Direct Detection of the Wino- and Higgsino-like Neutralino Dark Matters at One-Loop Levels

Osamu Saito
ICRR,University of Tokyo

Collaborated with
Junji Hisano (ICRR,University of Tokyo)
Shigeki Matsumoto (ICRR,University of Tokyo)
Mihoko Nojiri (YITP Kyoto University)

Papers
Phys.RevD71;015007,2005
hep-ph/0407168

Introduction

WMAP confirmed the existence of Cold Dark Matter

$$\Omega_m \sim 0.3$$
$$\Omega_B \sim 0.044$$
$$\Rightarrow 0.094 \leq \Omega_{CDM} h^2 \leq 0.129$$

Neutralino is one of the favored candidate of CDM

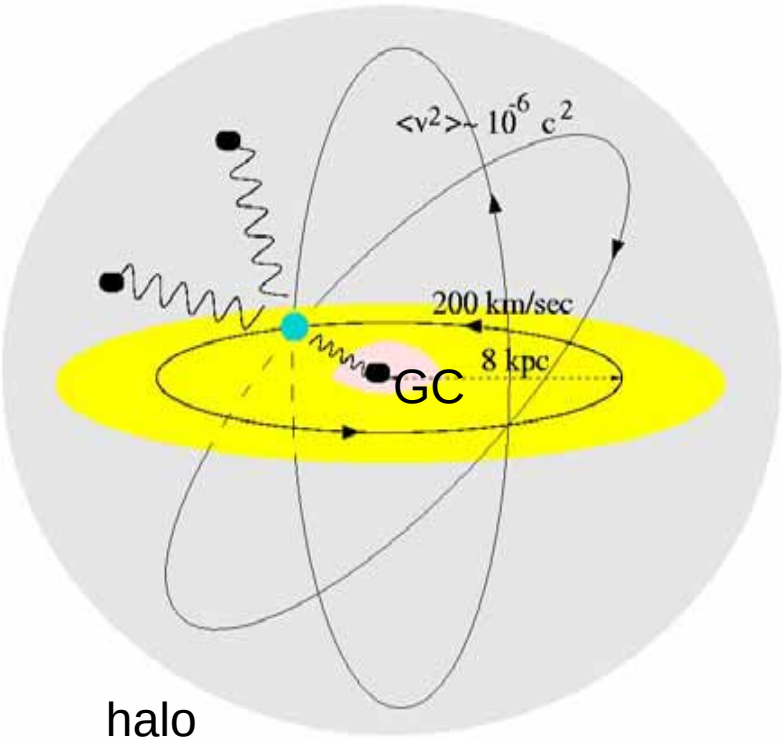
stable due to R-Parity conservation

Direct Detection of Neutralino

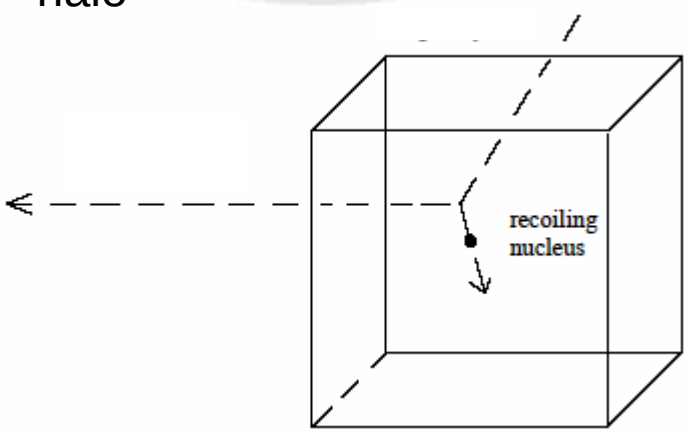
The content of this work is following;

For pure gaujino or pure higgsino- neutralino ,
the direct detection rate at tree level is suppressed.
In such a case, we evaluated one loop corrections.

