D-term Triggered Dynamical Supersymmetry Breaking

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- IJMPA 27 (2012) 1250159, arXiv:1109.2276
- PRD 88 (2013) 025012, arXiv:1301.7548
- Symmetry 7 (2015), arXiv:1312.4157
- NPB 893 (2015), arXiv:1411.1192
- latest work in progress on overall U(1) scalar mass

I)

- most desirable to break $\mathcal{N}=1$ SUSY dynamically (DSB)
- In the past, instanton generated superpotential e.t.c. $\langle F\rangle_{\rm nonpt} \to \langle D\rangle \neq 0$

In this talk, we will accomplish

D-term DSB (DDSB)

in a self-consistent

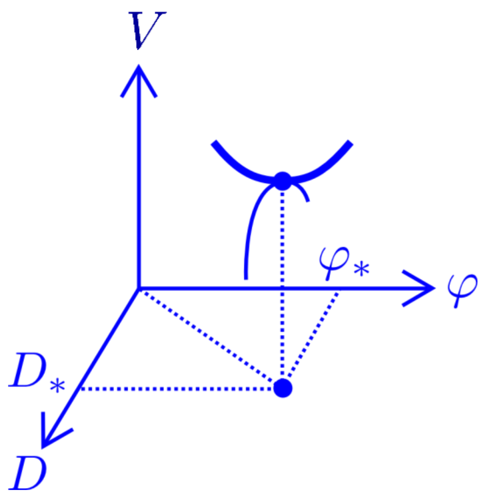
Hartree-Fock approximation

- based on the nonrenormalizable D-gaugino-matter fermion term which is present in generic $\mathcal{N}=1$ SUSY (effective) U(N) gauge action
- the vac. is metastable, can be made long lived
- requires the discovery of scalar gluons as well as the scalar in the overall U(1) in nature, so that distinct from the previous proposals
- no messenger field needed in application, overall U(1) the hidden sector DSB will be accomplished relatively easily and is robust

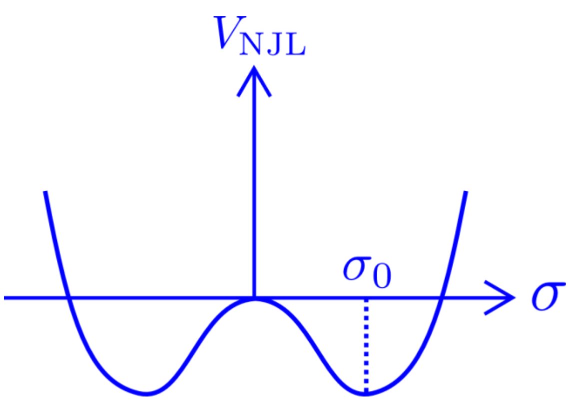
- **features of our work as Q. F. T.**

1) variational prob. of V_{eff} in QFT for multiple species of order parameters

2) beginning quantitative estimates of susy breaking order parameters and scalar gluon mass



compare this with the NJL ptl.



Contents

II) ・ action

$$\mathcal{L} = \int d^4\theta K(\Phi^a, \bar{\Phi}^a) + (gauging) + \int d^2\theta \mathrm{Im} \frac{1}{2}\tau_{ab}(\Phi^a)\mathcal{W}^{\alpha a}\mathcal{W}^b_\alpha + \left(\int d^2\theta W(\Phi^a) + c.c.\right)$$

$$= \mathcal{L}_{\text{Kähler}} + \mathcal{L}_{\text{gauge}} + \mathcal{L}_{\text{sup}}$$

K; Kähler potential

τ_{ab}; gauge kinetic superfield from the second derivatives of a generic holomorphic function $\mathcal{F}(\Phi^a)$

W; superpotential

We look at its component expansion

⋮

・assumptions made

1) general $\mathcal{N}=1$ action with adjoint Φ^a & V^a
with three input functions K, $\mathcal{F}_{ab}$, W

