Constrained Superfields in Dynamical Background

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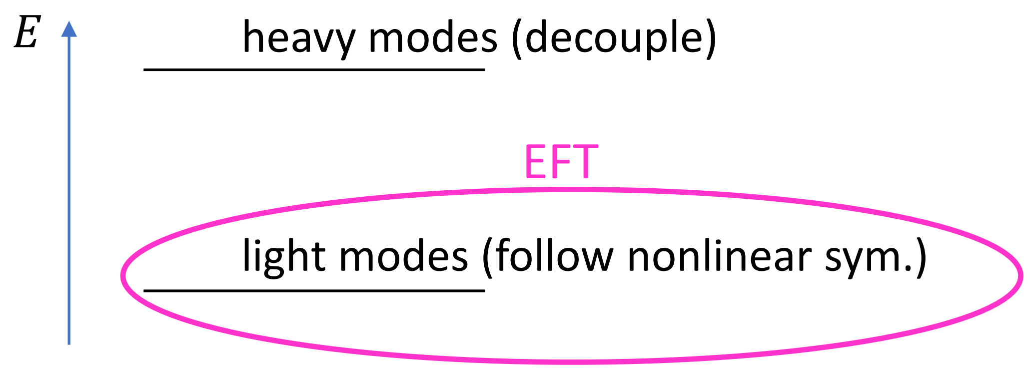
Introduction & Motivation of this work

New constraints from UV models in dynamical background

Summary

Nonlinear realization & constraint

- Symmetry is realized nonlinearly at low-energy EFT after symmetry breaking



- To get EFT (non-linear realization), constraint on field space is very powerful (c.f., linear sigma model ⇒ non-linear sigma model (EFT))

constraint

Constrained superfield

- SUSY breaking ⇒ NG fermion (goldstino)

- EFT of goldstino can be described by nilpotent constraint on superfield : $\boldsymbol{S}^2 = 0$ $\quad \boldsymbol{S} = S + \sqrt{2}\theta\chi + \theta\theta F$

  [R. Casalbuoni, S. De Curtis, D. Dominici, F. Feruglio, R. Gatto, Phys. Lett. B 220 (1989) 569-575]
  [Z. Komargodski, N. Seiberg, JHEP 09 (2009) 066]

- Solution: $S = \dfrac{\chi\chi}{2F}$, $\quad \boldsymbol{S} = \cancel{S} + \sqrt{2}\theta\chi + \theta\theta F$

  ⇒ Eliminate (decouple) scalar d.o.f

- $F \neq 0$ (broken SUSY) for consistency

- Very useful (model independent analysis)

Many applications

Inflation [I. Antoniadis, E. Dudas, S. Ferrara, and A. Sagnotti, 1403.3269],
[S. Ferrara, R. Kallosh, and A. Linde, 1408.4096]
...

late-time universe [C. P. Burgess and F. Quevedo, 2110.13275]

moduli stabilization [L. Aparicio, F. Quevedo, and R. Valandro,1511.08105]

Brane EFT, extended supersymmetry
[J. Bagger and A. Galperin, 9608177][I. Antoniadis, E. Dudas, A. Sagnotti, 9908023], ...

Nonlinear MSSM [I. Antoniadis, E. Dudas, D. M. Ghilencea and P. Tziveloglou, 1006.1662]
[F. Farakos and A. Kehagias, 1210.4941]
[M. D. Goodsell and P. Tziveloglou, 1407.5076]

Gravitino, DM, [K. Benakli, Y. Chen, E. Dudas, Y. Mambrini, 1701.06574], ...

...