Direct Detection of Dark Matter



halo



Target crystal

Neutralinos form halo

They scatter on material
in a detection on the Earth

We can detect DM
by observing the recoil energy
(Direct Detection)

Neutralino – nucleus
cross section is needed

Neutralino – proton cross section

Spin-Independent (S.I)

$$L_{S.I} = \alpha_q \bar{\chi}\chi\bar{q}q$$

$$\downarrow$$

$$L = f_p \bar{\chi}\chi\bar{p}p$$

$$\downarrow$$

$$\sigma_{S.I} = \frac{4}{\pi}\left(\frac{m_\chi m_p}{m_\chi + m_p}\right)^2 f_p^{\,2}$$

Spin-Dependent (S.D)

$$L_{S.D} = d_q \bar{\chi}\gamma^\mu\gamma_5\chi\bar{q}\gamma_\mu\gamma_5 q$$

$$\downarrow$$

$$L_{spin-spin} = 4A_p \vec{S}_\chi \bullet \vec{S}_p$$

$$\downarrow$$

$$\sigma_{S.D} = \frac{12}{\pi}\left(\frac{m_\chi m_p}{m_\chi + m_p}\right)^2 A_p^{\,2}$$

The nature of neutralino

arise in SUSY model

a linear combination of gauginos and neutral higgsino

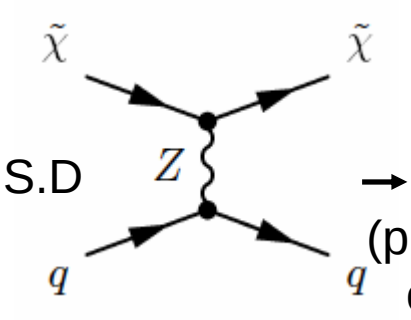
$$\tilde{\chi}_1^0 = N_{11}\tilde{B}^0 + N_{12}\tilde{W}^0 + N_{13}\tilde{H}_1^0 + N_{14}\tilde{H}_2^0$$

(Wino..... SU(2) triplet , Higgsino ..... SU(2) doublet)

stable (R-Parity conservation) $\longrightarrow$ Dark matter

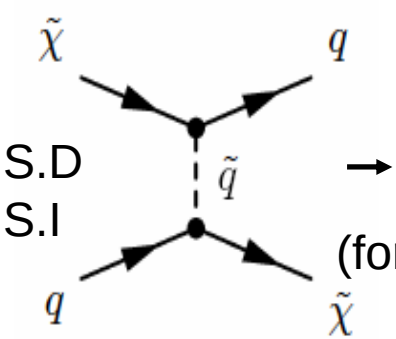
Wino- like (Anomaly mediation model)
Higgsino- like (in focus point region of mSUGRA model)

$\tilde{\chi}$-p cross section at tree level



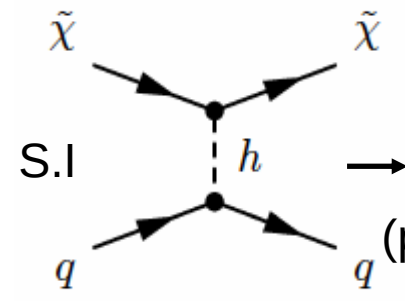
S.D → suppressed (pure gaugino or higgsino)