2) third derivatives of $\mathcal{F}$ at the scalar vev's nonvanishing

3) W at tree level preserves $\mathcal{N}=1$ susy

4) the gauge group $U(N)$, the vac. being in its unbroken phase

▪ supercurrent & D^a, F^a eqs

off-shell form of the $\mathcal{N}=1$ supercurrent

$$
\begin{aligned}
\eta_1 \mathcal{S}^{(1)\mu} =& \sqrt{2} g_{ab} \eta_1 \sigma^\nu \bar{\sigma}^\mu \psi^a \mathcal{D}_\nu \bar{\phi}^b + \sqrt{2} i g_{ab} \eta_1 \sigma^\mu \bar{\psi}^a F^b \\
& - i \mathcal{F}_{ab} \eta_1 \sigma_\nu \bar{\lambda}^a F^{\mu\nu b} + \frac{1}{2} \mathcal{F}_{ab} \epsilon^{\mu\nu\rho\delta} \eta_1 \sigma_\nu \bar{\lambda}^a F^{\rho\delta b} - \frac{i}{2} \bar{\mathcal{F}}_{ab} \eta_1 \sigma^\mu \bar{\lambda}^a D^b \\
& + \frac{\sqrt{2}}{4} \left(\mathcal{F}_{abc} \psi^c \sigma^\nu \bar{\sigma}^\mu \lambda^b - \bar{\mathcal{F}}_{abc} \bar{\lambda}^c \bar{\sigma}^\mu \sigma^\nu \bar{\psi}^b \right) \eta_1 \sigma_\nu \bar{\lambda}^a
\end{aligned}
$$

$\Rightarrow$ NGF will be l.c. of λ^0 & ψ^0

- $$
\begin{aligned}
D^a &= -\frac{1}{2} g^{ab} \mathfrak{D}_b - \frac{1}{2\sqrt{2}} g^{ab} \left(\mathcal{F}_{bcd} \psi^d \lambda^c + \bar{\mathcal{F}}_{bcd} \bar{\psi}^d \bar{\lambda}^c \right), \\
F^a &= -g^{ab} \overline{\partial_b W} - \frac{i}{4} g^{ab} \left(\mathcal{F}_{bcd} \psi^c \psi^d - \bar{\mathcal{F}}_{bcd} \bar{\lambda}^c \bar{\lambda}^d \right)
\end{aligned}
$$

・ reasoning to DDSB

- look at

$$-\frac{1}{2}(\lambda^a, \psi^a)\begin{pmatrix} 0 & -\frac{\sqrt{2}}{4}\mathcal{F}_{abc}D^b \\ -\frac{\sqrt{2}}{4}\mathcal{F}_{abc}D^b & \partial_a\partial_c W \end{pmatrix}\begin{pmatrix} \lambda^c \\ \psi^c \end{pmatrix} + (c.c.).$$

the non-vanishing vev of D^0 ⇒ Dirac mass to the fermions

- $$\langle D^0\rangle = -\frac{1}{2\sqrt{2}}\langle g^{00}\left(\mathcal{F}_{0cd}\psi^d\lambda^c + \bar{\mathcal{F}}_{0cd}\bar{\psi}^d\bar{\lambda}^c\right)\rangle,$$ namely,

condensation of the Dirac bilinear responsible for $\langle D^0\rangle \neq 0$.

- holomorphic part of the mass matrix:

$$M_{Fa} \equiv \begin{pmatrix} 0 & -\frac{\sqrt{2}}{4}\langle\mathcal{F}_{0aa}D^0\rangle \\ -\frac{\sqrt{2}}{4}\langle\mathcal{F}_{0aa}D^0\rangle & \langle\partial_a\partial_a W\rangle \end{pmatrix}.$$ mixed Majorana-Dirac type

eigenvalues: $$\Lambda^{(\pm)}_{a\mathbf{11}} = \frac{1}{2}\langle\partial_a\partial_a W\rangle\left(1 \pm \sqrt{1 + \frac{\langle\mathcal{F}_{0aa}D^0\rangle^2}{2\langle\partial_a\partial_a W\rangle^2}}\right).$$

- however, the non-vanishing F^0 term induced as well, as the stationary value of the scalar fields gets shifted.

