



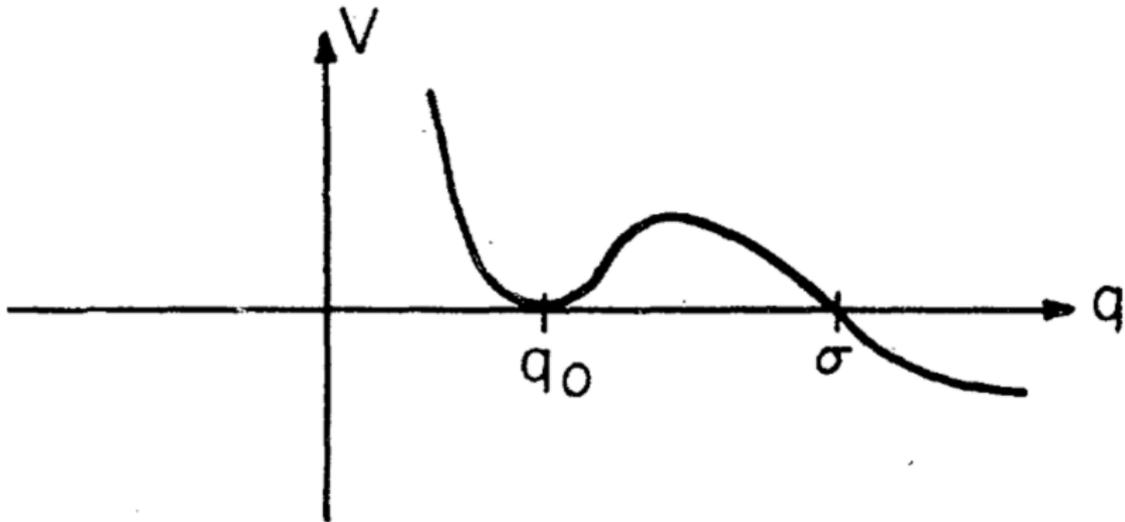
Efficient Perturbative Determination of Bubble Wall Profiles

Sujeet Akula

ARC Centre of Excellence for Particle Physics
School of Physics & Astronomy, Monash University

