Akitsugu Miwa (HRI)

Keyword: gauge / gravity dual (proof, check and applications)

Recent work: GCA in 2d (with A.Bagchi, R.Gopakumar and I.Mandal)

motivation: finding some solvable sector

contraction and infinite extension (any dim.):

d-dim. conformal algebra $SO(d,2)$

$$t \to t, \quad x_i \to \epsilon x_i \quad \Big\downarrow$$

Galilean conformal algebra (GCA) (infinite dim. extension is possible)

relation with Virasoro algebra (2d case):

relation with Virasoro: $L_n = \lim_{\epsilon \to 0} (\mathcal{L}_n + \bar{\mathcal{L}}_n) \qquad M_n = \lim_{\epsilon \to 0} \epsilon (\bar{\mathcal{L}}_n - \mathcal{L}_n)$

GCA in 2d:

$$[L_m, L_n] = (m-n) L_{m+n} + C_1 \delta_{m+n} m(m^2-1)$$

$$[L_m, M_n] = (m-n) M_{m+n} + C_2 \delta_{m+n} m(m^2-1)$$

central charge: $C_1 \sim c + \bar{c}, \quad C_2 \sim \epsilon(\bar{c} - c)$

so far: representation, null states, fusion rule, 2, 3, 4-pt functions, etc.

Higher Derivative BL theories and complex 3-algebras

Bobby Ezhuthachan
HRI, Allahabad

4th Asian winter school, Mahabaleshwar
Jan 2010

- Based on an ongoing work with C.Papageorgakis

Bagger, Lambert and Gustvasson had shown that in three dimensions, at the two derivative order, actions with $\mathcal{N}=8$ supersymmetry, $SO(8)$ symmetry and non-dynamical gauge fields are classified by a single four-indexed parameter (f^{abcd}), which satisfies a constraint named the fundamental identity(FI).

$$f^{abcd}f^{efgd}+f^{abed}f^{cfgd}+f^{aecd}f^{ecgd}+f^{ebcd}f^{efad}=0 \tag{1}$$

This parameter may be interpreted as the structure constants of a "3-algebra", with the FI being the generalized Jacobi identity satisfied by the generators of the algebra.

$$[T^a,T^b,T^c]=f^{abcd}T^d \tag{2}$$

- Maximally super symmetric actions in three dimensions, with $SO(8)$ symmetry are classified by a 3-algebra at the two derivative order.

- In a previous work, along with Sunil Mukhi and C. Papageorgakis, we argued that this holds true even when we add higher dimensional terms in the action. In particular, we constructed the four derivative cousin of the BLG action, which is also classified only by the '3-algebra'.

- Later, Bagger and Lambert had generalized their results to the case of actions which preserve $\mathcal{N}=6$ super symmetry and $SO(6)$ symmetry. In this case, their result was that these actions are classified by a complex four indexed parameter $f^{ab}{}_{cd}$, which satisfied some new fundamental identity.

$$[T^a, T^b, \bar{T}_c] = f^{ab}{}_{cd} T^d, \;\; [\bar{T}_a, \bar{T}_b, T^c] = f^{cd}{}_{ab} \bar{T}_d \tag{3}$$

In our on-going work, we argue that even in this case, the above result continues to hold when one adds higher dimension terms in the action, however in a slightly more interesting way. We see that at the higher derivative order, there appear more parameters in the action, which are actually the structure constants of the full complex 3-algebra, which did not appear at the two derivative order.

$$[T^a, T^b, T^c] = g^{abcd} \bar{T}_d, \;\; [\bar{T}_a, \bar{T}_b, \bar{T}_c] = g_{abcd} T^d \tag{4}$$

- In short, The full three algebra actually appears only at the higher derivative level.

Deconfinement Phase Transition in the Dense Medium

Chanyong Park (Center for Quantum Sapce Time, Korea)

@ 4-th Asian Winter School

Ref.

1) B. H. Lee, C. Park and S.J. Sin, JHEP 0907:087,2009.
2) C. Park, arXiv:0907.0064.
3) K. Jo, B. H. Lee, C. Park and S.J. Sin, arXiv:0909.3914.

Goal

investigate the 4-dimensional gauge theory (QCD) in the strong coupling region using the 5-dimensional dual gravity theory.

Set-up

To get information about the deconfinement phase transition in QCD, we consider the dual gravity theory including vector field, whose time component corresponds to the quark chemical potential or quark number density.

$$S = \int d^5x \sqrt{G} \left[\frac{1}{2\kappa^2} \left(-\mathcal{R} + 2\Lambda \right) + \frac{1}{4g^2} F_{MN} F^{MN} \right]$$

Solutions

$$ds^2 = \frac{R^2}{z^2}\left(f(z)dt^2 + d\vec{x}^2 + \frac{1}{f(z)}dz^2\right)$$

1) RNAdS BH (RN AdS black hole)

$$f(z) = 1 - mz^4 + q^2 z^6$$

$$A(z) = i\left(\mu - Qz^2\right)$$

m	black hole mass
q	black hole charge
μ	quark chemical potential
$Q = \sqrt{\frac{3g^2R^2}{2\kappa^2}}\, q$	quark number density

corresponds to the deconfining phase

(QGP, quark-gluon plasma)

2) non-black hole solution with the IR cut-off

the dual geometry of the confining (or hadronic) phase

$$f(z) = 1 + q^2 z^6$$

$$A(z) = i\left(\mu - Qz^2\right)$$

- baryonic chemical potential

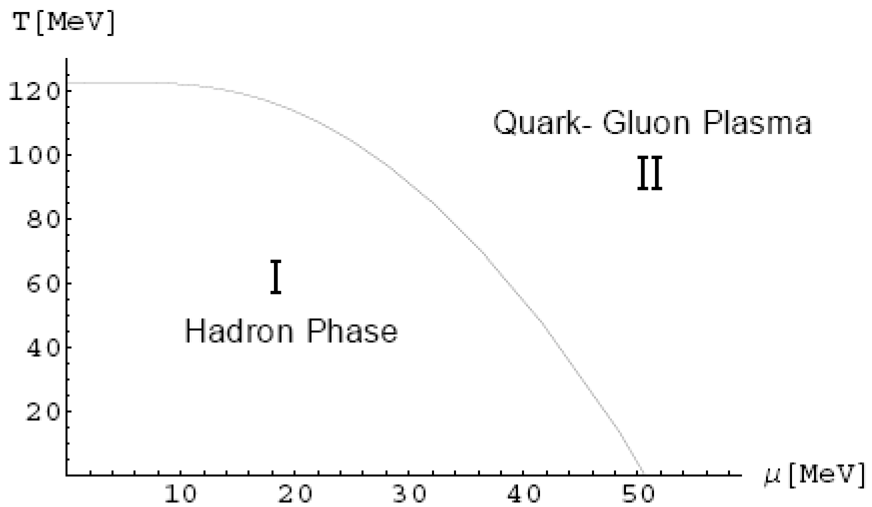
$$\mu_B = 3\mu$$

- baryon number density

$$Q_B = Q/3$$

We call it tcAdS (thermal charged AdS space)

Comparing the on-shell actions (or free energy) of two gravity solutions, we can see when the Hawking-Page transition dual to the deconfinement phase transition occurs.



