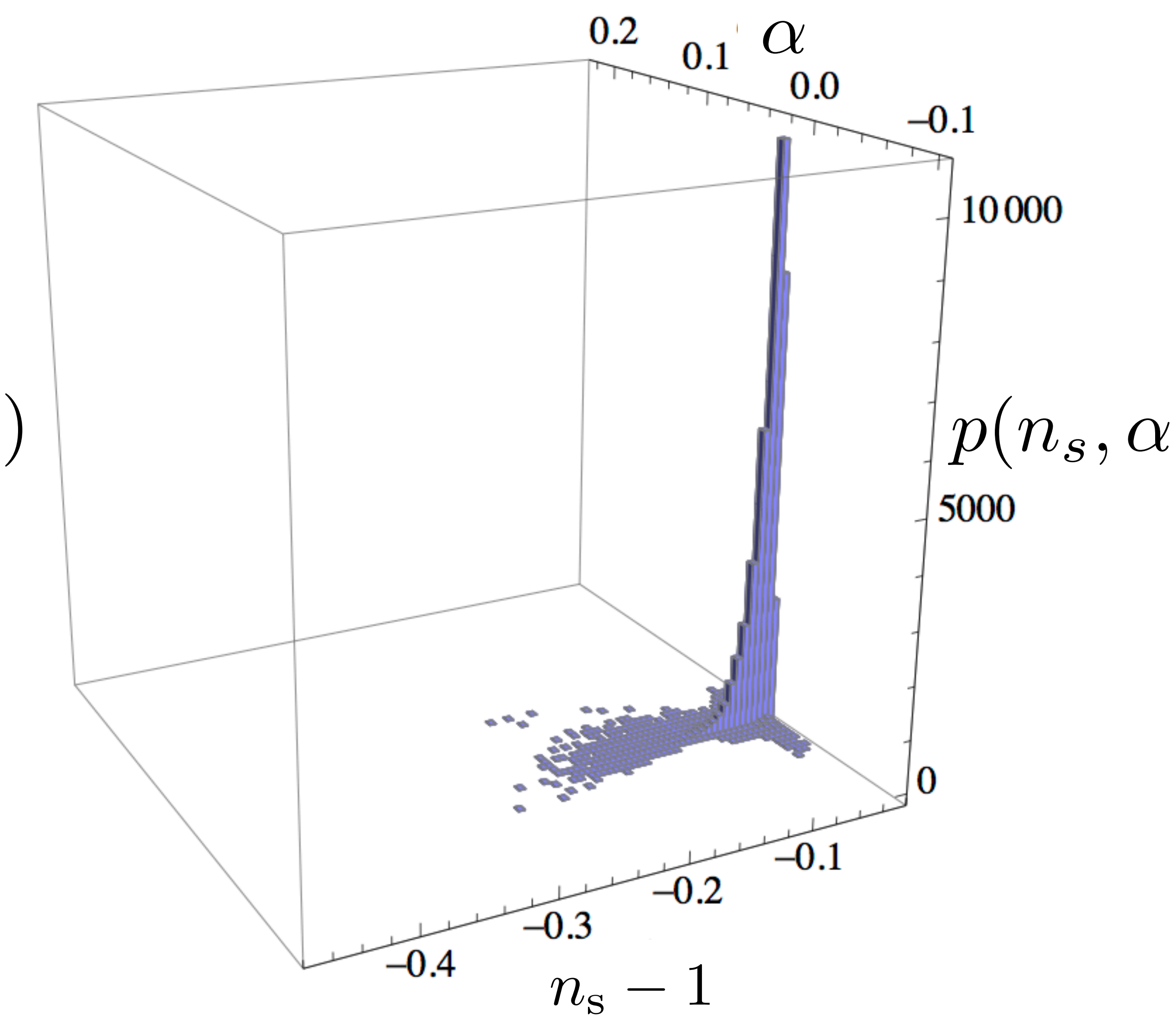
PDFs of observables for $N_{\rm f}$-quadratic inflation