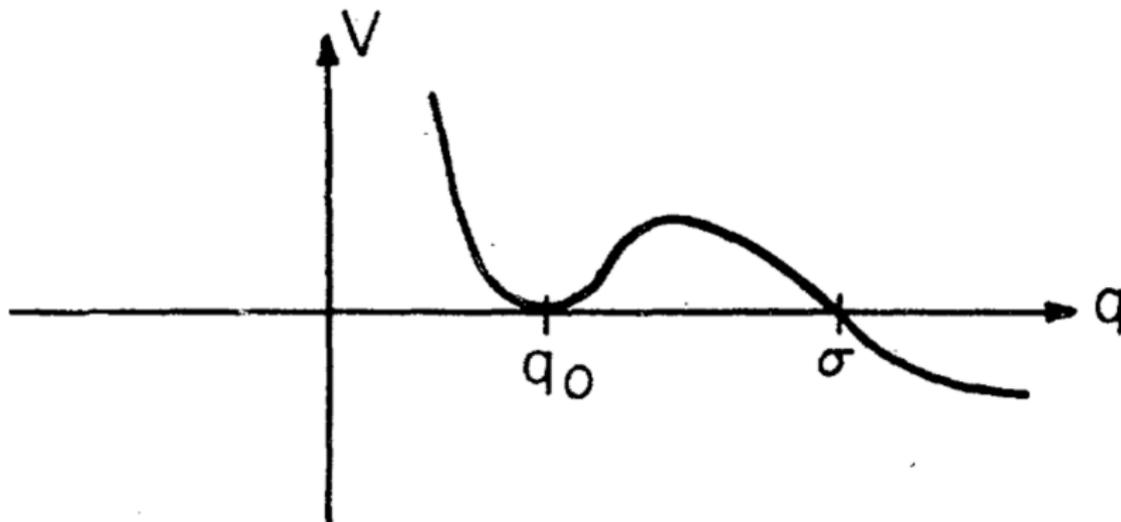
CosPA 2016
November 28–December 2

False Vacuum



False Vacuum

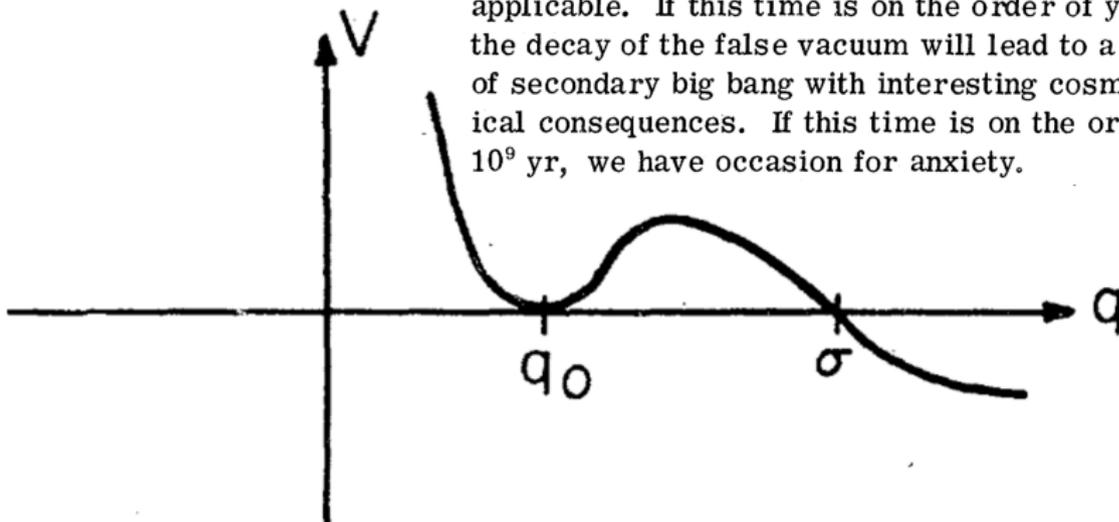
Vacuum Decay Rate?



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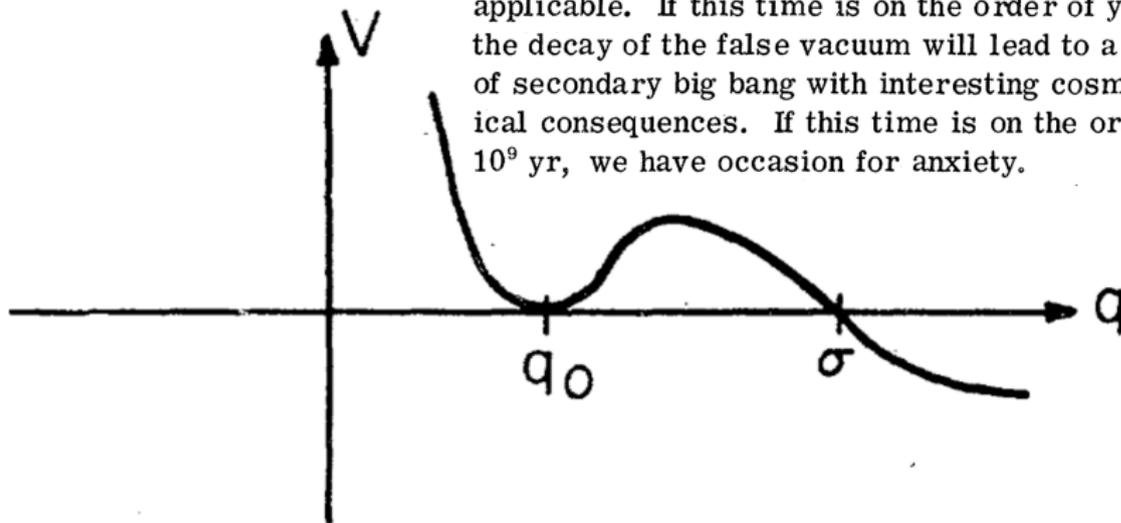
applicable. If this time is on the order of years, the decay of the false vacuum will lead to a sort of secondary big bang with interesting cosmological consequences. If this time is on the order of 10^9 yr, we have occasion for anxiety.



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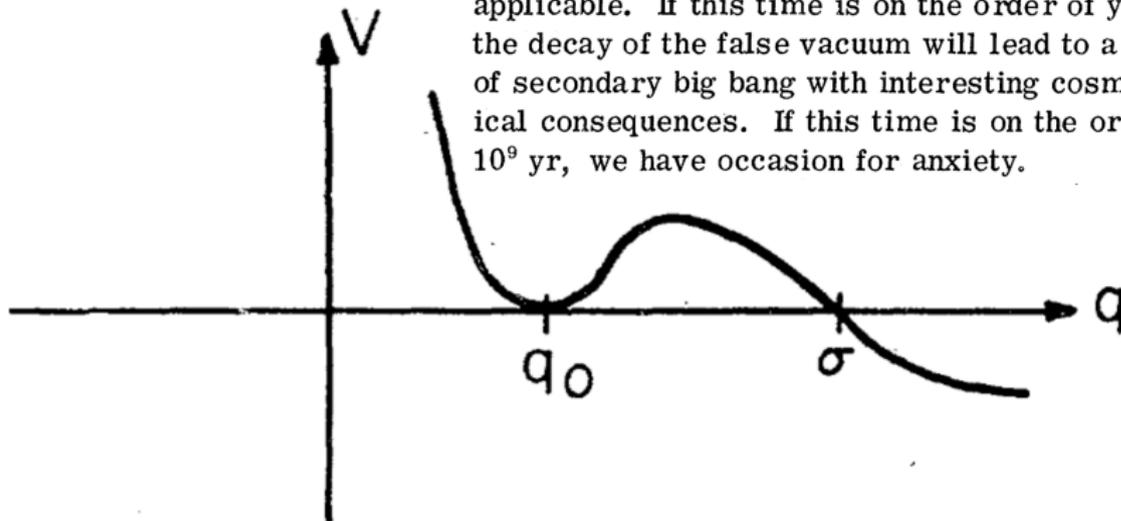