Z exchange



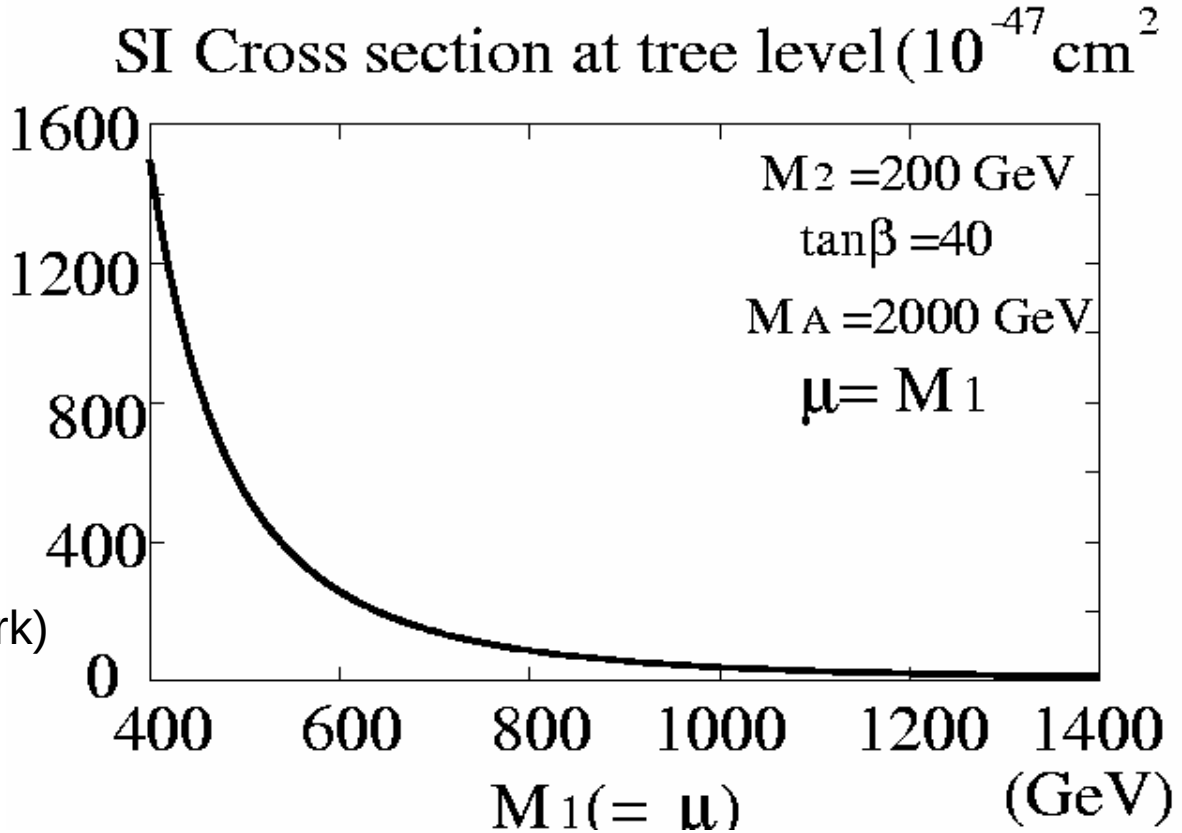
S.D → suppressed
S.I (for heavy squark)

Squark exchange



S.I → suppressed (pure gaugino or higgsino)