Inflation = Stabilizer model

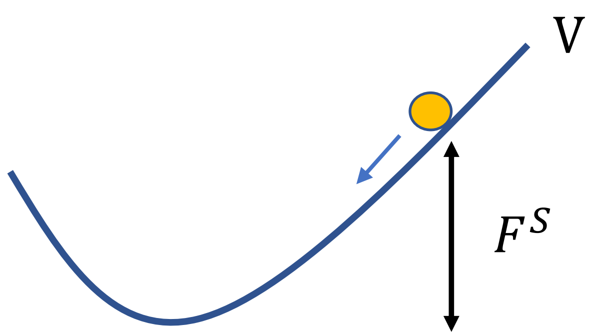
$$\begin{cases} K(\boldsymbol{\Phi}, \boldsymbol{S}, \bar{\boldsymbol{\Phi}}, \bar{\boldsymbol{S}}) = K(\boldsymbol{\Phi} + \bar{\boldsymbol{\Phi}}, \boldsymbol{S}, \bar{\boldsymbol{S}}) \\ W(\boldsymbol{\Phi}, \boldsymbol{S}) = \boldsymbol{S} f(\boldsymbol{\Phi}), \end{cases}$$

produce arbitrary potential

Φ : inflaton superfield ($\mathrm{Im}\Phi$: inflaton)
S : Stabilizer

[Kawasaki, Yamaguchi, Yanagida, hep-ph/004243; hep-ph/0011104],
[Kallosh, Linde, 1008.3375], [Kallosh, Linde, Rube, 1011.5945]

During inflation, stabilizer breaks SUSY & $V \sim |f(\Phi)|^2 \sim |F^S|^2 \neq 0$

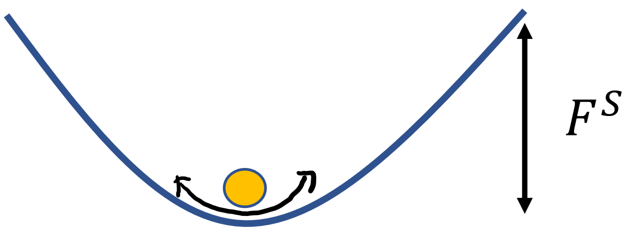


Stabilizer is often replaced by nilpotent superfield (This is okay because $F^S \neq 0$)
✓ No need to stabilization

[I. Antoniadis, E. Dudas, S. Ferrara, and A. Sagnotti, 1403.3269],
[S. Ferrara, R. Kallosh, and A. Linde, 1408.4096]
…

Questions

However, what about AFTER inflation ?



Inflaton starts to oscillate around minimum $\Rightarrow$ F^S cross 0
In this case, the description by $S^2 = 0$ becomes invalid !!

Note:
SUSY is still broken during oscillation
by not only potential energy but also kinetic energy of inflaton

Questions

Is it possible to extend applicable range of constrained superfield to after inflation (oscillation)?
Maybe, need to include kinetic energy to SUSY breaking source

What are the new constraints
that the low-energy EFT should obey?
⇒ derive them from UV models keeping kinetic terms

warm-up :

・Single superfield without shift symmetry

・with shift symmetry

⬇

Stabilizer model (two superfields)

Single superfield

UV model :

$$\begin{cases} K(\boldsymbol{S},\bar{\boldsymbol{S}}) = \bar{\boldsymbol{S}}\boldsymbol{S} - \frac{1}{4\Lambda^2}\left(\bar{\boldsymbol{S}}\boldsymbol{S}\right)^2, \\ \left(W(\boldsymbol{S}) = f\boldsymbol{S}. \quad \text{for simplicity} \right) \end{cases}$$

(Spectrum : $m^2_{\text{scalar}} \sim f^2/\Lambda^2,\ m^2_{\text{fermion}} = 0, F = f$ $\quad \boldsymbol{S} = \cancel{S} + \sqrt{2}\theta\chi + \theta\theta F$)

Single superfield

UV model :

$$\begin{cases} K(\boldsymbol{S}, \bar{\boldsymbol{S}}) = \bar{\boldsymbol{S}}\boldsymbol{S} - \frac{1}{4\Lambda^2}(\bar{\boldsymbol{S}}\boldsymbol{S})^2, \\ \left(W(\boldsymbol{S}) = f\boldsymbol{S}. \quad \text{for simplicity} \right) \end{cases}$$