In particular, the holo. part of the complete mass matrix

$$\mathcal{M}_a = \begin{pmatrix} -\frac{i}{2} g^{aa} \mathcal{F}_{0aa} F^0, & -\frac{\sqrt{2}}{4} \sqrt{g^{aa} (\mathrm{Im}\mathcal{F})^{aa}} \mathcal{F}_{0aa} D^0 \\ -\frac{\sqrt{2}}{4} \sqrt{g^{aa} (\mathrm{Im}\mathcal{F})^{aa}} \mathcal{F}_{0aa} D^0, & g^{aa} \partial_a \partial_a W + g^{aa} g_{0a,a} \bar{F}^0 \end{pmatrix} = \begin{pmatrix} m^a_{\lambda\lambda} & m^a_{\lambda\psi} \\ m^a_{\psi\lambda} & m^a_{\psi\psi} \end{pmatrix}.$$

- suppress the indices as we work with the unbroken phase U(N) phase

$$\Delta \equiv -\frac{2m_{\lambda\psi}}{m_{\psi\psi}}, \qquad f \equiv \frac{2im_{\lambda\lambda}}{\mathrm{tr}\mathcal{M}}.$$

The two eigenvalues of the holomorphic mass matrix

$$\Lambda^{(\pm)} \equiv (\mathrm{tr}\mathcal{M})\lambda^{(\pm)},$$

where

$$\lambda^{(\pm)} = \frac{1}{2}\left(1 \pm \sqrt{(1+if)^2 + \left(1 + \frac{i}{2} f\right)^2 \Delta^2}\right).$$

$\Rightarrow$ The masses for the two species of SU(N) fermions

Q: how to determine the stationary values of the scalar fields, D^0 and F^0 (perturbatively induced)

·coupling to $\mathcal{N}=1$ supergravity and super-Higgs mechanism

$$\mathcal{L}=\int d^2\Theta 2\mathcal{E}\left[\frac{3}{8}(\bar{\mathcal{D}}\bar{\mathcal{D}}-8\mathcal{R})\exp\left\{-\frac{1}{3}[K(\Phi,\Phi^\dagger)+\Gamma(\Phi,\Phi^\dagger,V)]\right\}\right.$$
$$\left.+\frac{1}{16g^2}\tau_{ab}(\Phi)W^{\alpha a}W^b_\alpha+W(\Phi)\right]+h.c.$$

The field redefinition of the gravitino

$$\psi'_\mu=\psi_\mu+i\frac{\sqrt{2}}{6W^*e^{K/2}}\sigma^\mu\bar{\psi}_{\rm NG}+\frac{\sqrt{2}}{3W^{*2}e^K}\partial_\mu\bar{\psi}_{\rm NG}$$

that eliminates the mixing with λ and ψ:

$$\bar{\psi}_{\rm NG}\equiv i\frac{g}{\sqrt{2}}D_a\bar{\lambda}^a+e^{K/2}D_{a^*}W^*\bar{\psi}^a.$$

- gravitino mass

$$m_{3/2}\simeq e^{\langle K\rangle/2}\frac{\sqrt{|\langle D_aW\rangle|^2+\frac{g^2}{2}\langle D^a\rangle^2}}{\sqrt{3}M_P^2}.$$

・special cases

- demand the Kähler function K to be special Kähler,

$\Rightarrow$

$$K = \mathrm{Im}\mathrm{Tr}\ \bar{\Phi}\frac{\partial \mathcal{F}(\Phi)}{\partial \Phi},$$

and $g_{ab} = \mathrm{Im}\mathcal{F}_{ab}$ etc.

- further, choose W such that the action possess the rigid $\mathcal{N}=2$ supersymmetry

$\Rightarrow$ tree vacua $\mathcal{N}=2 \to \mathcal{N}=1$ spontaneously

U(1): Antoniadis , Partouche, Taylor (1996)
U(N): Fujiwara, H. I., Sakaguchi (2004)

III)

change the notation for expectation values from $\langle \ldots \rangle$ to $\ldots_*$
(∵ vev.= the stationary value in the variational analysis.)

・point of the H.F. approximation

spirit: tree ~ 1-loop in the $\hbar$ expansion

⇒ optimal configuration, which is transcendental

- three const. bkgd fields,

  $\varphi \equiv \varphi^0$ (complex), U(N) invariant scalar,
  $D \equiv D^0$(real) ,
  $F \equiv F^0$ (complex).