Region I :

tcAdS (cofining phase) is dominant

Region II :

RNAdS BH (decofining phase) is dominant

Conclusion

We obtained the coincident deconfinement phase diagram of QCD using the AdS/CFT correspondence.

Hiroshi Isono

(National Taiwan University)

Basic Research Interests

conformal field theories in various dimensions

worldsheet theory, critical point, their gravity dual

up to now

2D BCFT (BS) description of gauge instantons on D-branes (e.g. D(-1) in D(-1)-D3)

4D N=1 quiver SCFT and its marginal deformations from brane tiling

2D CFT as a dual of rotating black hole (for 5D black hole)

now

quantum critical points of (1+1)D condensed matter system (TL liquid) and their gravity descriptions

to what extent gravity description can capture some exact results by (1+1)D CFT (correlation functions, critical exponents etc.)

Hirotaka Irie
from
National Taiwan University

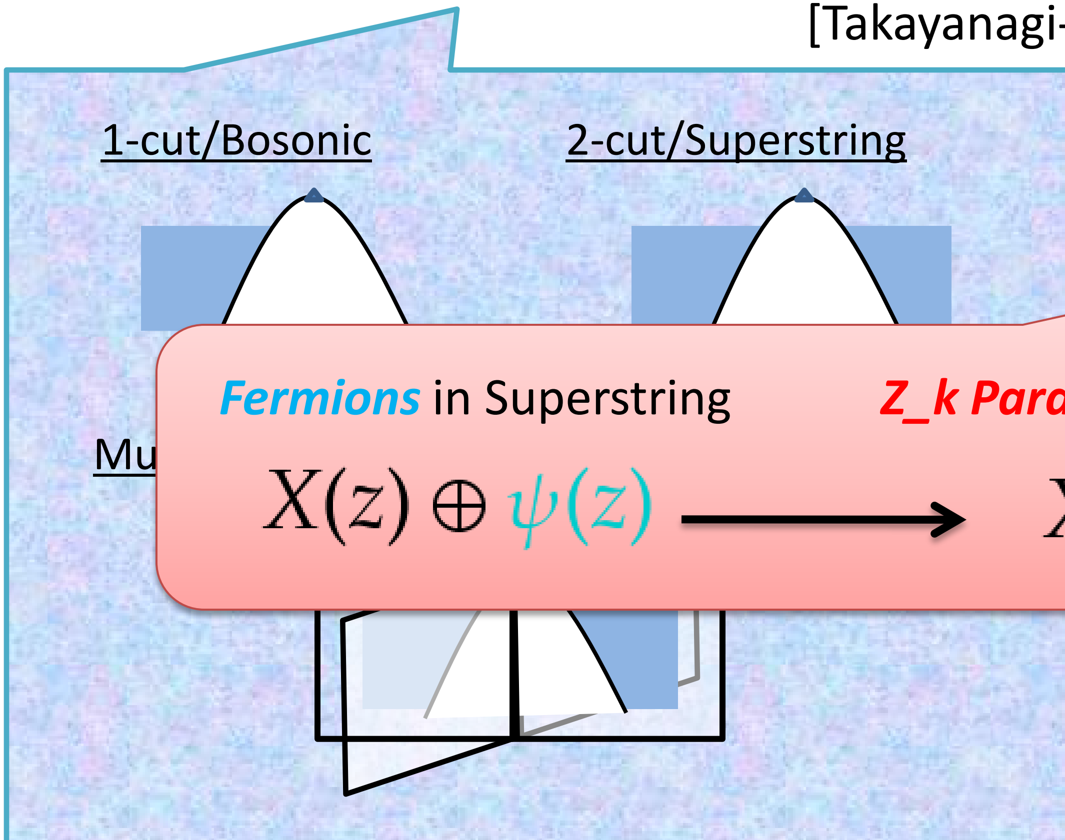
Hirotaka Irie (National Taiwan University)

My working area: ***Non-critical string theory*** (2D string theory, matrix models,…)

In 2003, Matrix Reloaded [McGreevy-Verlinde'03] and so on…:

Two-cut critical points of matrix models ⇔ (Type 0) superstring theory

[Takayanagi-Toumbas '03][Douglas, et al. '03]



fractional superstring theory

brane amplitudes

03]

Yeh '10]

Fermions in Superstring

Z_k Para-Fermions (kind of Anyon)

$$X(z) \oplus \psi(z) \longrightarrow X(z) \oplus \psi(z)$$

boundary CFT and so on…

odels

(Kontsevich type, Loop gas, c=1,…)

3. Beyond Non-perturbative completeness of multi-cut matrix models?

Everything You Ever Wanted to Know About Warped AdS_3[1]

S. Detournay[†], D. Israel[⋆], J. Lapan[†], and M. Romo[†]

[†]KITP/UCSB

[⋆]IAP - Paris

4th Asian Winter School on Strings, Particles, & Cosmology
January 12, 2010

[1]But were afraid to ask.

Description:

- $WAdS_3$ is a one-param deformation of AdS_3
- Breaks $SL(2;\mathbb{R}) \times SL(2;\mathbb{R}) \to SL(2;\mathbb{R}) \times U(1)$

Motivations

- 3D massive gravities
- 3D GR + matter theories
- NHEK geometry
- Admits *single* asymptotic Virasoro (dual 2D CFT? 1D?)