(Spectrum : $m^2_{\mathrm{scalar}} \sim f^2/\Lambda^2, m^2_{\mathrm{fermion}} = 0, F = f$ $\quad \boldsymbol{S} = \cancel{S} + \sqrt{2}\theta\chi + \theta\theta F$)

EOM of S :

$$S\bar{F}F = \frac{1}{2}\bar{F}\chi\chi \underbrace{- i\partial_\mu(\chi\sigma^\mu\bar{\chi}S) - \frac{1}{2}\bar{S}\Box(S^2) + iS\chi\sigma^\mu\partial_\mu\bar{\chi}}_{\text{keep derivative couplings}} + O(\Lambda^2)$$

Solution :

$$S = \frac{\chi\chi}{2F}, \quad \Longleftrightarrow \quad \boxed{\boldsymbol{S}^2 = 0,}$$

same as the one without kinetic term

Shift symmetric model

UV model :

$$\begin{cases} K(\mathbf{\Phi},\bar{\mathbf{\Phi}}) = \frac{1}{2}(\mathbf{\Phi}+\bar{\mathbf{\Phi}})^2 - \frac{1}{4!\Lambda^2}(\mathbf{\Phi}+\bar{\mathbf{\Phi}})^4 . \\ \text{Not specify } W \end{cases}$$

[Ketov, Terada, 1406.0252; 1408.6524]

$$\mathbf{\Phi} = \Phi + \sqrt{2}\theta\chi + \theta\theta F \qquad \Phi \equiv \frac{1}{\sqrt{2}}(\cancel{\phi} + i\varphi)$$

Shift symmetric model

UV model : $\begin{cases} K(\mathbf{\Phi},\bar{\mathbf{\Phi}}) = \frac{1}{2}(\mathbf{\Phi}+\bar{\mathbf{\Phi}})^2 - \frac{1}{4!\Lambda^2}(\mathbf{\Phi}+\bar{\mathbf{\Phi}})^4. \\ \text{Not specify } W \end{cases}$ [Ketov, Terada, 1406.0252; 1408.6524]

$$\mathbf{\Phi} = \Phi + \sqrt{2}\theta\chi + \theta\theta F \qquad \Phi \equiv \frac{1}{\sqrt{2}}(\cancel{\phi} + i\varphi)$$

Solution (keep derivative couplings):

$$\phi = \frac{1}{\sqrt{2}\rho}\left(\frac{\bar{F}}{2}\chi\chi + \frac{F}{2}\bar{\chi}\bar{\chi} + \frac{1}{\sqrt{2}}\chi\sigma^\mu\bar{\chi}\partial_\mu\varphi\right) + \cdots ,$$

$$\rho \equiv -\tfrac{1}{2}\partial^\mu\varphi\partial_\mu\varphi + \bar{F}F$$

= Kinetic energy + potential energy

kinetic term improves the situation !!

Shift symmetric model

Cubic constraint :

$$\Leftrightarrow \quad \boxed{(\mathbf{\Phi} + \bar{\mathbf{\Phi}})^3 = 0.}$$

Note : The cubic constraint was already discussed in [Aldabergenov, Chatrabhuti, and Isono, 2103.11207]
but we derived it from a UV model

Stabilizer model

UV model :

$$K = \frac{1}{2}(\boldsymbol{\Phi} + \bar{\boldsymbol{\Phi}})^2 + \bar{\boldsymbol{S}}\boldsymbol{S} - \frac{1}{4\Lambda_S^2}(\bar{\boldsymbol{S}}\boldsymbol{S})^2 - \frac{1}{2\Lambda_{S\phi}^2}\bar{\boldsymbol{S}}\boldsymbol{S}(\boldsymbol{\Phi} + \bar{\boldsymbol{\Phi}})^2 - \frac{1}{4!\Lambda_\phi^2}(\boldsymbol{\Phi} + \bar{\boldsymbol{\Phi}})^4.$$