- denote our effective potential by

$$V = V^{\rm tree} + V_{\rm c.t.} + V_{\rm 1-loop}.$$

after the elimination of the auxiliary fields denote by $V_{\rm scalar}$

・tree part & warm up

all config. U(N) inv. ⇒ suppress indices

$$V^{\rm tree}(D,F,\bar F,\varphi,\bar\varphi) = -gF\bar F - \frac{1}{2}({\rm Im}\mathcal{F}'')D^2 - FW' - \bar F\bar W'.$$

all minus signs correct

- stationary conditions ⇒

$$V^{\rm tree}_{\rm scalar}(\varphi,\bar\varphi) \equiv V^{\rm tree}(\varphi,\bar\varphi,D_*=0,F=F_*(\varphi,\bar\varphi),\bar F=\overline{F_*(\varphi,\bar\varphi)}) = g^{-1}(\varphi,\bar\varphi)|W'(\varphi)|^2.$$

$$\left.\frac{\partial^2 V^{\rm tree}_{\rm scalar}(\varphi,\bar\varphi)}{\partial\varphi\partial\bar\varphi}\right|_{\varphi_*,\bar\varphi_*} = g^{-1}(\varphi_*,\bar\varphi_*)\left|W''(\varphi_*)\right|^2,$$

$$m_s(\varphi,\bar\varphi) \equiv g^{-1}(\varphi,\bar\varphi)W''(\varphi),$$

$$m_{s*} = m_s(\varphi_*,\bar\varphi_*).$$

$$\Delta \equiv -2\frac{m_{\lambda\psi}}{m_{\psi\psi}} = \frac{\sqrt{2}}{2}\frac{\sqrt{g^{-1}({\rm Im}\mathcal{F}'')^{-1}}\mathcal{F}'''}{g^{-1}W'' + g^{-1}\partial g\bar F}D \equiv r(\varphi,\bar\varphi,F,\bar F)D.$$

$$f_3 \equiv \frac{g^{-1}\mathcal{F}'''F}{g^{-1}W'' + g^{-1}\partial g\bar F},$$

- the mass scales of the problem:

m_{s*}, the scalar gluon mass and $g^{-1}\mathcal{F}'''_*$, the third prepotential derivative, (and $g^{-1}\partial g$), SUSY breaking scale being essentially the geometric mean.

▪treatment of UV infinity

UV scale and infinity reside in $\mathcal{F}$. The supersymmetric counterterm:

$$V_{\rm c.t.} = -\frac{1}{2}{\rm Im}\int d^2\theta \Lambda \mathcal{W}^{0\alpha}\mathcal{W}_{0\alpha} = -\frac{1}{2}({\rm Im}\Lambda)D^2.$$

It is a counterterm associated with ${\rm Im}\mathcal{F}''$.

A renormalization condition

$$\frac{1}{N^2}\frac{\partial^2 V}{(\partial D)^2}\bigg|_{D=0,\varphi=\varphi_*,\bar{\varphi}=\bar{\varphi}_*} = 2c,$$

relate (or transmute) the original infinity of the dimensional reduction scheme with that of ${\rm Im}\mathcal{F}''$.

▪the one-loop part

$$V_{1-{\rm loop}} = \frac{N^2|{\rm tr}\mathcal{M}|^4}{32\pi^2}\left[A(\varepsilon,\gamma)\left(|\lambda^{(+)}|^4 + |\lambda^{(-)}|^4 - \left|\frac{m_s}{{\rm tr}\mathcal{M}}\right|^4\right)\right.$$
$$\left. -|\lambda^{(+)}|^4\log|\lambda^{(+)}|^2 - |\lambda^{(-)}|^4\log|\lambda^{(-)}|^2 + \left|\frac{m_s}{{\rm tr}\mathcal{M}}\right|^4\log\left|\frac{m_s}{{\rm tr}\mathcal{M}}\right|^4\right].$$

$$A(\varepsilon,\gamma) = \frac{1}{2} - \gamma + \frac{1}{\varepsilon}, \qquad \varepsilon = 2 - \frac{d}{2}.$$