2-field



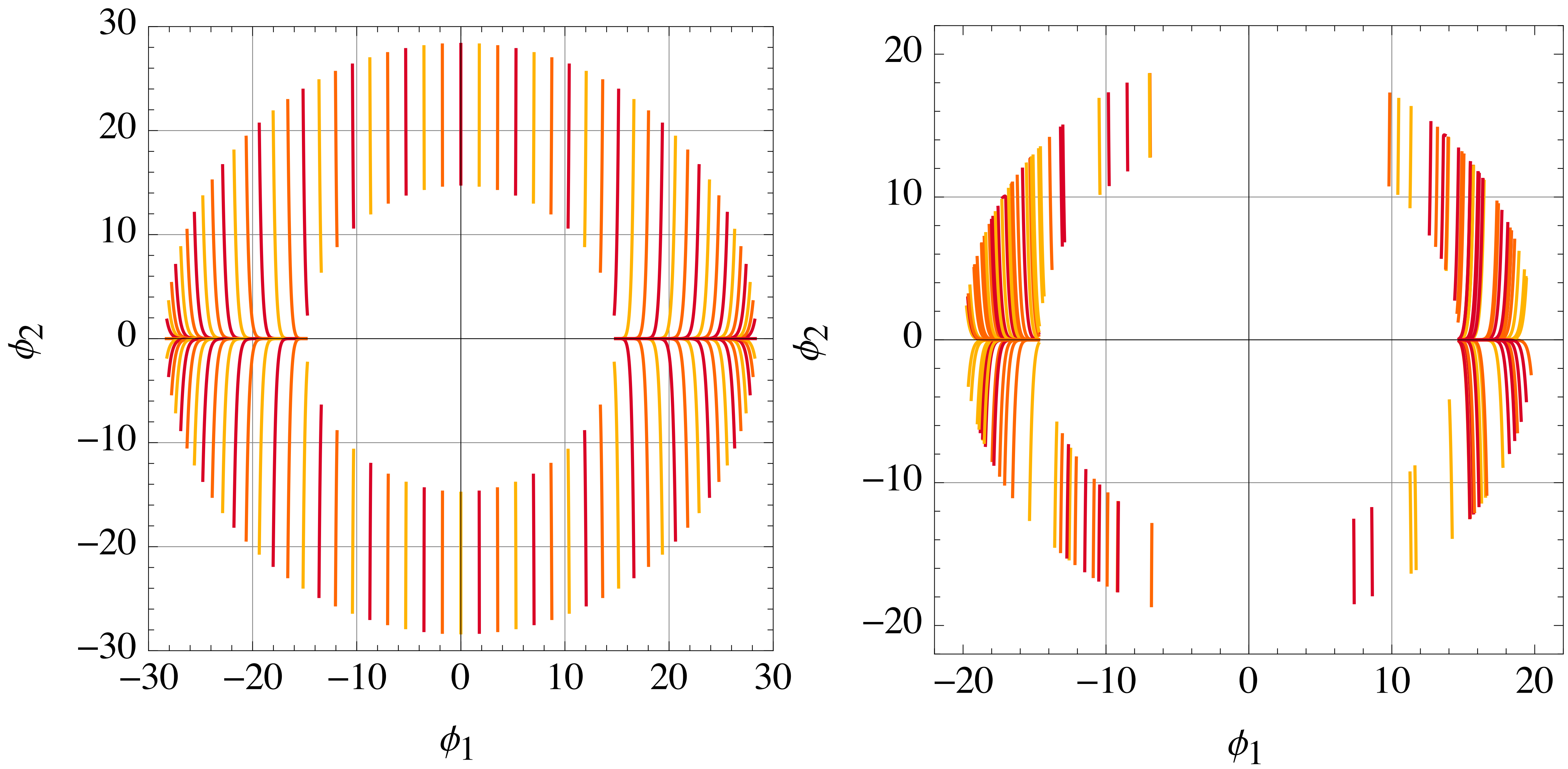
$$\frac{m_1}{m_2} = 7, 9$$

9-field



$$\frac{m_1}{m_2} = 2 \quad \ldots \quad \frac{m_1}{m_9} = 9$$

- Expect sharp spike in PDF to be a common characteristic
- Prediction is surprisingly insensitive to initial conditions



Is there a better way to study this?

- What are the criteria for a predictive model?
- Is it sensible to consider initial conditions and model parameters separately?
- Is there a better way to study multifield inflation than evolving individual classical trajectories?

$$p(o)|do| = f(\theta)|d\theta|$$

Conclusions

- Spike in PDF is robust to different slicings.
- Expect this property in a broad class of models but still WIP.
- Numerical tools extendable to arbitrary potentials.