$$\boxed{W(\boldsymbol{\Phi}, \boldsymbol{S}) = \boldsymbol{S} f(\boldsymbol{\Phi}),}$$

$$\boldsymbol{\Phi} = \Phi + \sqrt{2}\theta\chi^\Phi + \theta\theta F^\Phi \qquad \boldsymbol{S} = \cancel{S} + \sqrt{2}\theta\chi^S + \theta\theta F^S$$

$$\Phi \equiv \frac{1}{\sqrt{2}}(\cancel{\phi} + i\varphi)$$

Stabilizer model

UV model :

$$K = \frac{1}{2}(\boldsymbol{\Phi} + \bar{\boldsymbol{\Phi}})^2 + \bar{\boldsymbol{S}}\boldsymbol{S} - \frac{1}{4\Lambda_S^2}(\bar{\boldsymbol{S}}\boldsymbol{S})^2 - \frac{1}{2\Lambda_{S\phi}^2}\bar{\boldsymbol{S}}\boldsymbol{S}(\boldsymbol{\Phi} + \bar{\boldsymbol{\Phi}})^2 - \frac{1}{4!\Lambda_\phi^2}(\boldsymbol{\Phi} + \bar{\boldsymbol{\Phi}})^4.$$

$$W(\boldsymbol{\Phi}, \boldsymbol{S}) = \boldsymbol{S} f(\boldsymbol{\Phi}),$$

EOM of S :

$$\begin{aligned}
0 =& -\frac{1}{\Lambda_S^2} S \left(F^S \bar{F}^{\bar{S}} - \frac{i}{2}\left(\chi^S \sigma^\mu \partial_\mu \bar{\chi}^{\bar{S}} + \bar{\chi}^{\bar{S}} \bar{\sigma}^\mu \partial_\mu \chi^S \right) \right) - \frac{1}{\Lambda_{S\phi}^2} S \left(F^\Phi \bar{F}^{\bar{\Phi}} - \frac{i}{2}\left(\chi^\Phi \sigma^\mu \partial_\mu \bar{\chi}^{\bar{\Phi}} + \bar{\chi}^{\bar{\Phi}} \bar{\sigma}^\mu \partial_\mu \chi^\Phi \right) \right) \\
&- \frac{\sqrt{2}}{\Lambda_{S\phi}^2} \phi \left(F^S \bar{F}^{\bar{\Phi}} - \frac{i}{2}\left(\chi^S \sigma^\mu \partial_\mu \bar{\chi}^{\bar{\Phi}} + \bar{\chi}^{\bar{\Phi}} \bar{\sigma}^\mu \partial_\mu \chi^S \right) \right) + \left(-\frac{1}{\Lambda_{S\phi}^2}\phi^2 - \frac{1}{\Lambda_S^2}\bar{S}S \right) \Box S - \frac{\sqrt{2}}{\Lambda_{S\phi}^2} S\phi\Box\Phi \\
&- \frac{1}{\Lambda_S^2}\bar{S}\partial^\mu S \partial_\mu S - \frac{2\sqrt{2}}{\Lambda_{S\phi}^2}\phi\partial^\mu S\partial_\mu \Phi - \frac{1}{\Lambda_{S\phi}^2} S\partial^\mu\Phi\partial_\mu\Phi \\
&- \frac{i}{\Lambda_S^2}\chi^S\sigma^\mu\bar{\chi}^{\bar{S}}\partial_\mu S - \frac{i}{\Lambda_{S\phi}^2}\chi^S\sigma^\mu\bar{\chi}^{\bar{\Phi}}\partial_\mu\Phi - \frac{i}{\Lambda_{S\phi}^2}\chi^\Phi\sigma^\mu\bar{\chi}^{\bar{\Phi}}\partial_\mu S \\
&- \frac{i}{2\Lambda_S^2} S\partial_\mu(\chi^S\sigma^\mu\bar{\chi}^{\bar{S}}) - \frac{i}{\sqrt{2}\Lambda_{S\phi}^2}\phi\partial_\mu(\chi^S\sigma^\mu\bar{\chi}^{\bar{\Phi}}) - \frac{i}{2\Lambda_{S\phi}^2} S\partial_\mu(\chi^\Phi\sigma^\mu\bar{\chi}^{\bar{\Phi}}) \\
&+ \frac{1}{2\Lambda_{S\phi}^2} F^S\bar{\chi}^{\bar{\Phi}}\bar{\chi}^{\bar{\Phi}} + \frac{1}{2\Lambda_S^2}\bar{F}^{\bar{S}}\chi^S\chi^S + \frac{1}{\Lambda_{S\phi}^2}\bar{F}^{\bar{\Phi}}\chi^\Phi\chi^S,
\end{aligned} \tag{21}$$