IV) ·variational analysis

$$\begin{cases} \dfrac{\partial V}{\partial D} = 0 \\ \dfrac{\partial V}{\partial F} = 0 \text{ and its complex conjugate} \\ \dfrac{\partial V}{\partial \varphi} = 0 \text{ and its complex conjugate} \end{cases}$$

- work in the region where the strength $\|F_*\|$ small and can be treated perturbatively.

gap eq.

$$\frac{\partial V(D, \varphi, \bar{\varphi}, F=0, \bar{F}=0)}{\partial D} = 0,$$

stationary cond. for scalars

$$\frac{\partial V(D, \varphi, \bar{\varphi}, F=0, \bar{F}=0)}{\partial \varphi} = 0$$

$\Rightarrow$ stationary values $(D_*, \varphi_*, \bar{\varphi}_*)$

- $$\left.\frac{\partial V(D = D_*(0,0), \varphi = \varphi_*(0,0), \bar{\varphi} = \bar{\varphi}_*(0,0), F, \bar{F})}{\partial F}\right|_{D, \varphi, \bar{\varphi}, \bar{F} \text{ fixed}} = 0$$

$\Rightarrow$ $\bar{F} = \bar{F}_*$ perturbatively

▪the analysis in the region $F_* \approx 0$

- explicit determination of $V(D, \phi, \bar{\phi}, F=0, \bar{F}=0)$:
  first solve the normalization condition

$$2cN^2 = \left.\frac{\partial^2 V}{(\partial D)^2}\right|_{D=0,*}$$

  to obtain

$$A = \frac{1}{2} + \frac{32\pi^2}{|m_{s*}|^4 (r_{0*}^2 + \bar{r}_{0*}^2)} \left(2c + \frac{\mathrm{Im}\mathcal{F}_*''}{N^2} + \frac{\mathrm{Im}\Lambda}{N^2}\right) \equiv \tilde{A}(c, \Lambda, \varphi_*, \bar{\varphi}_*).$$

- r, Δ, complex in general, put sub. 0, as $F,\ \bar{F} \to 0$

$$V_0 = V(D, \varphi, \bar{\varphi}, F=0, \bar{F}=0)$$

$$\frac{V_0}{N^2 |m_s|^4} = \left(\frac{1}{64\pi^2} + \tilde{c} - \tilde{\delta}(\varphi, \bar{\varphi})\right) \left(\frac{\Delta_0 + \bar{\Delta}_0}{2}\right)^2 + \frac{1}{32\pi^2} \tilde{A} \left(\frac{1}{8}|\Delta_0|^4 + f(\Delta_0, \bar{\Delta}_0)\right)$$
$$- \frac{1}{32\pi^2} \left(|\lambda_0^{(+)}|^4 \log|\lambda_0^{(+)}|^2 + |\lambda_0^{(-)}|^4 \log|\lambda_0^{(-)}|^2\right),$$

$$f(\Delta_0, \bar{\Delta}_0) = \frac{1}{2}\left(\sqrt{1+\Delta_0^2}\sqrt{1+\bar{\Delta}_0^2} - |\Delta_0|^2 - 1\right).$$

- If Δ_0 real,

$$\frac{V_0}{N^2 |m_s|^4} = \left(\left(c' + \frac{1}{64\pi^2}\right) - \delta\right)\Delta_0^2 + \frac{1}{32\pi^2}\left[\frac{\tilde{A}}{8}\Delta_0^4 - {\lambda_0^{(+)}}^4 \log {\lambda_0^{(+)}}^2 - {\lambda_0^{(-)}}^4 \log {\lambda_0^{(-)}}^2\right]$$

From now on, Δ_0 real case only,

- gap equation

$$\left.\frac{\partial V_0}{\partial D}\right|_{\varphi,\bar{\varphi}} = 0.$$

$$0 = \Delta_0 \left[2\left(\left(c' + \frac{1}{64\pi^2} \right) - \delta \right) + \frac{1}{32\pi^2} \left\{ \frac{\tilde{A}}{2}\Delta_0^2 - \frac{1}{\sqrt{1+\Delta_0^2}} \left(\lambda_0^{(+)3} \left(2\log \lambda_0^{(+)2} + 1 \right) - \lambda_0^{(-)3} \left(2\log \lambda_0^{(-)2} + 1 \right) \right) \right\} \right],$$

$$\delta_* = 0$$

IMaru1

- stationary cond.