Bubble Profile?

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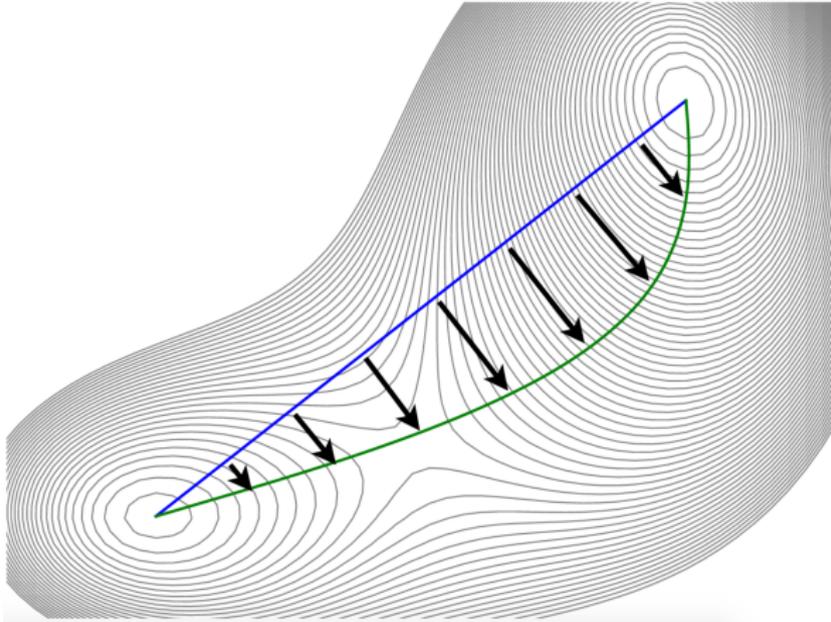


Bubble Profile?

⇒ Baryon Asymmetry

Path Deformation

cosmoTransitions



Compute the **bounce solution** for

$$V(\varphi_1, \varphi_2, \dots)$$

Be as generic as possible

Sketch

- Rotate & rescale
- Reparametrize potential
- Interpolate “solutions”
- Compute perturbative correction functions

Rotate & rescale

$$\{\varphi_1, \varphi_2, \dots\} \rightarrow \{\phi_1, \phi_2, \dots\}$$

So that $\hat{\phi}_1$ is direction of true vacuum from false vacuum

Reparametrize potential

$$V(\phi) = m^2\phi^2 + b\phi^3 + \lambda\phi^4$$

Reparametrize potential

$$V(\phi) = \frac{4\alpha - 3}{2} E\phi^2 + E\phi^3 - \alpha E\phi^4$$

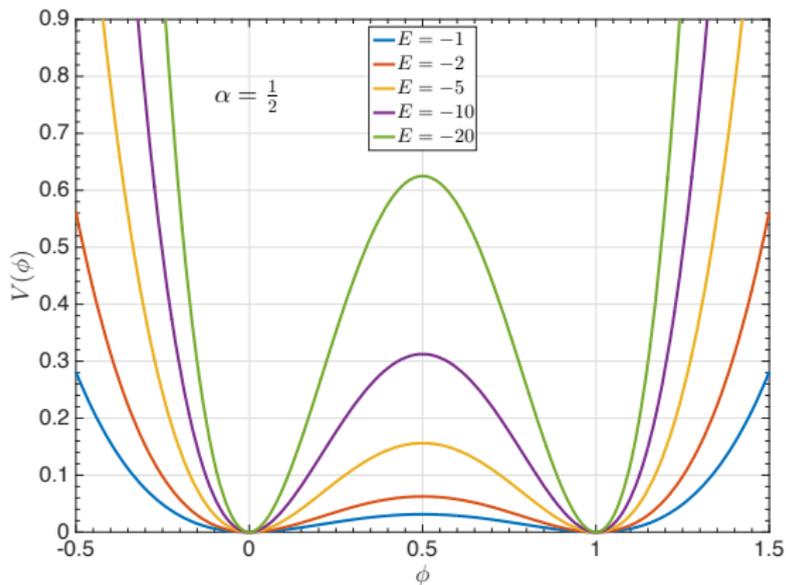
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What are α and E ?