EOM of ϕ :

$$\begin{aligned}
0 =& -\frac{\sqrt{2}}{\Lambda_\phi^2}\phi \left(F^\Phi \bar{F}^{\bar{\Phi}} - \frac{i}{2}\left(\chi^\Phi \sigma^\mu \partial_\mu \bar{\chi}^{\bar{\Phi}} + \bar{\chi}^{\bar{\Phi}} \bar{\sigma}^\mu \partial_\mu \chi^\Phi \right) \right) - \frac{\sqrt{2}}{\Lambda_{S\phi}^2}\phi \left(F^S \bar{F}^{\bar{S}} - \frac{i}{2}\left(\chi^S \sigma^\mu \partial_\mu \bar{\chi}^{\bar{S}} + \bar{\chi}^{\bar{S}} \bar{\sigma}^\mu \partial_\mu \chi^S \right) \right) \\
&- \frac{1}{\Lambda_{S\phi}^2} S \left(F^\Phi \bar{F}^{\bar{S}} - \frac{i}{2}\left(\chi^\Phi \sigma^\mu \partial_\mu \bar{\chi}^{\bar{S}} + \bar{\chi}^{\bar{S}} \bar{\sigma}^\mu \partial_\mu \chi^\Phi \right) \right) - \frac{1}{\Lambda_{S\phi}^2}\bar{S} \left(F^S \bar{F}^{\bar{\Phi}} - \frac{i}{2}\left(\chi^S \sigma^\mu \partial_\mu \bar{\chi}^{\bar{\Phi}} + \bar{\chi}^{\bar{\Phi}} \bar{\sigma}^\mu \partial_\mu \chi^S \right) \right) \\
&- \frac{1}{\sqrt{2}\Lambda_\phi^2}\phi\left(\partial^\mu\phi\partial_\mu\phi - \partial^\mu\varphi\partial_\mu\varphi\right) - \frac{1}{\sqrt{2}\Lambda_{S\phi}^2}\partial^\mu\phi\partial_\mu(\bar{S}S) \\
&- \frac{i}{\sqrt{2}\Lambda_{S\phi}^2}\partial^\mu\varphi(\bar{S}\partial_\mu S - S\partial_\mu\bar{S}) - \frac{1}{\sqrt{2}\Lambda_{S\phi}^2}\phi\left(\partial^\mu S\partial_\mu S + \partial^\mu\bar{S}\partial_\mu\bar{S}\right) \\
&- \frac{1}{\sqrt{2}}\left(\frac{1}{\Lambda_{S\phi}^2} S\bar{S} + \frac{1}{\Lambda_\phi^2}\phi^2 \right)\Box\phi - \frac{1}{\sqrt{2}\Lambda_{S\phi}^2}\phi(\bar{S}\Box S + S\Box\bar{S}) \\
&+ \frac{1}{\sqrt{2}\Lambda_\phi^2}\chi^\Phi\sigma^\mu\bar{\chi}^{\bar{\Phi}}\partial_\mu\varphi + \frac{1}{\sqrt{2}\Lambda_{S\phi}^2}\chi^S\sigma^\mu\bar{\chi}^{\bar{S}}\partial_\mu\varphi - \frac{i}{2\Lambda_{S\phi}^2}\chi^\Phi\sigma^\mu\bar{\chi}^{\bar{S}}\partial_\mu S + \frac{i}{2\Lambda_{S\phi}^2}\chi^S\sigma^\mu\bar{\chi}^{\bar{\Phi}}\partial_\mu\bar{S} \\
&+ \frac{1}{2\Lambda_\phi^2}\left(F^\Phi\bar{\chi}^{\bar{\Phi}}\bar{\chi}^{\bar{\Phi}} + \bar{F}^{\bar{\Phi}}\chi^\Phi\chi^\Phi \right) + \frac{1}{\Lambda_{S\phi}^2}\left(F^S\bar{\chi}^{\bar{S}}\bar{\chi}^{\bar{\Phi}} + \bar{F}^{\bar{S}}\chi^S\chi^\Phi \right).
\end{aligned} \tag{22}$$

