Single Scale SUSY Breaking, Gauge Mediation, and Dark Matter

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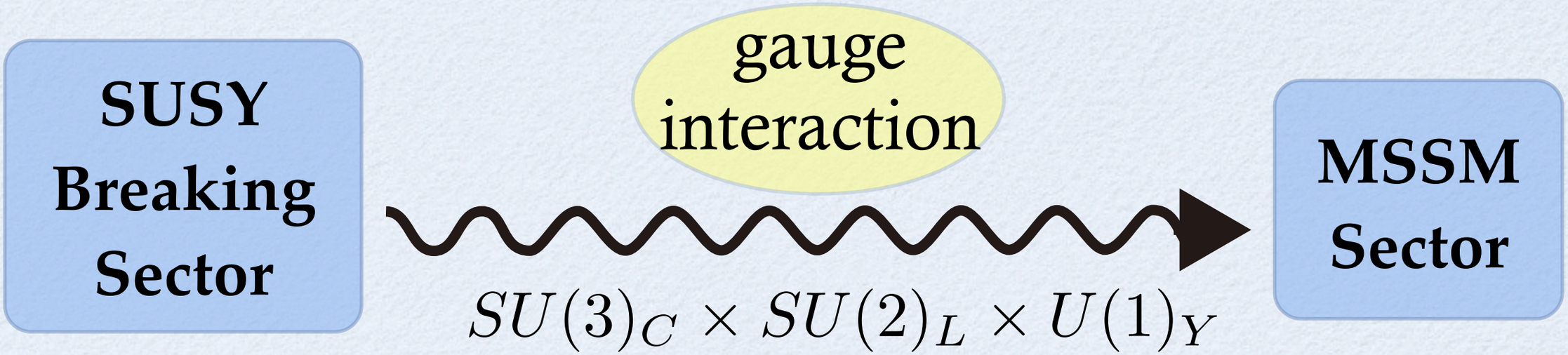
- Phys.Rev.D80:085017 with K.I-Izawa,F.Takahashi,T.T.Yanagida
- Phys.Rev.D81:125017
- Phys.Lett.B693:281

with T.T.Yanagida

Introduction

Low scale direct gauge mediation



- Theoretically elegant !
- There may be only one scale in the SUSY breaking sector (no separate SUSY breaking and messenger scales)

$$\Lambda \sim 100 \text{ TeV}$$

Introduction

Phenomenological Advantages

MSSM soft mass

$$m_{\rm soft} \sim \frac{g_{\rm SM}^2}{16\pi^2}\Lambda \sim 1 \text{ TeV}$$

SUSY breaking scale

$$\Lambda \sim 100 \text{ TeV}$$

- gravitino mass

$$m_{3/2} \sim \Lambda^2/M_{\rm Planck} \sim 1 \text{ eV}$$

- hidden sector particle mass

$$m_{\rm hid} \sim \Lambda \sim 100 \text{ TeV}$$

Introduction

Phenomenological Advantages

- gravitino mass $m_{3/2} \sim \Lambda^2/M_{\rm Planck} \sim 1$ eV

→ No cosmological gravitino problems
if $m_{3/2} < 16$ eV [Viel et al., 2005]

gravitino problem : { •overclosure of the universe
•spoiling the big-bang nucleosynthesis

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<u>Phenomenological Advantages</u>

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gravitino problem : {•overclosure of the universe •spoiling the big-bang nucleosynthesis

•hidden sector particle mass $m_{\rm hid} \sim \Lambda \sim 100$ TeV

→ Strongly coupled dark matter [Dimopoulos et al., 1996]

$$\Omega_{\rm DM} h^2 \propto \langle \sigma v^2 \rangle^{-1}_{\rm annihilation} \propto \left(g^2/m_{\rm DM} \right)^{-2}$$

$$\begin{cases} g^2 \sim 0.1, \quad m_{\rm DM} \sim 100 \text{ GeV} & \text{(WIMP)} \\ g^2 \sim (4\pi)^2, \quad m_{\rm DM} \sim 100 \text{ TeV} & \text{(strongly coupled)} \end{cases}$$

Introduction

- Strongly coupled SUSY breaking sector with a single mass scale $\Lambda \sim 100\ \mathrm{TeV}$ is very attractive !

SUSY breaking sector with $\Lambda \sim 100\ \mathrm{TeV}$

→ MSSM soft masses

→ No gravitino problems

→ Strongly coupled thermal relic dark matter

- We would like to construct a model which realizes this scenario.