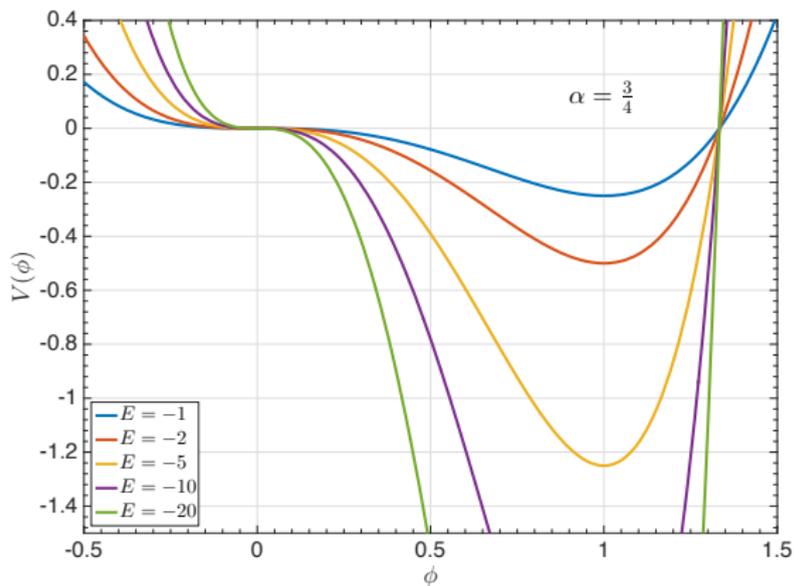
Strategy

Reparametrize potential



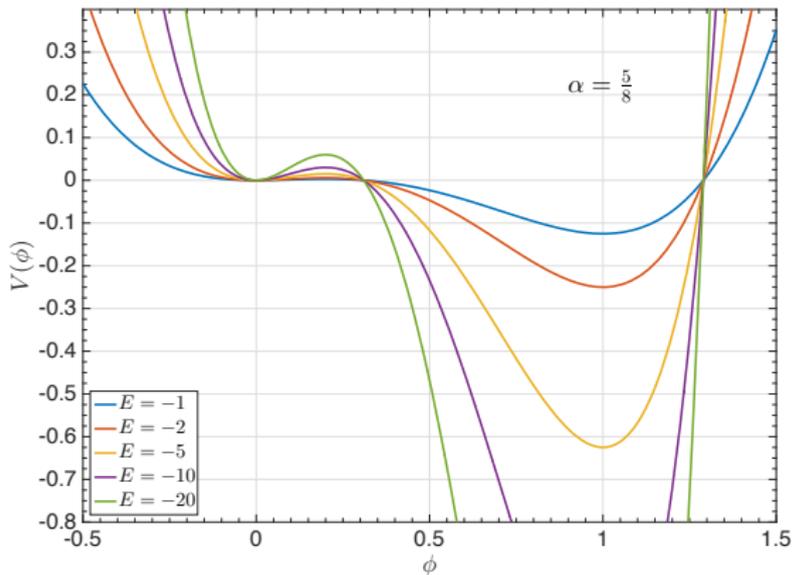
Strategy

Reparametrize potential



Strategy

Reparametrize potential



Strategy

Interpolate “solutions”

$$\phi \sim \tanh\left(\frac{\rho - \delta}{L_w}\right)$$

Kink solution

Strategy

Interpolate “solutions”

$$\phi \sim \tanh\left(\frac{\rho - \delta}{L_w}\right)$$

Spatial coordinate

Interpolate “solutions”

$$\phi \sim \tanh\left(\frac{\rho - \delta}{L_w}\right)$$

Offset

Strategy

Interpolate “solutions”

$$\phi \sim \tanh\left(\frac{\rho - \delta}{L_w}\right)$$

Bubble wall width

Interpolate “solutions”