Stabilizer model

Solution (keep derivative couplings):

$\Lambda_S^2 = \Lambda_\phi^2 = \Lambda_{S\phi}^2 \equiv \Lambda^2$ & $F^\Phi = 0$ for simplicity

$$\begin{cases} S = \frac{\bar{F}^{\bar{S}}}{2\rho}\chi^S\chi^S + \frac{F^S}{2\rho}\bar{\chi}^{\bar{\Phi}}\bar{\chi}^{\bar{\Phi}} + \frac{\partial_\mu\varphi}{\sqrt{2}\rho}\chi^S\sigma^\mu\bar{\chi}^{\bar{\Phi}} + \ldots \\ \phi = \frac{F^S}{\sqrt{2}\rho}\bar{\chi}^{\bar{S}}\bar{\chi}^{\bar{\Phi}} + \frac{\bar{F}^{\bar{S}}}{\sqrt{2}\rho}\chi^S\chi^\Phi + \frac{\partial_\mu\varphi}{2\rho}(\chi^\Phi\sigma^\mu\bar{\chi}^{\bar{\Phi}} + \chi^S\sigma^\mu\bar{\chi}^{\bar{S}}) + \ldots \end{cases}$$

Stabilizer model

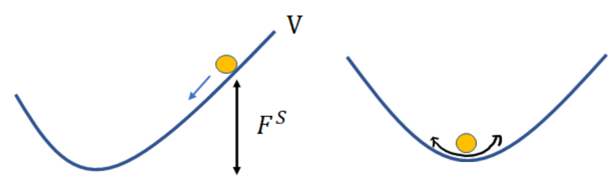
Solution (keep derivative couplings):

$\Lambda_S^2 = \Lambda_\phi^2 = \Lambda_{S\phi}^2 \equiv \Lambda^2$ & $F^\Phi = 0$ for simplicity

$$\left\{ \begin{aligned} S &= \frac{\bar{F}^{\bar{S}}}{2\rho}\chi^S\chi^S + \frac{F^S}{2\rho}\bar{\chi}^{\bar{\Phi}}\bar{\chi}^{\bar{\Phi}} + \frac{\partial_\mu\varphi}{\sqrt{2}\rho}\chi^S\sigma^\mu\bar{\chi}^{\bar{\Phi}} + \ldots \\ \phi &= \frac{F^S}{\sqrt{2}\rho}\bar{\chi}^{\bar{S}}\bar{\chi}^{\bar{\Phi}} + \frac{\bar{F}^{\bar{S}}}{\sqrt{2}\rho}\chi^S\chi^\Phi + \frac{\partial_\mu\varphi}{2\rho}(\chi^\Phi\sigma^\mu\bar{\chi}^{\bar{\Phi}} + \chi^S\sigma^\mu\bar{\chi}^{\bar{S}}) + \ldots \end{aligned} \right.$$

$$\rho = -\frac{1}{2}\partial^\mu\varphi\partial_\mu\varphi + |F^S|^2$$

= Kinetic energy + potential energy from stabilizer



No singularity even after inflation !!