Model

Our model

I will discuss
- SUSY breaking
- Gauge mediation
- Dark matter

Model (SUSY breaking)

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A new SUSY breaking model

$SU(N_C)$ gauge theory

matter:

quarks: $\begin{cases} Q, \tilde{Q} & (N_Q \text{ flavor}) \\ P, \tilde{P} & (N_P \text{ flavor}) \end{cases}$

singlets: $S \qquad (N_Q \times N_Q)$

tree level superpotential:

$$W_{\text{tree}} = \lambda S Q \tilde{Q} + m_P P \tilde{P}$$

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The only mass scale

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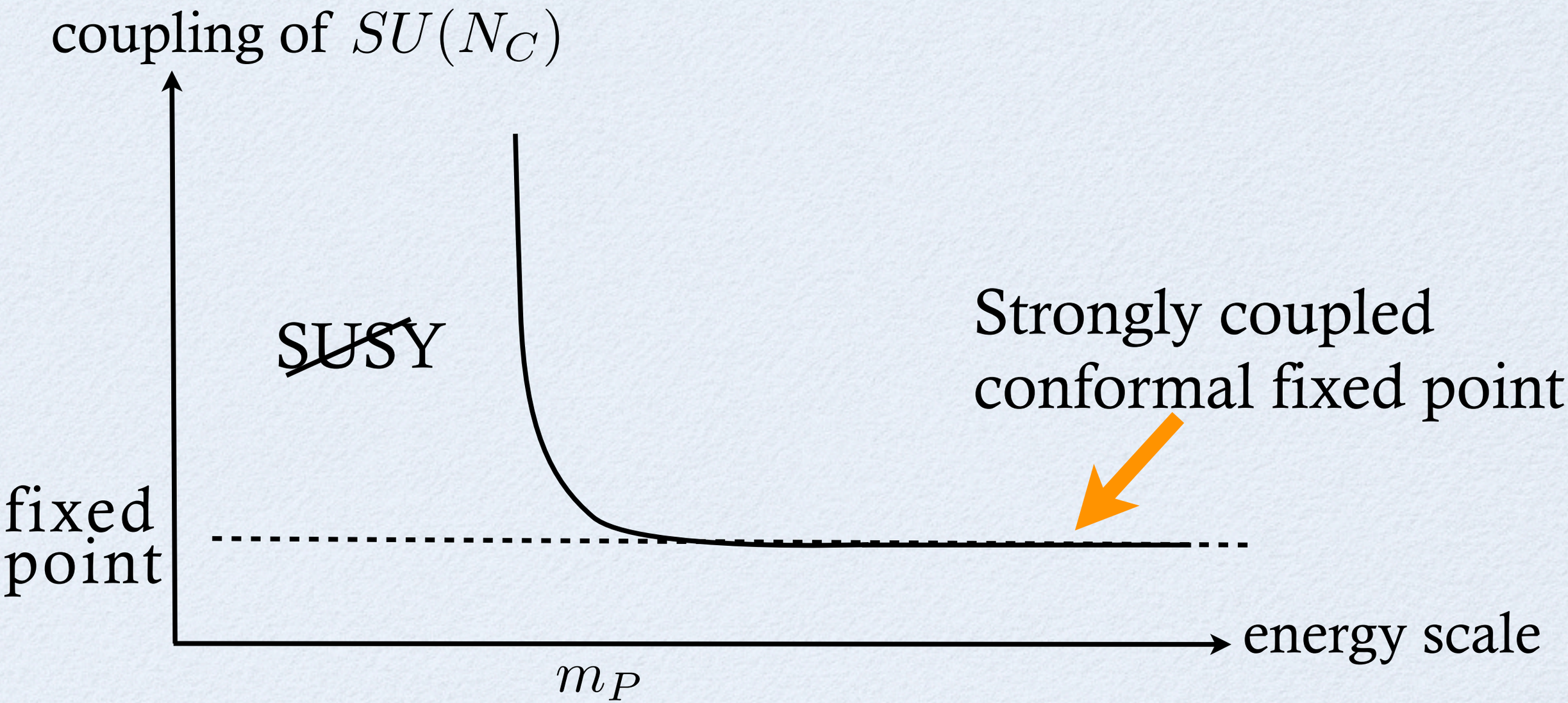