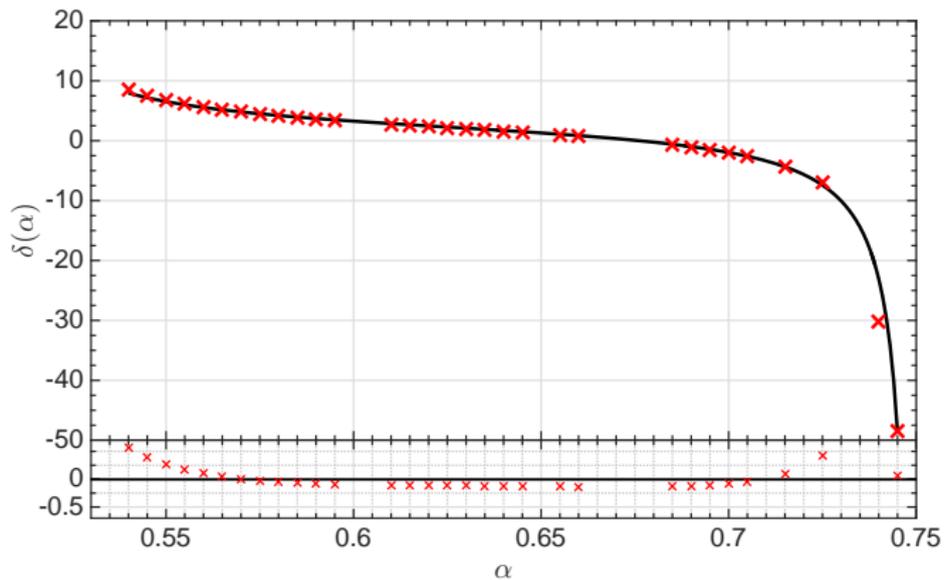
$$\phi \sim \tanh\left(\frac{\rho - \delta}{L_w}\right)$$

Also:

$$S_E \sim \frac{f(\alpha)}{\sqrt{|E|}}$$

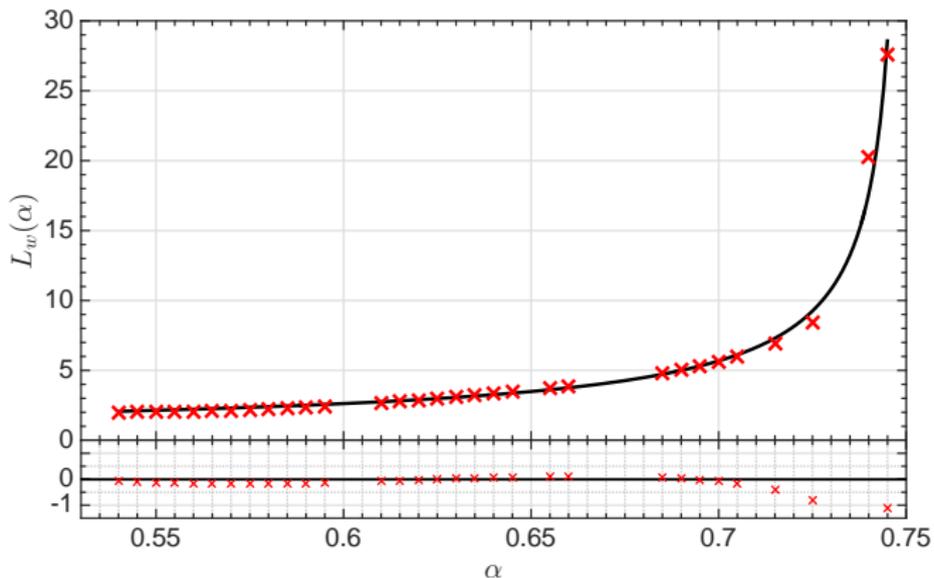
Strategy

Interpolate: offset



Strategy

Interpolate: bubble wall width



For our next trick...

Perturbative Corrections

Start with the 'kink' ansatz, add a **correction function**.

Equations of motion:

$$\hat{D}(\mathcal{A} + \epsilon) = 0$$

Rearrange:

$$\hat{D}'\epsilon = B(\rho)$$

Error function $B(\rho)$ determined by ansatz, measures how well EOMs solved.

\hat{D}' is **linearized** into a simple eigenvalue problem

Restore **non-linear term**, add correction to correction, rinse & repeat.

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Toy Model

Two fields

Original potential:

$$V(x, y) = (x^2 + y^2) [1.8(x - 1)^2 + 0.2(y - 1)^2 - \delta]$$

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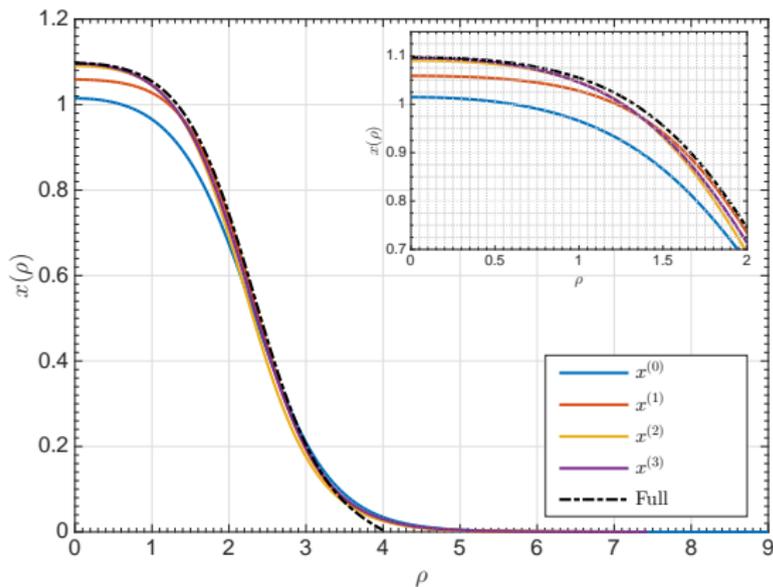
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Setup **ansatz**, compute **corrections...**