Superfield Constraint ?

$\Longleftrightarrow$ Cubic & Quartic constraint :

$$\boxed{\boldsymbol{S}^3 = (\boldsymbol{\Phi} + \overline{\boldsymbol{\Phi}})^3 \boldsymbol{S} = (\boldsymbol{\Phi} + \overline{\boldsymbol{\Phi}}) \boldsymbol{S}^2 = 0}$$

Moreover, for general case $\Lambda_S^2 \neq \Lambda_\phi^2 \neq \Lambda_{S\phi}^2$ & $F^\Phi \neq 0$

Quintic constraint :

$$\begin{aligned}
&(\boldsymbol{\Phi} + \bar{\boldsymbol{\Phi}})^5 = (\boldsymbol{\Phi} + \bar{\boldsymbol{\Phi}})^4 \boldsymbol{S} = (\boldsymbol{\Phi} + \bar{\boldsymbol{\Phi}})^3 \boldsymbol{S}^2 = (\boldsymbol{\Phi} + \bar{\boldsymbol{\Phi}})^3 \boldsymbol{S} \bar{\boldsymbol{S}} = (\boldsymbol{\Phi} + \bar{\boldsymbol{\Phi}})^2 \boldsymbol{S}^3 = (\boldsymbol{\Phi} + \bar{\boldsymbol{\Phi}})^2 \boldsymbol{S}^2 \bar{\boldsymbol{S}} \\
&= (\boldsymbol{\Phi} + \bar{\boldsymbol{\Phi}}) \boldsymbol{S}^4 = (\boldsymbol{\Phi} + \bar{\boldsymbol{\Phi}}) \boldsymbol{S}^3 \bar{\boldsymbol{S}} = (\boldsymbol{\Phi} + \bar{\boldsymbol{\Phi}}) \boldsymbol{S}^2 \bar{\boldsymbol{S}}^2 = \boldsymbol{S}^5 = \boldsymbol{S}^4 \bar{\boldsymbol{S}} = \boldsymbol{S}^3 \bar{\boldsymbol{S}}^2 = 0.
\end{aligned} \tag{31}$$

Conclusion :

cubic, quartic, quintic constraints for dynamical (cosmological) background

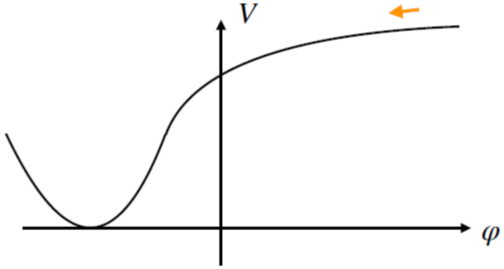
usual : $\boldsymbol{S}^2 = 0,$

$\Downarrow$

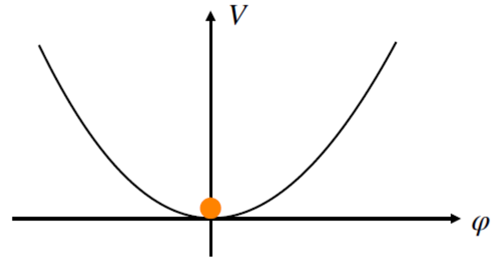
extended : $\boldsymbol{S}^3 = (\boldsymbol{\Phi} + \overline{\boldsymbol{\Phi}})^3 \boldsymbol{S} = (\boldsymbol{\Phi} + \overline{\boldsymbol{\Phi}}) \boldsymbol{S}^2 = 0$