Methods

- In many stringy models,

$$AdS_3 \longleftrightarrow SL(2,\mathbb{R}) \text{ WZW model}$$

- Want to utilize WZW methods
- S^1 bundle over $WAdS_3 \longleftrightarrow$ deformation of $SL(2;\mathbb{R}) \times U(1)$ WZW by

$$\Delta S = H \int d^2\sigma J\bar{g}$$

with $J \in SL(2;\mathbb{R})_L$ and $\bar{g} \in U(1)_R$
- Dim. red. on $S^1 \Longrightarrow WAdS_3$ + C.S. gauge fields

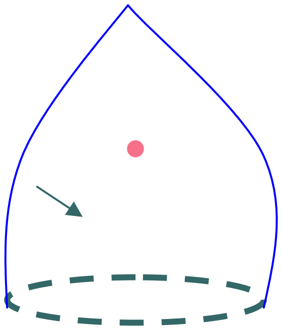
Current Conclusions/Results

- Independent of gauge coupling λ, always find at least one Virasoro
- For special values of H and λ, find a second one with a different central charge!
- Still trying to make sense of this . . . asymmetric orbifold is tempting, but that wouldn't change the central charge.

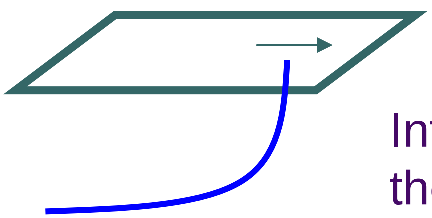
Shoichi Kawamoto (NTNU, Taiwan)

Various aspects of AdS/CFT

- Anyonic branes in $AdS_4 * \mathbf{CP}^3$



D2 + k F1 and D0 pair -> Get phase through CS coupling
(cf. $AdS_5 * S^5$ case, Hartnoll)



- Accelerated temperature and AdS/CFT

Introduce "comoving frame" of accelerated string and discuss its thermal effect in the context of AdS/CFT

other keywords: Wilson loops in AdS/CFT,
(supersymmetric) Matrix model (IIB MM)
noncritical string theory, ...

Shou-Huang Dai
National Taiwan Normal University

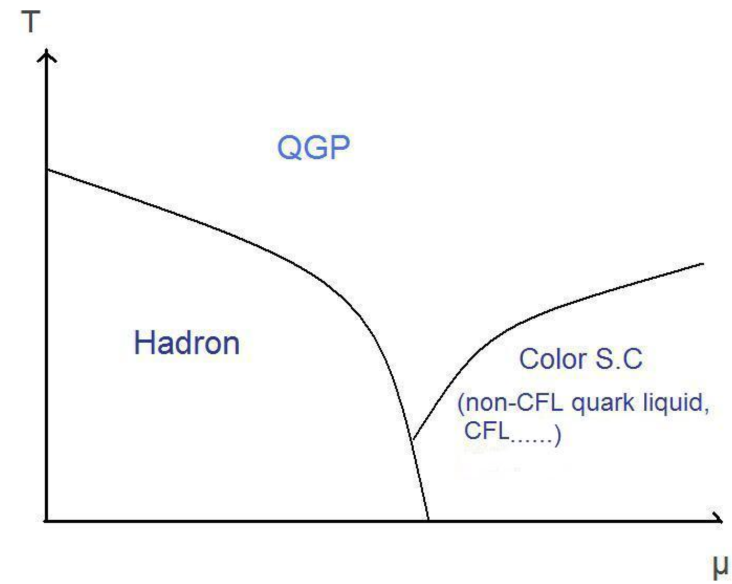
Research Interest: AdS/CFT and its applications

- Supergravity dual of non-anticommutative SYM

- Holographic description of QCD
  at very high baryon density
  @Large Nc
  → Chiral density wave?

$$\langle \bar{\psi}(x)\psi(y)\rangle \propto e^{ip(x+y)}F(x-y)$$

$$F(0) \propto e^{-\mathrm{const}/(g^2 N_c)^{1/2}}$$



(in collaboration with S. Kawamoto, WY Chuang, FL Lin & CP Yeh)

Shingo Takeuchi (APCTP, Korea)

Holographic QCD with S.J. Sin, Y.Kim, KwangHyun Jo, Y.Matsuo and members of APCTP

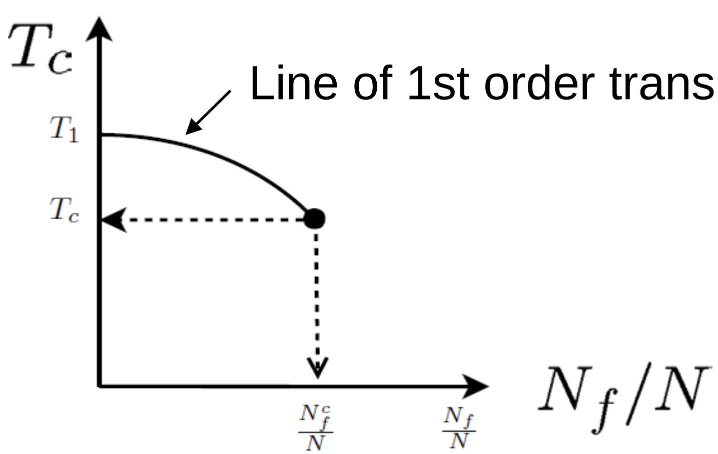
D3-D7 / D4-D8 / Ghoroku b.g.	Deform →	Soft-wall / Hard-wall / Magnetic b.g.	→	Zero temp. / Spectrum func. / Hydrodynamics	→	Phase transition / Fermi surface / Transport coefficients

↑ To dual field theory side

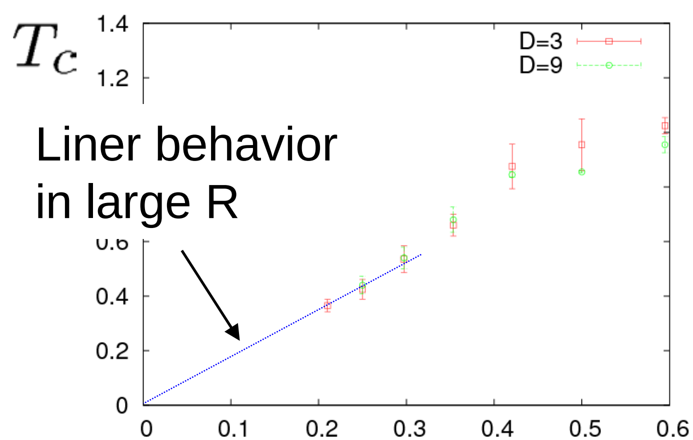
Matrix Model with A.Mukherjee, P.Basu, T.Azuma

1d Large-N SU(N) Yang-Mills at finite temperature + N_f fundamental matters

- Expected behavior we will study



- Current result we have obtained



$$R \equiv \frac{N^2}{N_f}$$

$(1/R)^{1/4}$

What is way to analytically understand this ?

recent research of SHINJI SHIMASAKI

HRI & Kyoto U.