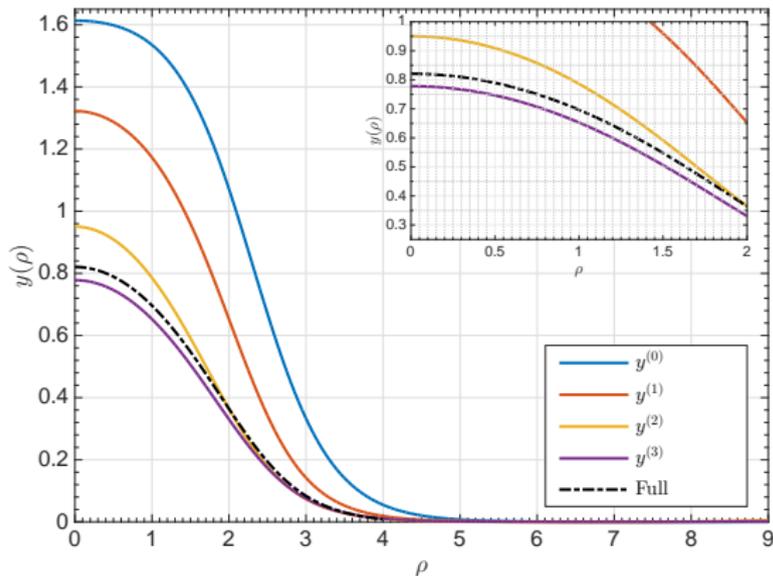
Toy Model

x field



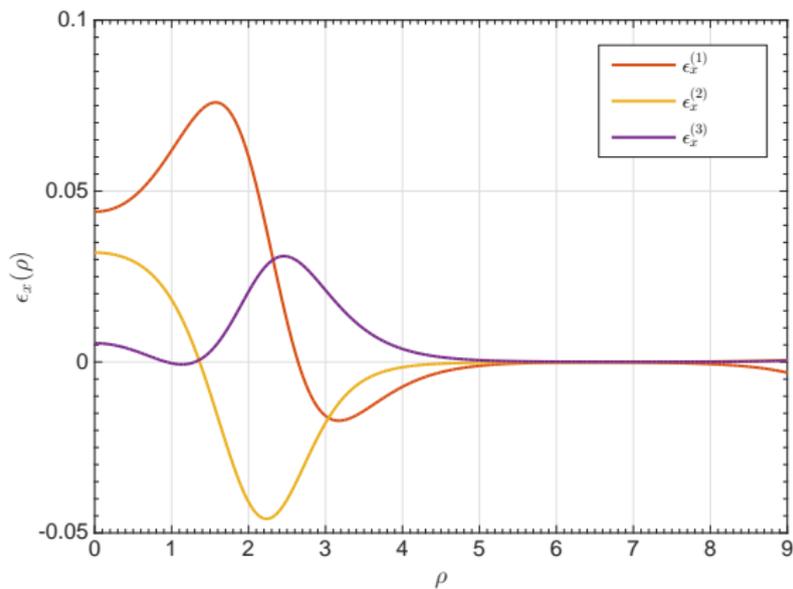
Toy Model

y field



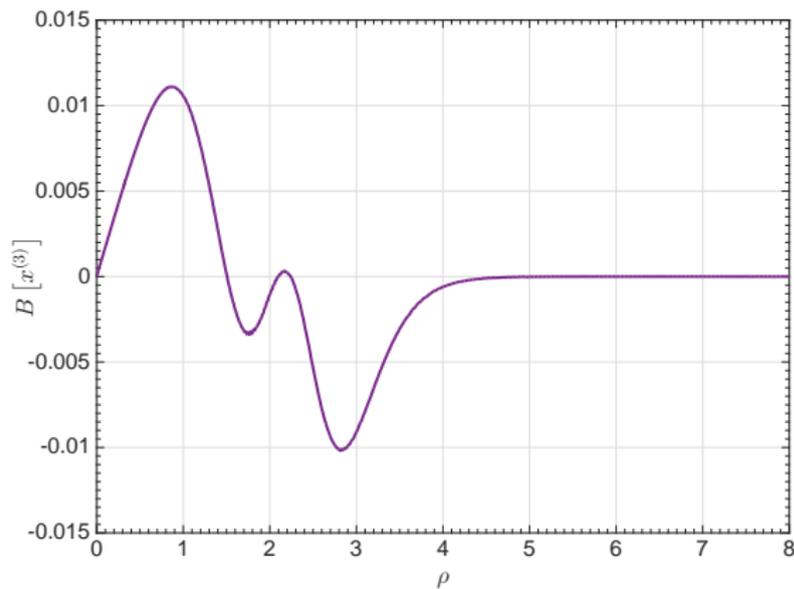
Toy Model

x corrections



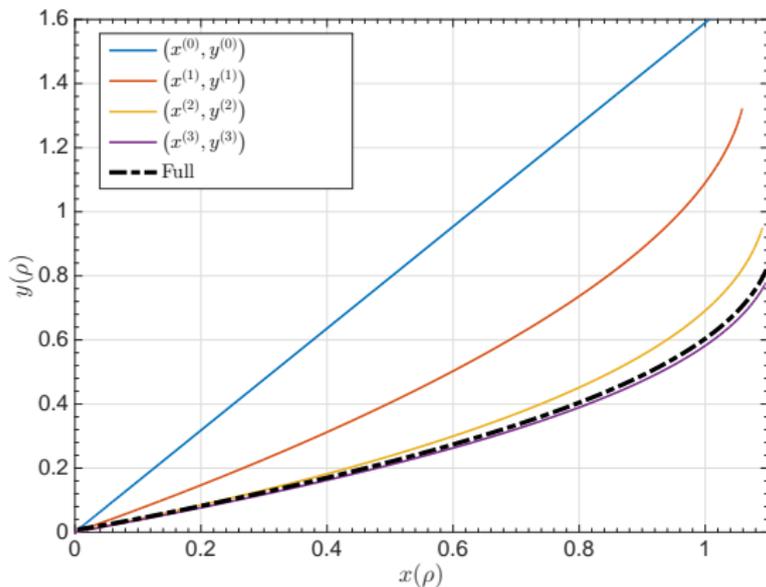
Toy Model

x error function



Toy Model

Trajectory



Stay Tuned

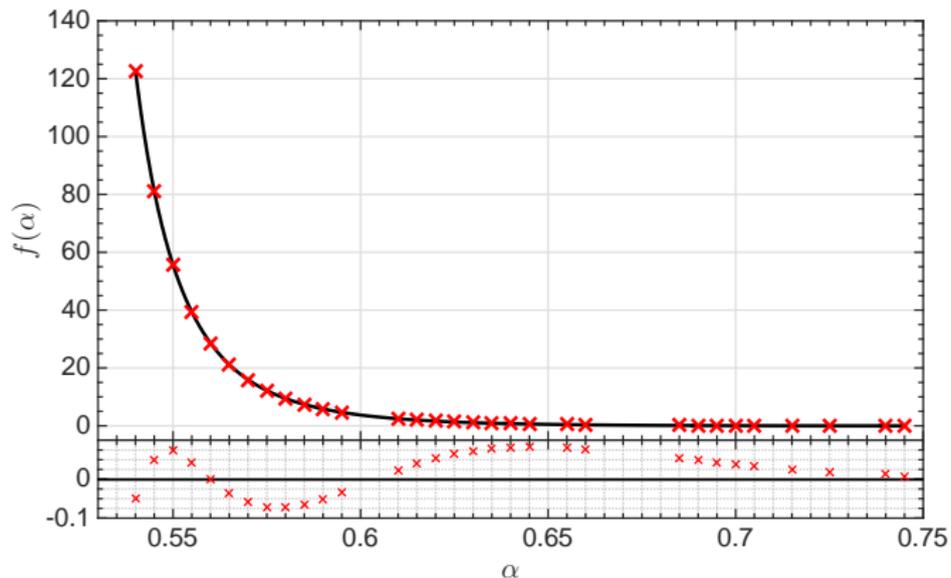
Future work

- Automatic solver
- Applications in NMSSM cosmology
- Component in generalized cosmology solving framework

Thank you!