SUSY is dynamically broken at the scale m_P

$$\Lambda \sim m_P$$

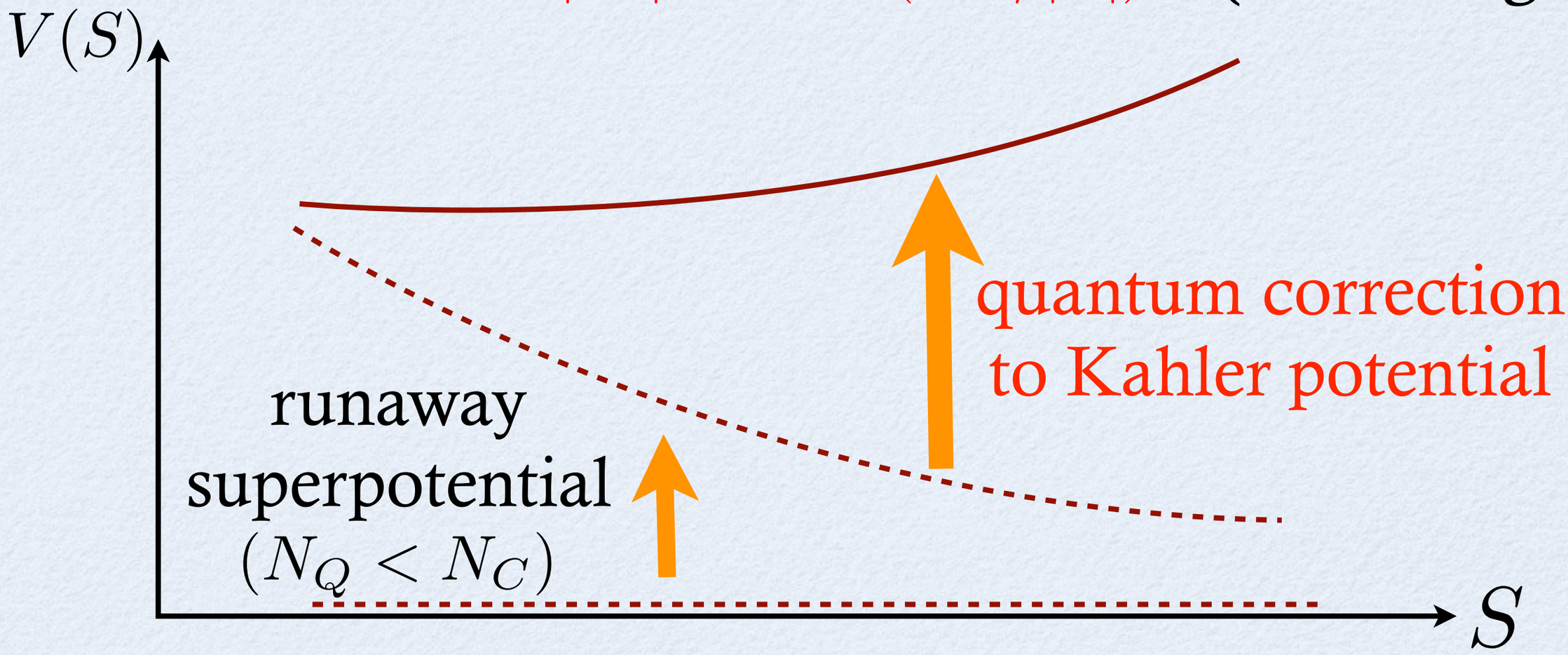
Model (SUSY breaking)

<u>SUSY breaking mechanism</u>

In the region $|S| \gg m_P$

$$\begin{cases} W_{\text{eff}} \propto S^{N_Q/N_C} \\ K_{\text{eff}} \propto |S^2|^{1/\Delta} + \mathcal{O}(m_P/|S|) \end{cases}$$

(Δ :scaling dim.)



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$P, \tilde{P}$: Bi-fundamental of $SU(N_C)_{\text{gauge}} \times SU(N_P)_{\text{flavor}}$

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$SU(N_P) \to SU(5)_{\text{GUT}}$

$(N_P = 5)$

:gauge mediation

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$P, \tilde{P}$: Bi-fundamental of $SU(N_C)_{\text{gauge}} \times SU(N_P)_{\text{flavor}}$

$N_C = 4$: No Landau pole problem of the SM gauge coupling

$SU(N_P) \to SU(5)_{\text{GUT}}$
$(N_P = 5)$
:gauge mediation

Model (Dark matter)

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- Hidden sector accidental "baryon" symmetry $U(1)_{\rm hid}$

quarks	$Q, P : +1$
anti-quarks	$\tilde{Q}, \tilde{P} : -1$
singlets	$S : 0$

The lightest particle charged under $U(1)_{\rm hid}$ is stable.

→ Dark matter candidate

Summary

- Strongly coupled SUSY breaking sector with a single mass scale $\Lambda \sim 100\ \mathrm{TeV}$ is very attractive !
- We have constructed an explicit model.

SUSY breaking sector with $\Lambda \sim 100\ \mathrm{TeV}$

→ MSSM soft masses

→ No gravitino problems

→ Strongly coupled thermal relic dark matter