- **How are curved spaces included in matrices?**

◆ Large N reduction [Eguchi-Kawai]

Large N field theory is equivalent to the matrix model obtained by dimensionally reducing it to zero dimension.

➢ Large N reduction on group manifolds

In collaboration with Hikaru Kawai and Asato Tsuchiya [0912.1456]

Large N field theories defined on group manifolds are equivalent to some corresponding matrix models.

Ex) matrix regularization of gauge theory on S^3 (N=4 SYM on RxS^3) in a gauge invariant and SO(4) invariant manner.

➢ Large N reduction for Chern-Simons theory on S^3

In collaboration with Goro Ishiki and Asato Tsuchiya [0908.1711] PRD80:086004,2009

We study the reduced matrix model of CS on S^3.

It reproduces the original theory in the large N limit.

Ex) partition function, unknot Wilson loop in the fund. rep.

Shuichi Yokoyama University of Tokyo

based on Y.Imamura-SY, PTP121(2009), NPB827(2010) 12. Jan. 2010 @ Mahabaleshwar

proposed! known

3d SC Chern-Simons $\Leftrightarrow$ M2s $\Leftrightarrow$ M theory on $AdS_4 \times X^7$

CFT_3 $\longleftrightarrow$ AdS_4

check!

what we did.

N=4 SC Chern-Simons theory

$X^7 = S^7 / \Gamma$

Result

Monopole operators $\Leftrightarrow$ M2 wrapped on 2-cycle

Ranks of gauge group $\Leftrightarrow$ M5 wrapped on 3-cycle

Baryonic operators $\Leftrightarrow$ M5 wrapped on 5-cycle

3d SC index $\overset{!}{=}$ AdS_4 index

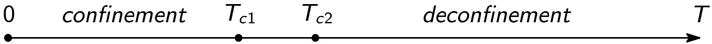
with monopole contribution with wrapped M2 contribution

Phases of Lower dimensional Large-N Gauge Theories

Takeshi Morita, TIFR

In [0910.4526], G. Mandal, M. Mahato and I revealed the phase structure of the following 1 dim large-N gauge theory by using a large-D expansion

$$S = \int_0^\beta dt \, \mathrm{Tr} \left(\sum_{I=1}^{D} \frac{1}{2} \left(D_t Y^I \right)^2 - \sum_{I,J} \frac{g^2}{4} [Y^I, Y^J][Y^I, Y^J] \right).$$



We can evaluate several quantities even in the strong coupling region.
By applying this result, I am interested in the following topics:

- extension to the two dimensional model. ($\int_0^\beta dt \to \int_0^\beta dt \int_0^L dx$)
  $\to$ Rich phase structures are obtained. (partially done)
- extension to the supersymmetric models.
  $\to$ 0 dim: IKKT matrix model.
  $\to$ 1 dim: BFSS matrix theory, black hole thermodynamics.
  $\to$ 2 dim: DVV matrix string,
  Dynamical BS/BH phase transition (with Basu, Mandal and Wadia)
- If we can replace $Y^I \to D^I$ and $\int_0^\beta dt \to \int_0^\beta dt \int d^D x$, we will obtain the pure YM. $\to$ the confinement/deconfinement transition of YM.

Dan Tomino（富野　弾）

National Center for Theoretical Sciences (Taiwan)
(國家理論科學研究中心)

Main research interests:

- IIB matrix model :

  a proposal for non-perturbative definition of superstring theory

- BLG (and ABJM) model :

  a model for multiple membranes

Recent Work

- Large N matrix can describe **curved space** covariant derivative. **(Hanada Kawai and Kimura [05])**
- Adopting this idea, we can easily derive a field equation of a **torsion gravity** from equation of motion of IIB matrix model.
- I studied classical solutions of this field equation:

Time dependent solution with homogeneity and isotropy

Static solution with spherical symmetry

(with Hiroshi Isono [0911.1769])

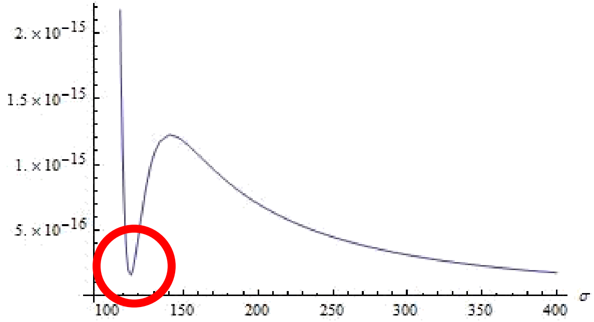
SUSY breaking near the tip of Klebanov-Strassler

Yoske Sumitomo
TIFR

Non-SUSY near the tip

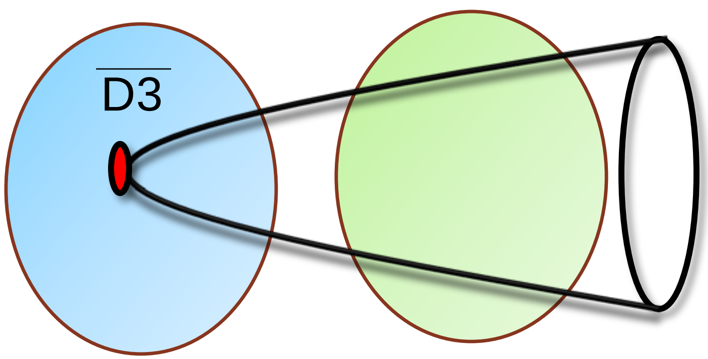
SUSY breaking? (as we saw in Herman's lecture)

Adding $\overline{\text{D3}}$ near the tip of Klebanov-Strassler



→ de Sitter vacua (KKLT)

Back reaction of $\overline{\text{D3}}$



→ Non Calabi-Yau

McGuirk-Shiu-Y.S. DeWolfe-Kachru-Mulligan

Holographic Gauge Mediation

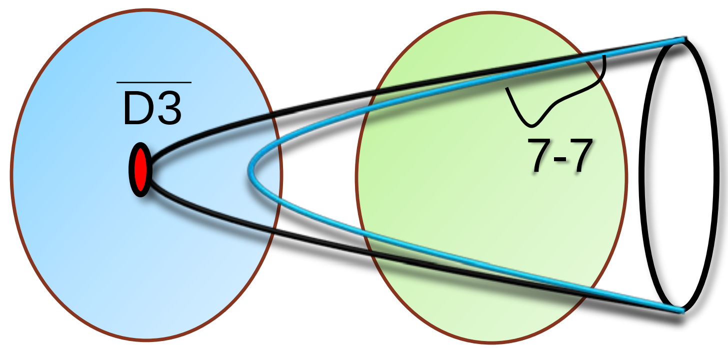
McGuirk-Shiu-Y.S.