$$\left.\frac{\partial V_0}{\partial \varphi}\right|_{D,\bar{\varphi}} = 0$$

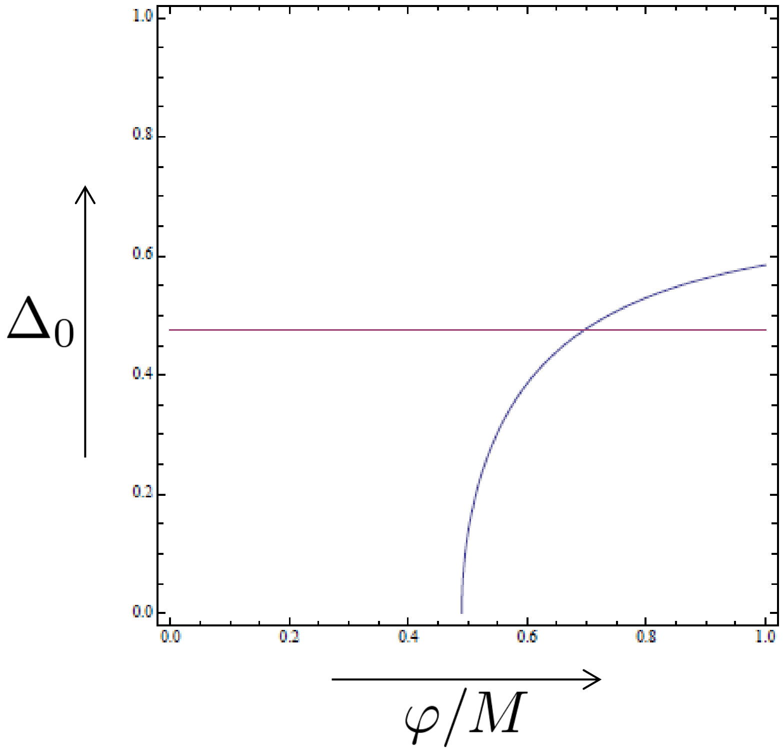
$$2\partial(\ln |m_s|^2) \frac{V_0}{N^2 |m_s|^4} = \left(\frac{\partial \delta}{\partial \varphi} \right) \Delta_0^2 - \frac{\partial \Delta_0}{\partial \varphi} \frac{\partial}{\partial \Delta_0} \left(\frac{V_0}{N^2 |m_s|^4} \right)$$

using the gap eq.

$$\frac{V_0}{N^2 |m_s|^4} = \frac{\frac{\partial \delta}{\partial \varphi}}{2\partial(\ln |m_s|^2)} \Delta_0^2$$

$(\Delta_{0*}, \varphi_* = \bar{\varphi}_*)$ determined as the point of intersection of the two real curves in the $(\Delta_0, \varphi = \bar{\varphi})$ plane

Schematically,



DSB HAS BEEN REALIZED

・numerical study

- the minimal choice for DDSB:

$$\mathcal{F} = \frac{c}{2N}\mathrm{tr}\varphi^2 + \frac{1}{3!MN}\mathrm{tr}\varphi^3 \equiv \frac{1}{2}c\varphi^2 + \frac{1}{3!M}\varphi^3,$$

$$W = \frac{m^2}{N}\mathrm{tr}\varphi + \frac{d}{3!N}\mathrm{tr}\varphi^3 \equiv m^2\varphi + \frac{d}{3!}\varphi^3,$$

