Single Scale SUSY Breaking, Gauge Mediation, and Dark Matter

Kazuya Yonekura (U.Tokyo)

based on works:

- Phys.Rev.D81:125017,2010
- Phys.Lett.B693:281,2010

with T.T.Yanagida

Introduction

Gauge Mediation

An attractive scenario to mediate SUSY breaking to the MSSM sector

Introduction

Some drawbacks of gauge mediation:

- Absence of thermal relic dark matter
- Cosmological gravitino problems
- Artificial messenger sector

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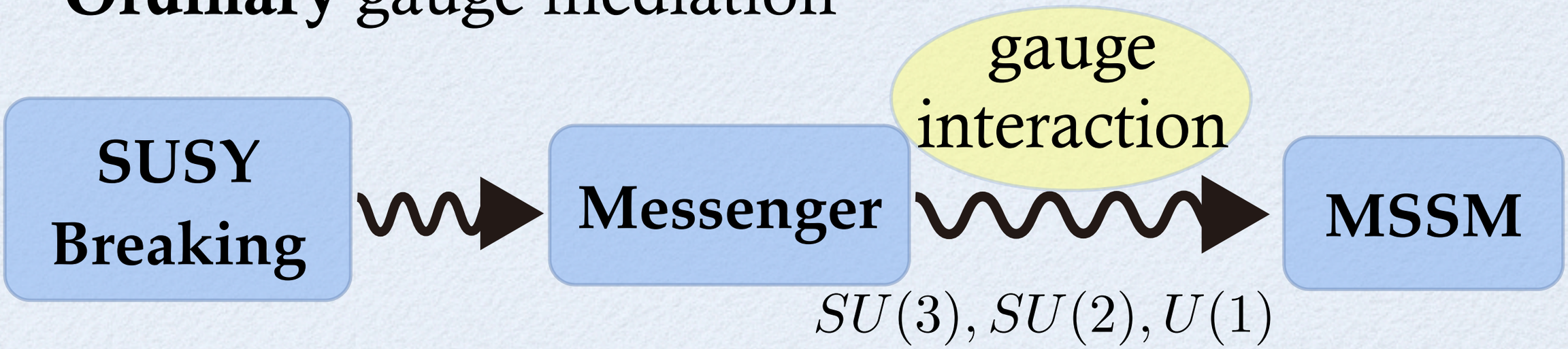
We attempt to solve these problems by:

Low Scale Direct Gauge Mediation

Low Scale Direct Mediation

Theoretical elegance

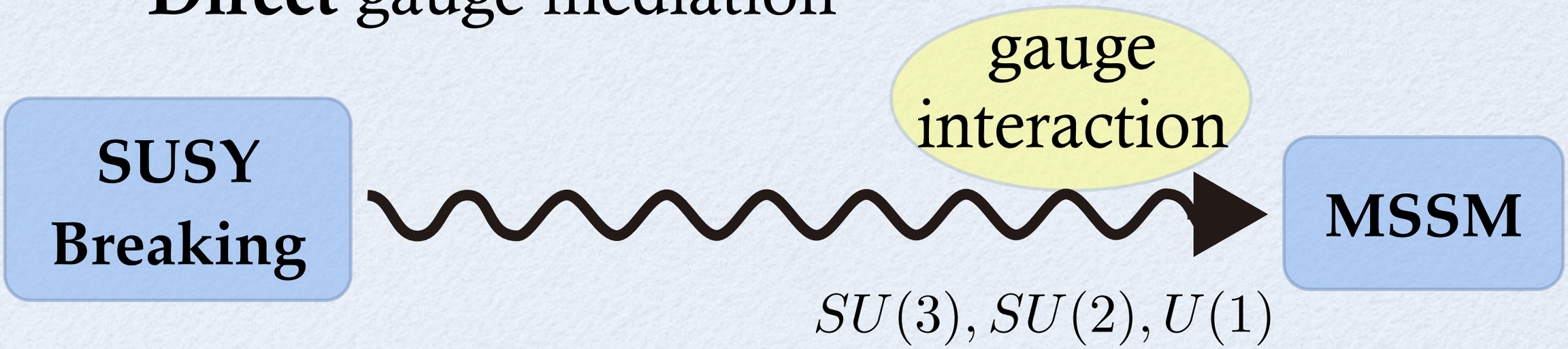
Ordinary gauge mediation



Low Scale Direct Mediation

Theoretical elegance

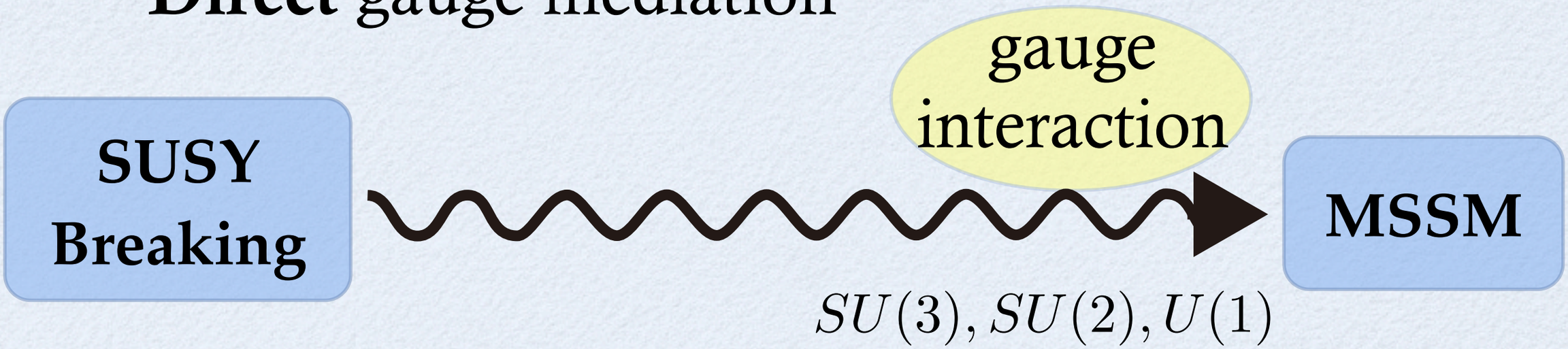
Direct gauge mediation



Low Scale Direct Mediation

Theoretical elegance

Direct gauge mediation



We need only a single SUSY breaking scale : Λ

(We assume this.)