Benini-Dymarsky-Franco
-Kachru-Simic-Verlinde

Visible: 7-7

Hidden: KS + $\overline{\text{D3}}$

Messenger: 3-7



R-symmetry: (discrete)	$\mathbb{Z}_2$	$\mathbb{Z}_{2M}$
Gaugino mass in classical gravity: (tree level of DBI)	non zero	zero

⇒ Agree with R-sym. argument: ~~Gaugino mass~~ for R-sym. $> \mathbb{Z}_2$

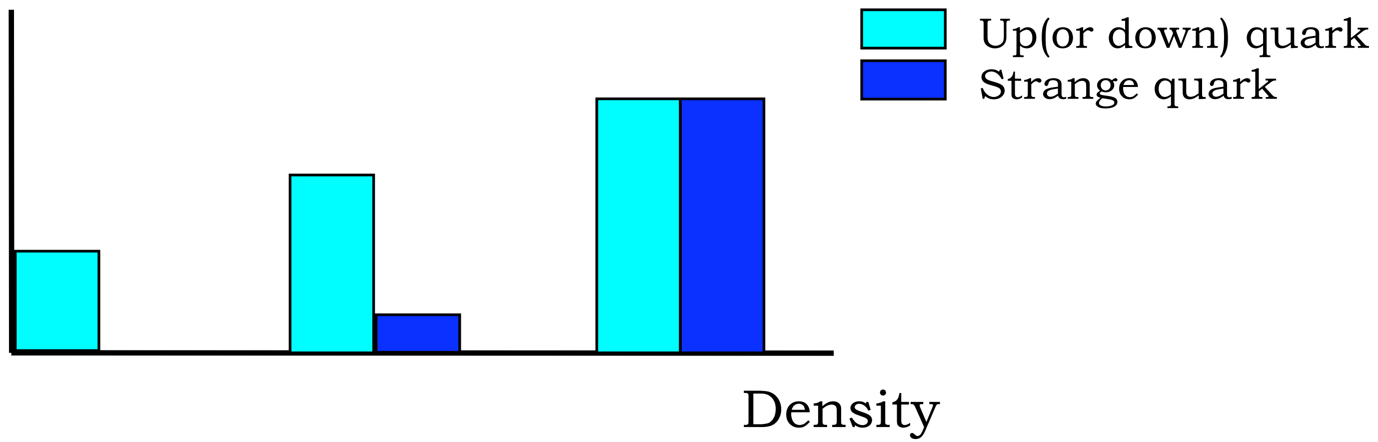
Nuclear matter to strange matter transition in holographic QCD

Yunseok Seo
CQUeST

in collaboration with Youngman Kim and Sang-Jin Sin
arXive: 0911.3685

Motivation

- Nuclear matter to strange matter transition



In low density, mass of strange quarks too heave to be piled up in ground state

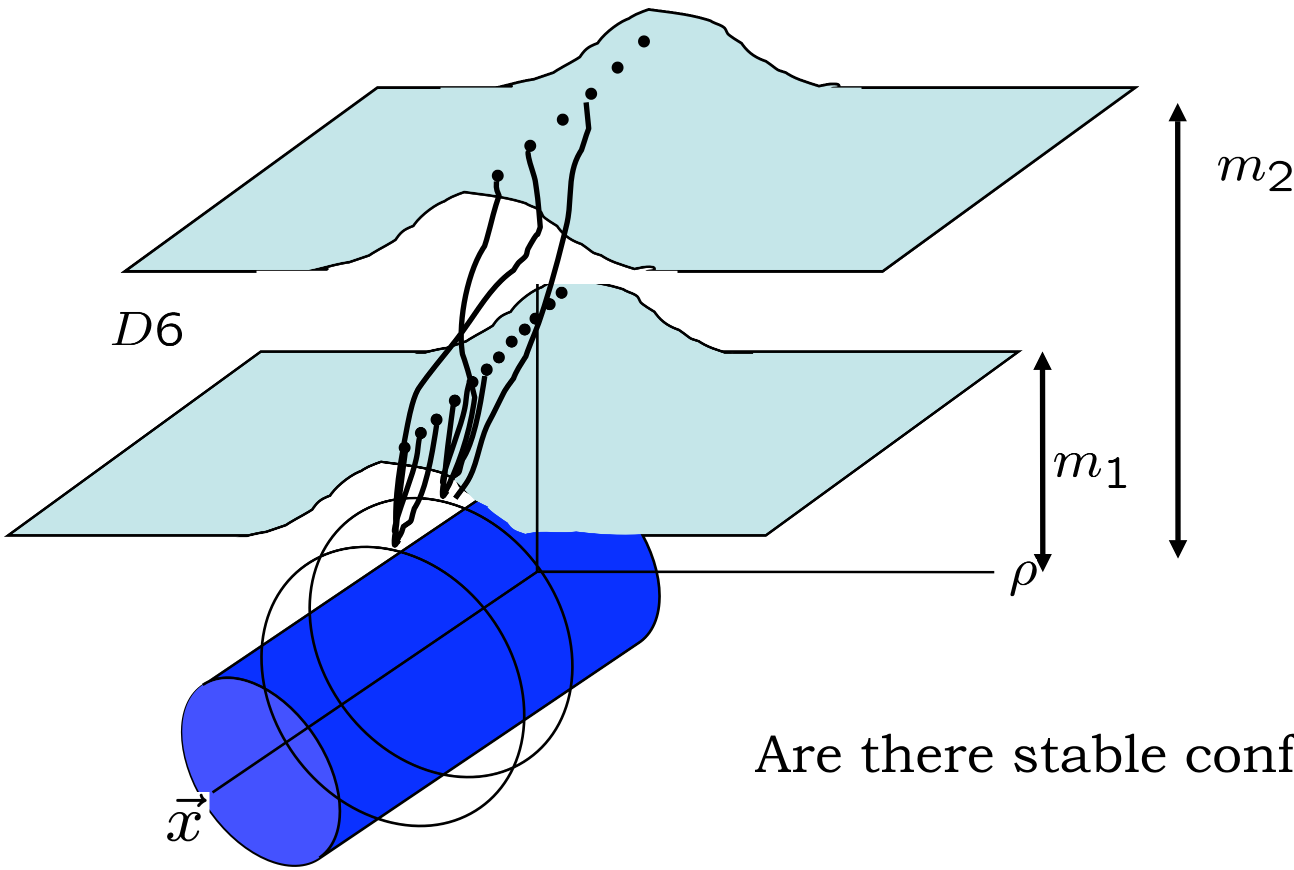
As density increase, chemical potential of light (up or down) quarks become comparable with the mass of strange quark