Higgs exchange



Tree level can be suppressed

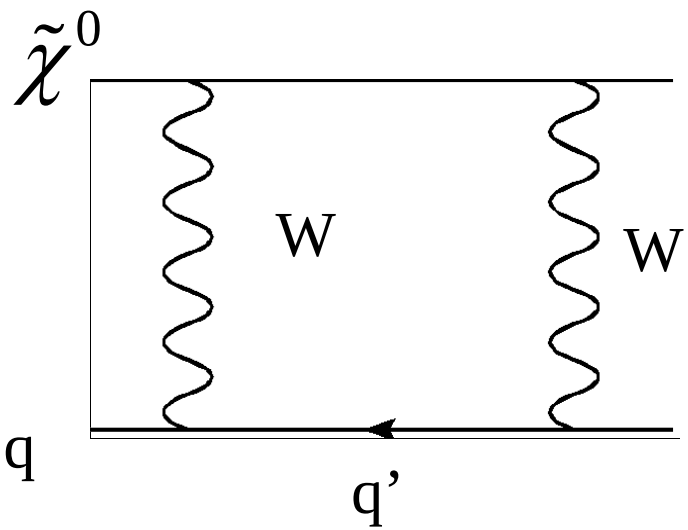
↓

We have to evaluate

One- loop order cross section

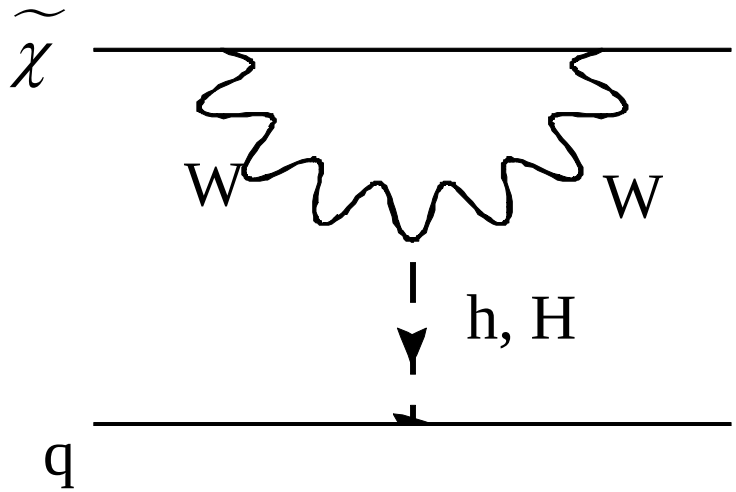
Feynman diagram at one loop level

W boson box diagram



$$\propto \frac{m_q}{m_W{}^3}$$

Higgs vertex correction

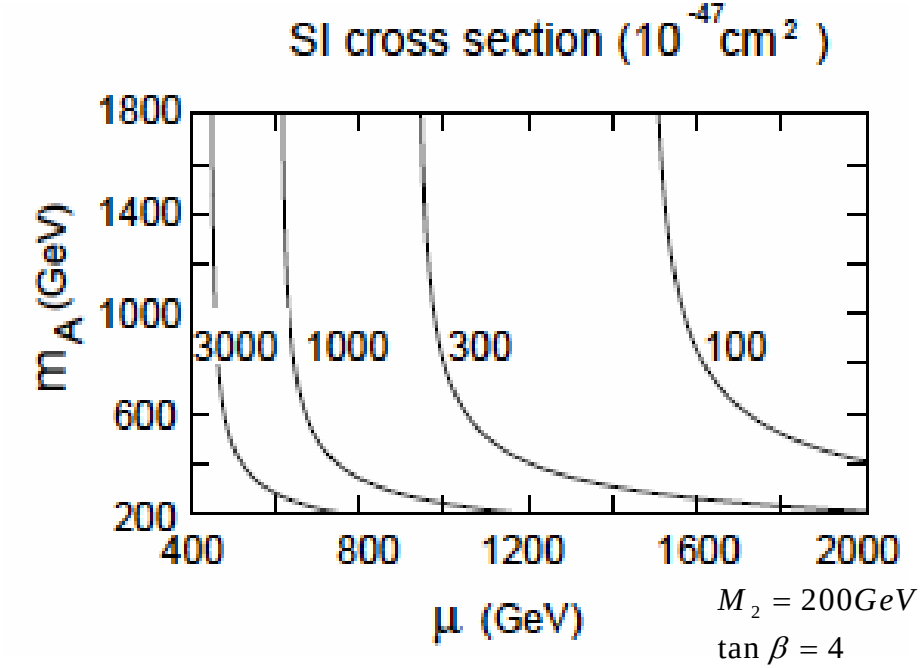


$$\propto \frac{m_q}{m_W m_h{}^2}$$

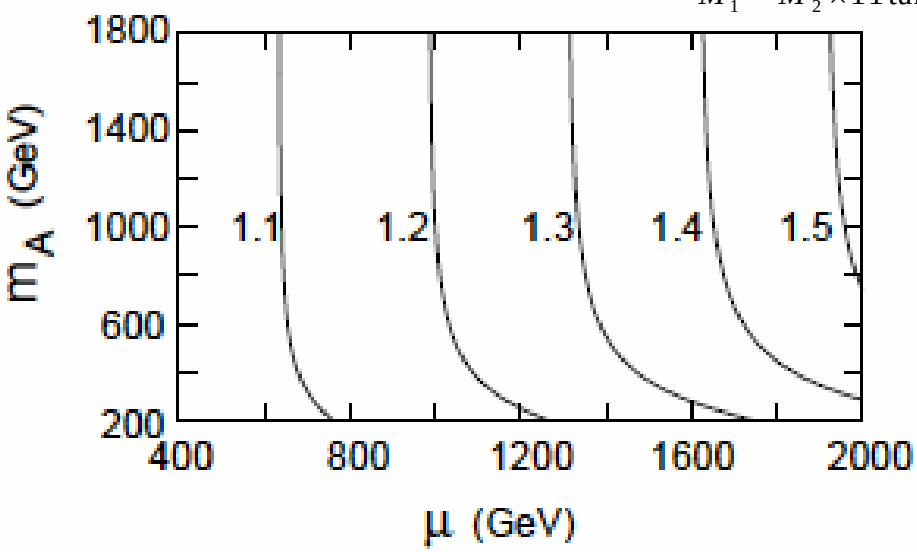
If $m_A \to \infty$

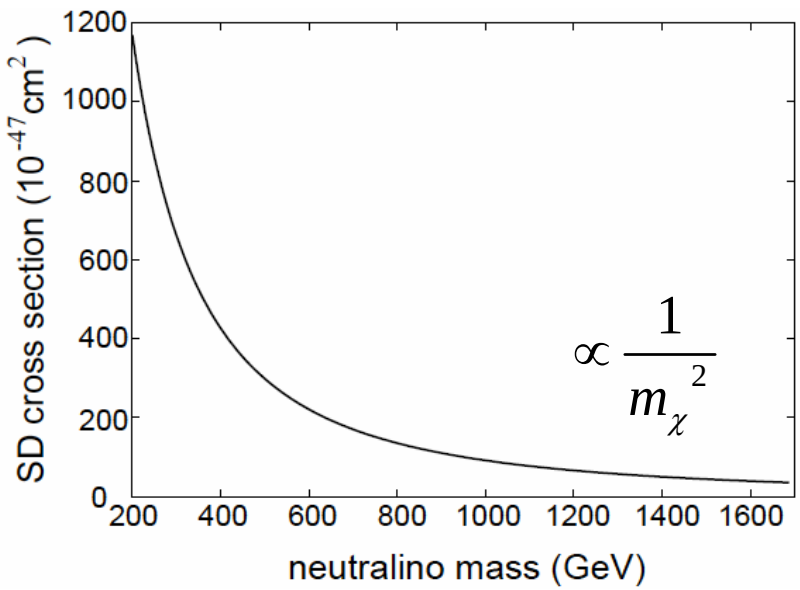
the above amplitudes are not sensitive to $\tan\beta$

Result of numerical calculation (Wino)



$M_2 = 200GeV$
$\tan\beta = 4$
$m_h = 114GeV$
$M_1 = M_2 \times 11\tan^2\theta_W$





$\sigma_{S.I} \to \neq 0 (m_{SUSY} \to \infty)$

$\sim 10^{-47}\, cm^2$ (Wino)

$\sim 10^{-48}\, cm^2$ (Higgsino)

Experiments
for future Direct Detection

CDMS ZEPLIN
CRESST ⋮

Summary

We consider direct detection of neutralino dark matter.

If neutralino is pure gaugino or higgsino, neutralino – proton cross section at tree level is very small.

We evaluated the neutralino – proton cross section at one loop level ,and obtained a reliable cross section.

S.I cross section isn't suppressed
even if supersymmetric mass scale is large.
We obtain lower limit of S.I cross section.