- consistency check: $\left|\frac{F_*}{D_*}\right| \ll 1, \; |f_{3*}| \ll 1$

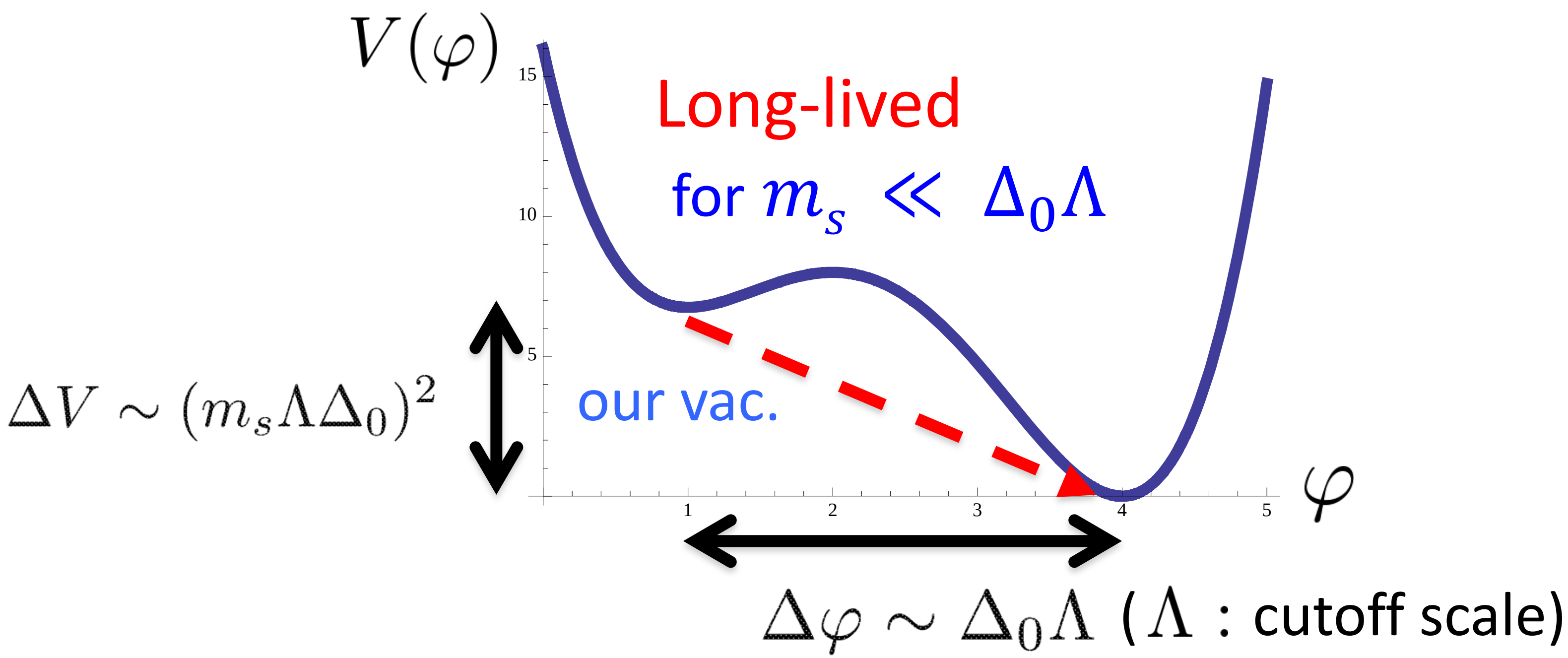
- samples:

$c' + \frac{1}{64\pi^2}$	$\tilde{A}/(4\cdot 32\pi^2)$	Δ_{0*}	$\varphi_*/M \; (-\frac{N^2}{\mathrm{Im}(i+\Lambda)})$	$\lvert F_*/D_*\rvert$	$\lvert f_{3*}\rvert$
0.002	0.0001	0.477	0.707 (10000)	2.621 ($m = M$)	1.77
0.002	0.0001	0.477	0.707 (10000)	0.524 ($m \ll M$)	0.35
0.002	0.0001	0.477	0.707 (10000)	0.860 ($m = 0.4M$)	0.58
0.003	0.001	1.3623	0.8639 (2000)	0.825 ($m = M$)	>1
0.003	0.001	1.3623	0.8639 (2000)	0.224 ($m \ll M$)	0.43
0.003	0.001	1.3623	0.5464 (5000)	1.092 ($m = M$)	>1
0.003	0.001	1.3623	0.5464 (5000)	0.142 ($m \ll M$)	0.27
0.003	0.001	1.3623	0.5464 (5000)	0.911 ($m = 0.9M$)	1.76
0.003	0.001	1.3623	0.3863 (10000)	1.444 ($m = M$)	>1
0.003	0.001	1.3623	0.3863 (10000)	0.100 ($m \ll M$)	0.19
0.003	0.001	1.3623	0.3863 (10000)	0.960 ($m = 0.8M$)	1.85