In certain density, strange quark can be entered to the system

$$\rho_c \sim (2 - 4)\rho_0$$

Basic setup

Two flavor



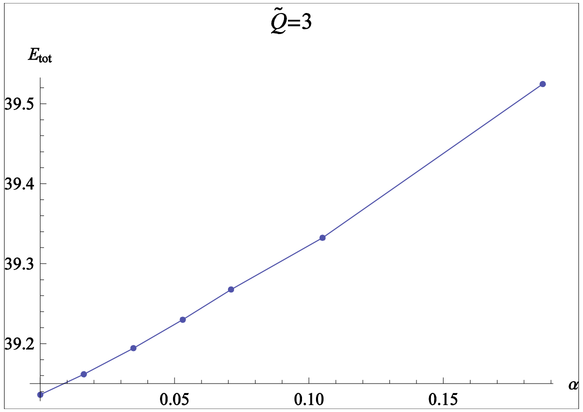
Are there stable configurations?

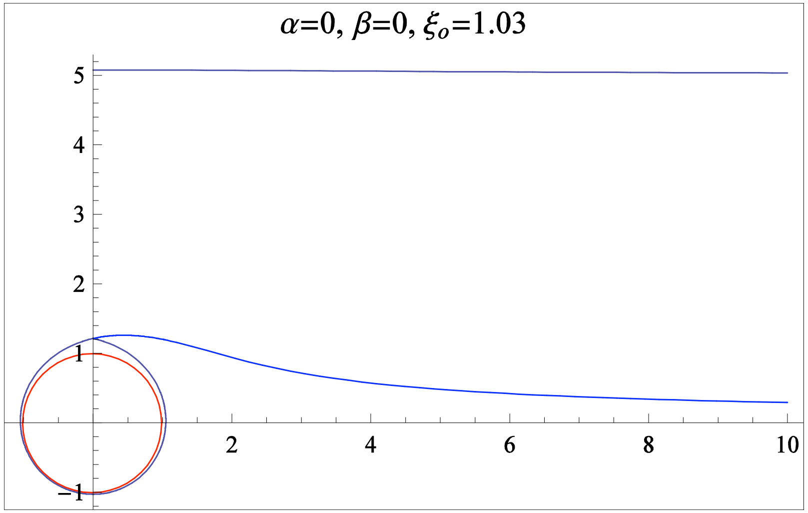
$$ds^2 = \left(\frac{U}{R}\right)^{3/2}\left(\eta_{\mu\nu}dx^\mu dx^\nu + f(U)dx_4^2\right) + \left(\frac{R}{U}\right)^{3/2}\left(\frac{dU^2}{f(U)} + U^2 d\Omega_4^2\right)$$

$$e^\phi = g_s\left(\frac{U}{R}\right)^{3/4}, \quad F_4 = \frac{2\pi N_c}{\Omega_4}\epsilon_4, \quad f(U) = 1 - \left(\frac{U_{KK}}{U}\right)^3, \quad R^3 = \pi g_s N_c l_s^3.$$