Low Scale Direct Mediation

Phenomenological Advantages

SUSY breaking scale
$\Lambda \sim 100$ TeV

MSSM soft mass

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

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Free from gravitino problem
$m_{3/2} < 16$ eV [Viel et al., 2005]

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

Low Scale Direct Mediation

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

SUSY breaking sector with $\Lambda \sim 100$ TeV

→ MSSM soft mass

→ No gravitino problem

→ Strongly coupled thermal relic dark matter

We want to construct a model realizing this scenario.

Model

Model (SUSY breaking)

The SUSY breaking model

[Izawa,Takahashi,Yanagida,KY,2009]

$SU(N_C)$ gauge theory

matter:

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

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

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tree level superpotential:

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

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tree level superpotential:

The only mass scale

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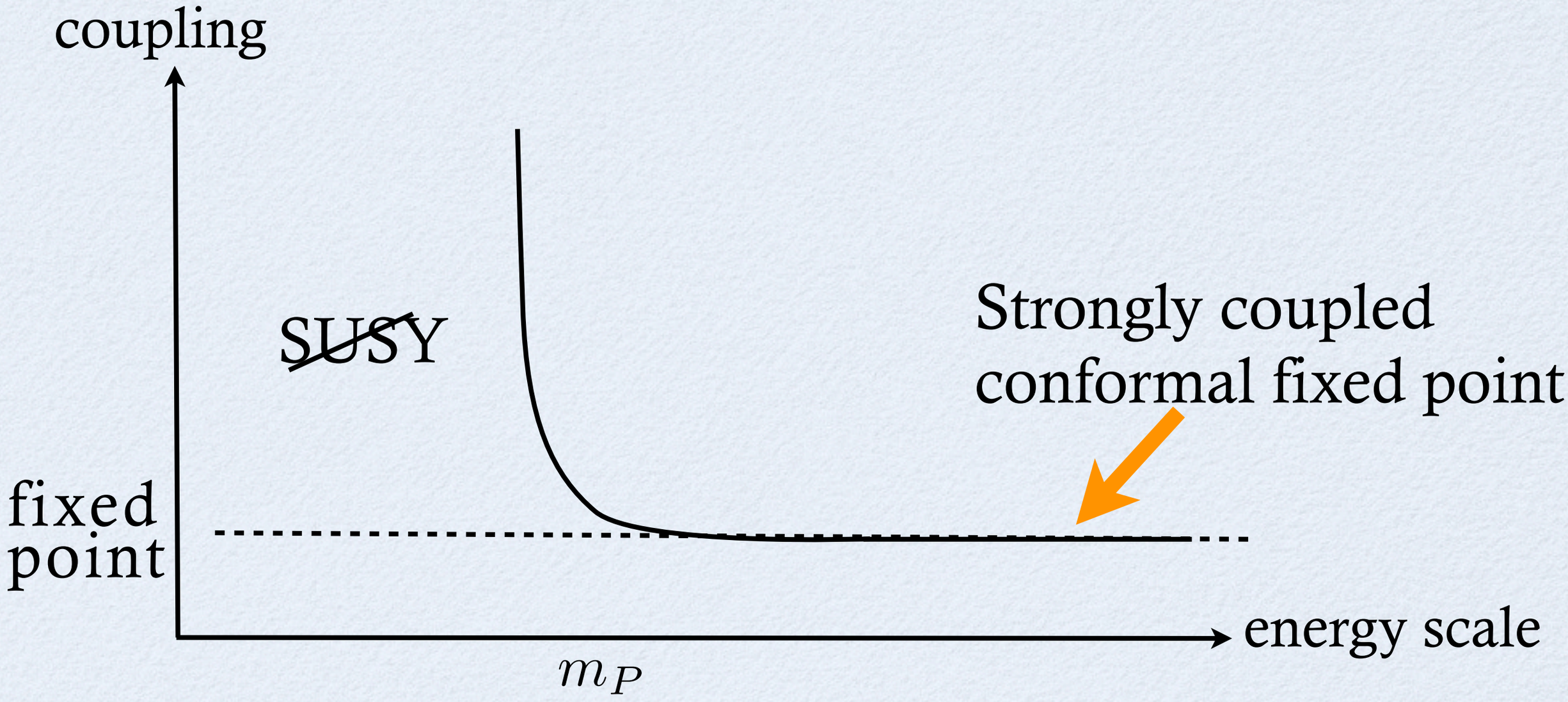

SUSY is broken at the scale m_P

Model (Gauge mediation)

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

$(N_P = 5)$

:gauge mediation

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singlet: $S \quad (N_Q \times N_Q)$

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

$N_C = 4$: no Landau pole problem

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

$(N_P = 5)$

:gauge mediation

Model (Dark matter)

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

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

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quarks	$Q, P : +1$
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singlets	$S : 0$

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

→ Dark matter candidate

Summary

- Direct gauge mediation with a single mass scale is very attractive.

Strongly coupled SUSY breaking sector with $\Lambda \sim 100$ TeV

→ MSSM soft mass

→ No gravitino problem

→ Strongly coupled thermal relic dark matter

- We have constructed a model realizing the above scenario.