・Metastability of our false vacuum

$\langle D \rangle = 0$ tree vacuum is not lifted

$\Rightarrow$ check if our vacuum $\langle D \rangle \neq 0$ is sufficiently long-lived



Coleman & De Luccia (1980)

Decay rate of our vacuum $\propto \exp\left[-\frac{\langle \Delta\phi \rangle^4}{\langle \Delta V \rangle}\right] = \exp\left[-\frac{(\Delta_0 \Lambda)^2}{m_s^2}\right] \ll 1 \qquad \Delta_0 \Lambda \gg m_s$

・second variation and mass of scalar gluons

$$V_{\text{scalar}} = V(D = D_*(\varphi,\bar{\varphi}), F = F_*(\varphi,\bar{\varphi}) \approx 0, \bar{F} = \bar{F}_*(\varphi,\bar{\varphi}) \approx 0, \varphi, \bar{\varphi})$$

at the stationary point $(D_*(\varphi_*, \bar{\varphi}_*), 0, 0, \varphi_*, \bar{\varphi}_*)$.

separate $V(D, F, \bar{F}, \varphi, \bar{\varphi})$ into two parts:

$$V = \mathcal{V} + V_0$$

Here

$$\mathcal{V}(F,\bar{F},\varphi,\bar{\varphi}) \approx -gF\bar{F} - FW' - \bar{F}\bar{W}' + (\partial_F V_{1-\text{loop}})_* F + (\partial_{\bar{F}} V_{1-\text{loop}})_* \bar{F} + \frac{1}{2}(\partial_F^2 V_{1-\text{loop}})_* F^2 + \frac{1}{2}(\partial_{\bar{F}}^2 V_{1-\text{loop}})_* \bar{F}^2 + (\partial_F \partial_{\bar{F}} V_{1-\text{loop}})_* F\bar{F},$$

$$V_0(D,\varphi,\bar{\varphi}) = V(D,\varphi,\bar{\varphi}, F = 0, \bar{F} = 0).$$

make exploit “implicit fn derivatives”

e.g. For $\mathcal{V}$, $\vec{y}_L = (F, \bar{F}), \vec{y}_R = (\varphi, \bar{\varphi}),$

$$\delta^2 \mathcal{V}_* \approx \frac{1}{2}\delta\vec{y}_R^{\,t} M_{RL_*}(-M_{LL_*}^{-1}) M_{LR_*} \delta\vec{y}_R \qquad M_{RR_*} \approx 0$$

- scalar gluon mass: $\frac{1}{g}|W'' - (\partial\partial_F V_{1-\text{loop}})|_*^2$

in the region $|(\partial_F \partial_{\bar{F}} V)_0|_*, |(\partial_F^2 V)_0|_*, \ll g_*,$

consistency checked

- samples:

$c' + \frac{1}{64\pi^2}$	$\tilde{A}/(4 \cdot 32\pi^2)$	Δ_{0*}	φ_*/M $(-\frac{N^2}{\mathrm{Im}(i+\Lambda)})$	scalar gluon mass
0.002	0.0001	0.477	0.707 (10000)	$0.4998 + 0.0056\ N^2 + 8.607 \times 10^{-7} N^4$
0.003	0.001	1.3623	0.8639 (2000)	$0.7463 + 0.0106\ N^2 + 2.653 \times 10^{-4} N^4$
0.003	0.001	1.3623	0.5464 (5000)	$0.2986 + 0.0008\ N^2 + 4.694 \times 10^{-5} N^4$
0.003	0.001	1.3623	0.3863 (10000)	$0.1492 - 0.0024\ N^2 + 7.235 \times 10^{-5} N^4$

Summary

- A dynamical mechanism of DDSB proposed
- A nontrivial solution to the gap eq. for <D>
  found in a self-consistent HF approx.
- Our vacuum is metastable
  & can be made long-lived
- Numerical examples found