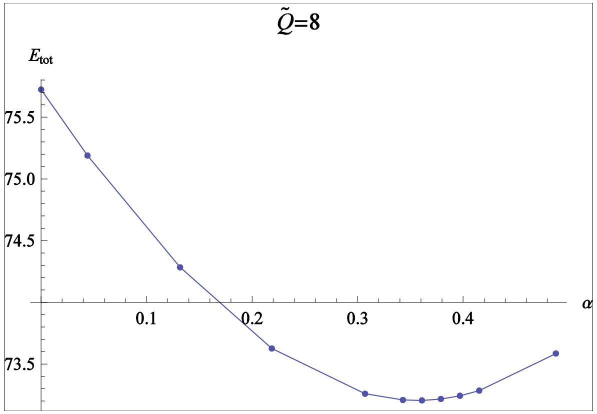
Energy minimization

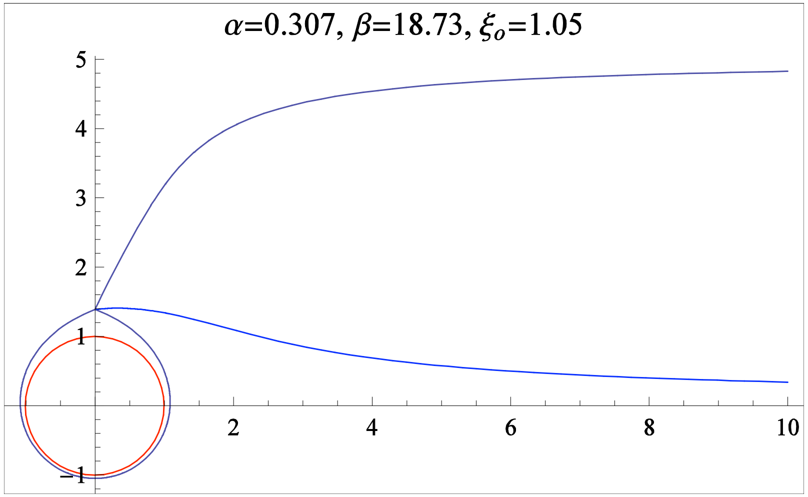
Small density





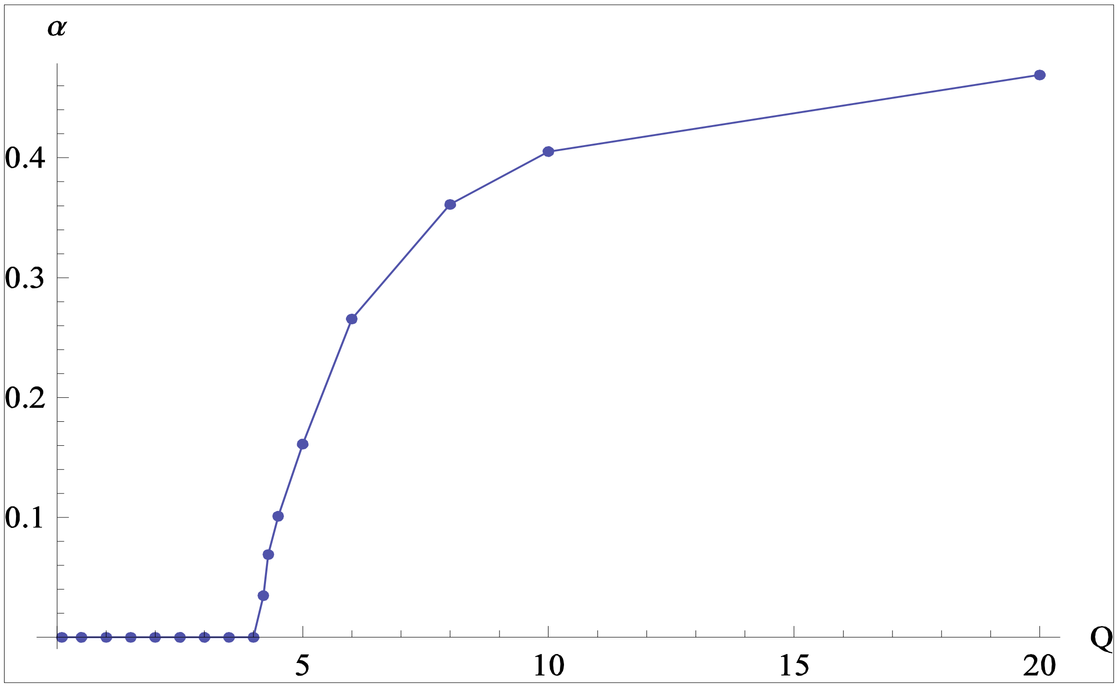
Large density





Nuclear matter to Strange matter

- Density dependence of ratio of strange quark



$$M_q = \frac{m_q \lambda M_{KK}}{9\pi}$$

$$\rho \equiv \frac{N_B}{V_3} = \frac{Q}{N_C V_3} = \frac{2 \cdot 2^{2/3}}{81(2\pi)^3} \lambda M_{KK}^3 \tilde{Q}$$

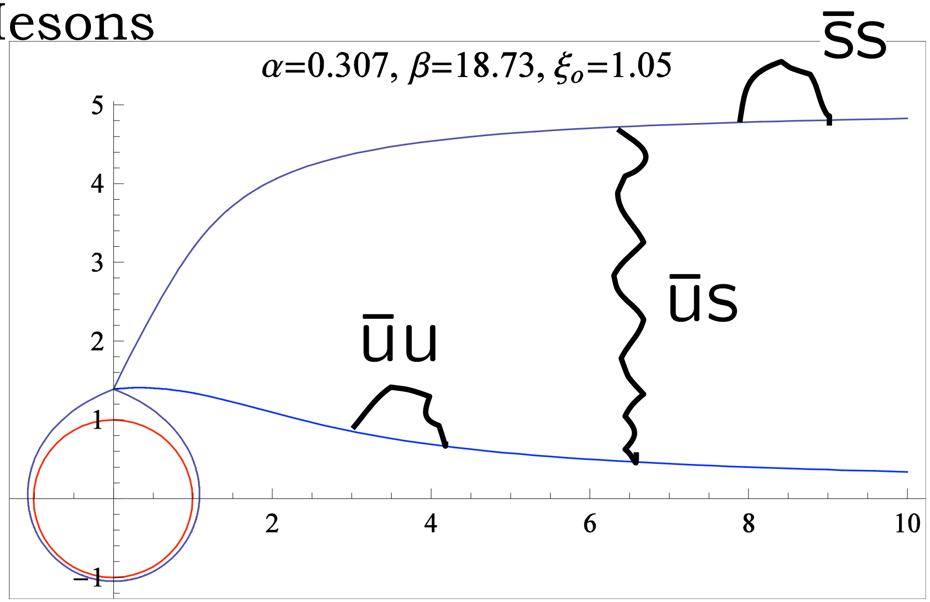
Choose

$$\lambda = 1.2$$
$$M_{KK} = 1.5\text{GeV}$$

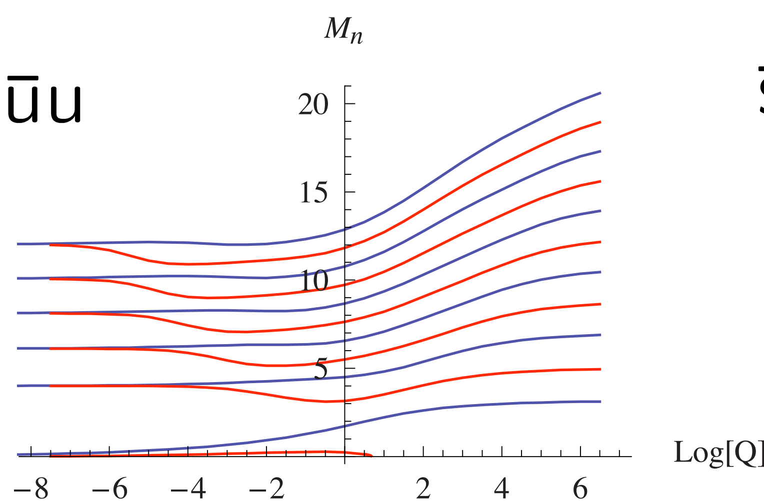
$$\Rightarrow \quad M_1 \sim 6.4\text{MeV}, \ M_2 \sim 318\text{MeV}, \quad \rho_c \sim 1.96\rho_0$$

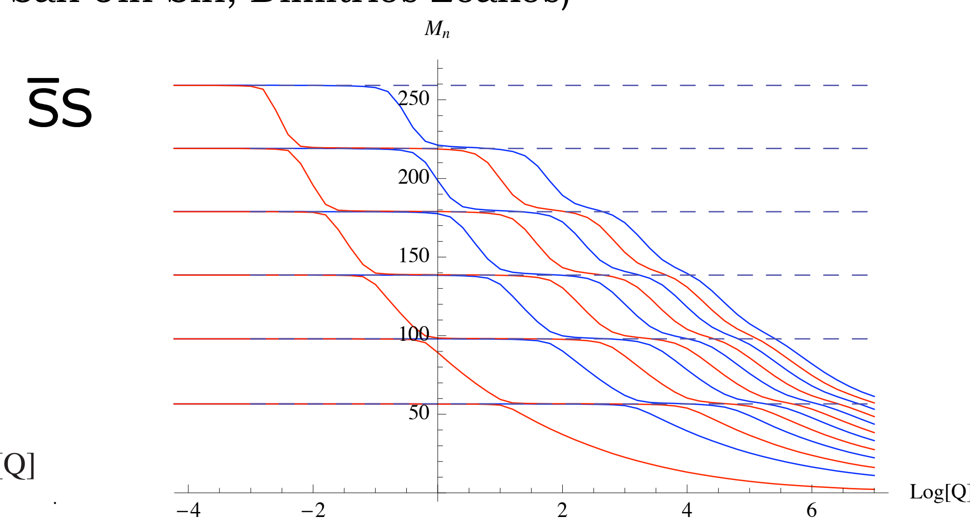
Fluctuation

- Mesons



arXiv: 0912:4013 (YS, Jonathan P. Shock, San-Jin Sin, Dimitrios Zoakos)