Strategy

Interpolate: Euclidean action



Toy Model

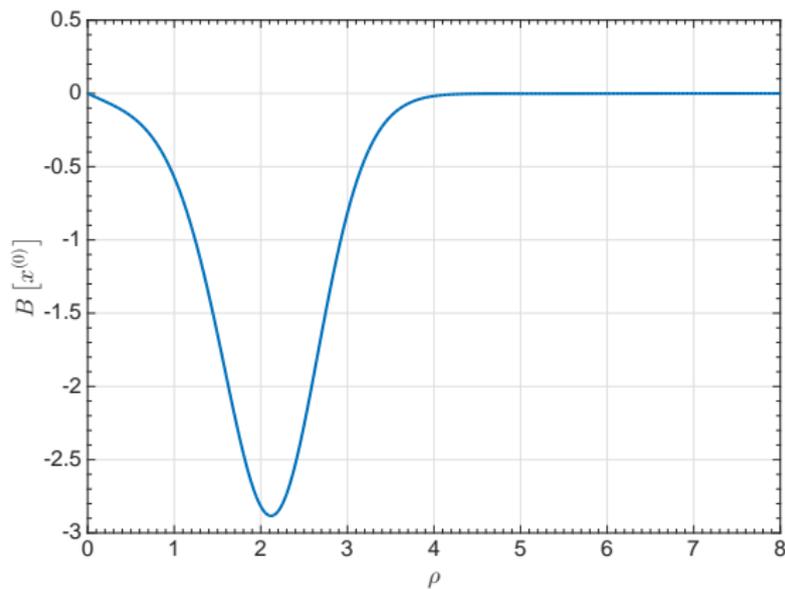
Ansatz

Ansatz forms in original $\{x, y\}$ basis:

$$x(\rho) = 1.046 \left(1 - \tanh \left[\frac{\rho - 0.437}{1} \right] \right)$$
$$y(\rho) = 1.663 \left(1 - \tanh \left[\frac{\rho - 0.437}{1} \right] \right)$$

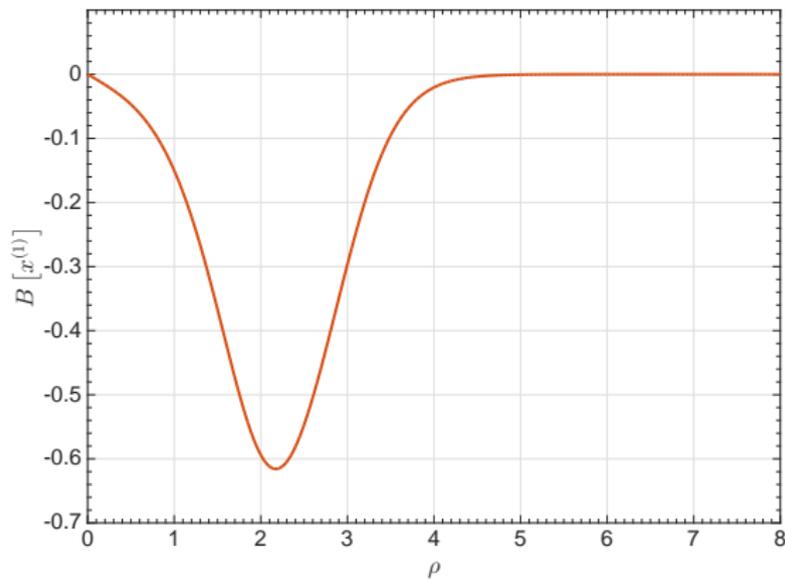
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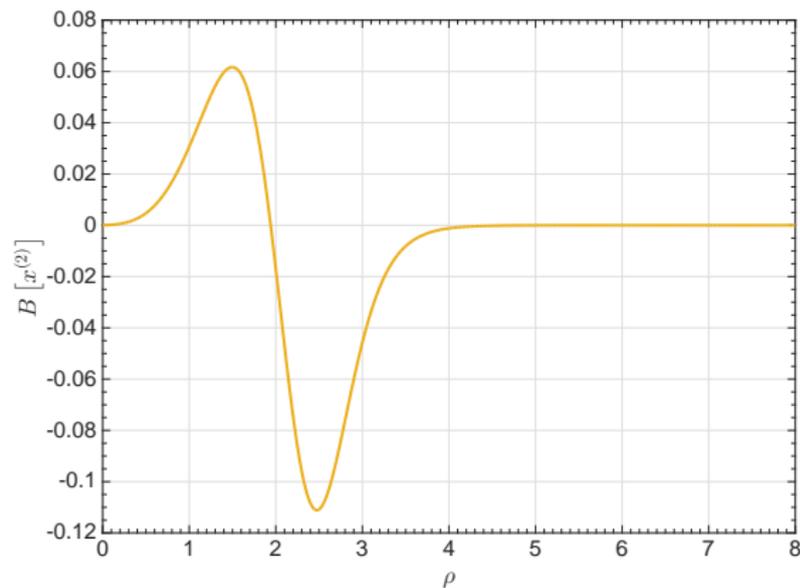
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