or

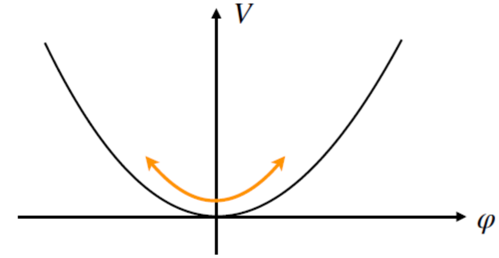
$$(\boldsymbol{\Phi} + \bar{\boldsymbol{\Phi}})^5 = (\boldsymbol{\Phi} + \bar{\boldsymbol{\Phi}})^4 \boldsymbol{S} = (\boldsymbol{\Phi} + \bar{\boldsymbol{\Phi}})^3 \boldsymbol{S}^2 = (\boldsymbol{\Phi} + \bar{\boldsymbol{\Phi}})^3 \boldsymbol{S} \bar{\boldsymbol{S}} = (\boldsymbol{\Phi} + \bar{\boldsymbol{\Phi}})^2 \boldsymbol{S}^3 = (\boldsymbol{\Phi} + \bar{\boldsymbol{\Phi}})^2 \boldsymbol{S}^2 \bar{\boldsymbol{S}}$$
$$= (\boldsymbol{\Phi} + \bar{\boldsymbol{\Phi}}) \boldsymbol{S}^4 = (\boldsymbol{\Phi} + \bar{\boldsymbol{\Phi}}) \boldsymbol{S}^3 \bar{\boldsymbol{S}} = (\boldsymbol{\Phi} + \bar{\boldsymbol{\Phi}}) \boldsymbol{S}^2 \bar{\boldsymbol{S}}^2 = \boldsymbol{S}^5 = \boldsymbol{S}^4 \bar{\boldsymbol{S}} = \boldsymbol{S}^3 \bar{\boldsymbol{S}}^2 = 0.$$



Inflation,
quintessence, dark energy

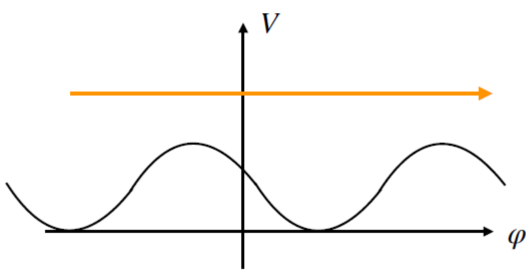


SUSY breaking in vacuum

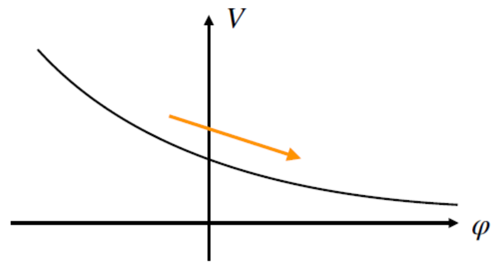


Inflaton oscillation, preheating,
axion misalignment, curvaton

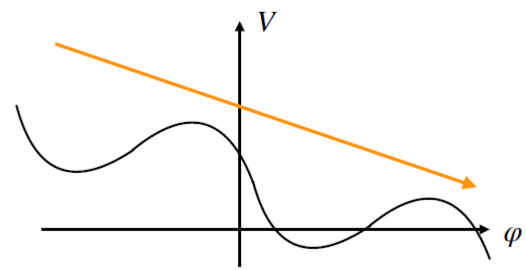
Cosmological Applications



axion kinetic misalignment



Kination



cosmological relaxation

From Takahiro's slide at IBS-IFT-MultiDark Workshop

Summary

Constrained superfields give a generic and model independent prediction for inflation analysis.
However, the usual nilpotent constraint $S^2 = 0$ loses its validity after inflation due to the singularity.

Based on some UV models, we extended the applicable range of constrained superfields to after inflation, or whole cosmological regime, keeping kinetic terms (= constrained superfields at dynamical background).

Examples : cubic, quartic, quintic constraints

Many situations where kinetic terms become important in cosmology.

Thank you !!