SUSY and tree level R-symmetry breaking

Zheng Sun

DTP, TIFR

4th Asian School, January 12, 2010

SUSY breaking

$$V = K^{\bar{i}j}(\partial_i W)^* \partial_j W, \quad K^{\bar{i}j} = (\partial_{\bar{i}} \partial_j K)^{-1}.$$

SUSY breaking

$$V = K^{\bar{i}j}(\partial_i W)^* \partial_j W, \quad K^{\bar{i}j} = (\partial_{\bar{i}} \partial_j K)^{-1}.$$

When the Kähler potential is minimal,

$$K = z_i^* z_i, \quad V = |\partial_i W|^2.$$

SUSY breaking

$$V = K^{\bar{i}j}(\partial_i W)^* \partial_j W, \quad K^{\bar{i}j} = (\partial_{\bar{i}} \partial_j K)^{-1}.$$

When the Kähler potential is minimal,

$$K = z_i^* z_i, \quad V = |\partial_i W|^2.$$

F-type SUSY breaking $\Leftrightarrow$ $\partial_i W \neq 0$ at the vacuum.

SUSY breaking

$$V = K^{\bar{i}j}(\partial_i W)^* \partial_j W, \quad K^{\bar{i}j} = (\partial_{\bar{i}} \partial_j K)^{-1}.$$

When the Kähler potential is minimal,

$$K = z_i^* z_i, \quad V = |\partial_i W|^2.$$

F-type SUSY breaking $\Leftrightarrow$ $\partial_i W \neq 0$ at the vacuum.
$\partial_X W \neq 0$ $\Leftrightarrow$ Goldstino direction ψ_X $\Leftrightarrow$ Pseudomodulus X.

SUSY breaking

$$V = K^{\bar{i}j} (\partial_i W)^* \partial_j W, \quad K^{\bar{i}j} = (\partial_{\bar{i}} \partial_j K)^{-1}.$$

When the Kähler potential is minimal,

$$K = z_i^* z_i, \quad V = |\partial_i W|^2.$$

F-type SUSY breaking $\Leftrightarrow$ $\partial_i W \neq 0$ at the vacuum.
$\partial_X W \neq 0$ $\Leftrightarrow$ Goldstino direction ψ_X $\Leftrightarrow$ Pseudomodulus X.

R-symmetry

Nelson & Seiberg: SUSY breaking $\Leftrightarrow$ R-symmetry.
(generic model, global minimum)

SUSY breaking

$$V = K^{\bar{i}j}(\partial_i W)^* \partial_j W, \quad K^{\bar{i}j} = (\partial_{\bar{i}}\partial_j K)^{-1}.$$

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F-type SUSY breaking $\Leftrightarrow$ $\partial_i W \neq 0$ at the vacuum.
$\partial_X W \neq 0$ $\Leftrightarrow$ Goldstino direction ψ_X $\Leftrightarrow$ Pseudomodulus X.

R-symmetry

Nelson & Seiberg: SUSY breaking $\Leftrightarrow$ R-symmetry.
(generic model, global minimum)
Gaugino mass requires R-breaking.

SUSY breaking

$$V = K^{\bar{i}j}(\partial_i W)^* \partial_j W, \quad K^{\bar{i}j} = (\partial_{\bar{i}}\partial_j K)^{-1}.$$

When the Kähler potential is minimal,

$$K = z_i^* z_i, \quad V = |\partial_i W|^2.$$

F-type SUSY breaking $\Leftrightarrow$ $\partial_i W \neq 0$ at the vacuum.
$\partial_X W \neq 0$ $\Leftrightarrow$ Goldstino direction ψ_X $\Leftrightarrow$ Pseudomodulus X.

R-symmetry

Nelson & Seiberg: SUSY breaking $\Leftrightarrow$ R-symmetry.
(generic model, global minimum)
Gaugino mass requires R-breaking.

- Explicit breaking,
- Spontaneous breaking $\Rightarrow$ R-axion.

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R-breaking by non-zero vev. of X (CW potential).

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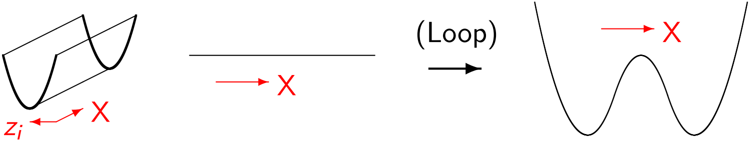

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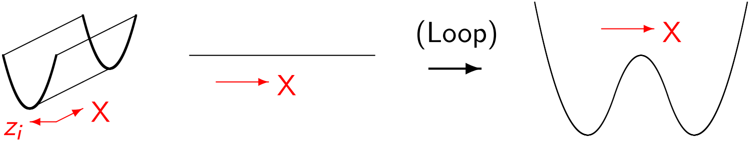

Spontaneous R-breaking at tree level

R-breaking everywhere on the pseudomoduli space.

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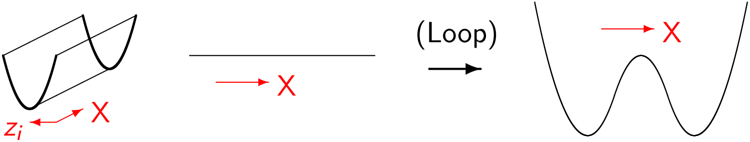

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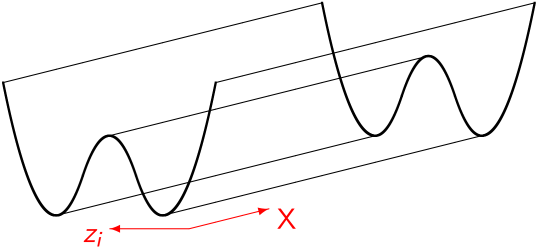

Tree level R-breaking models

R-breaking requires some $q_i \neq 0,\ 2$.

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- Explicit R-breaking (ISS, fine-tuning...).