Asymmetric Dark Matter and Sneutrino Inflation
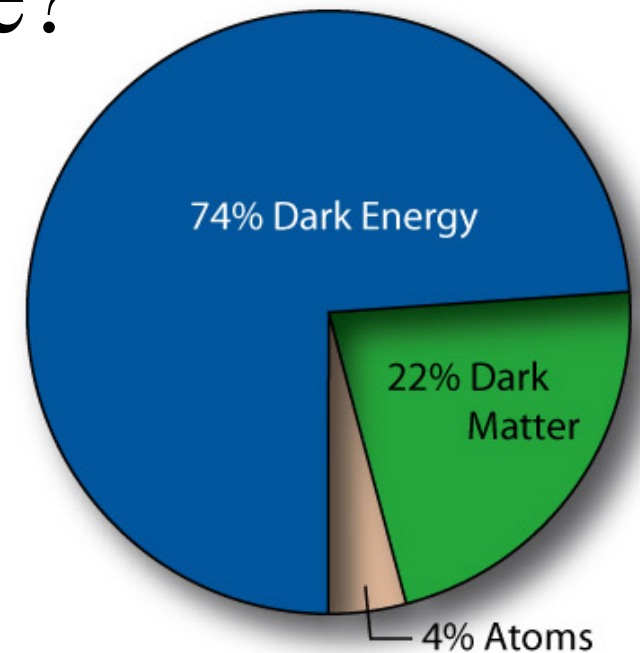
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Introduction

What is the origin of the baryon asymmetry in the Universe?

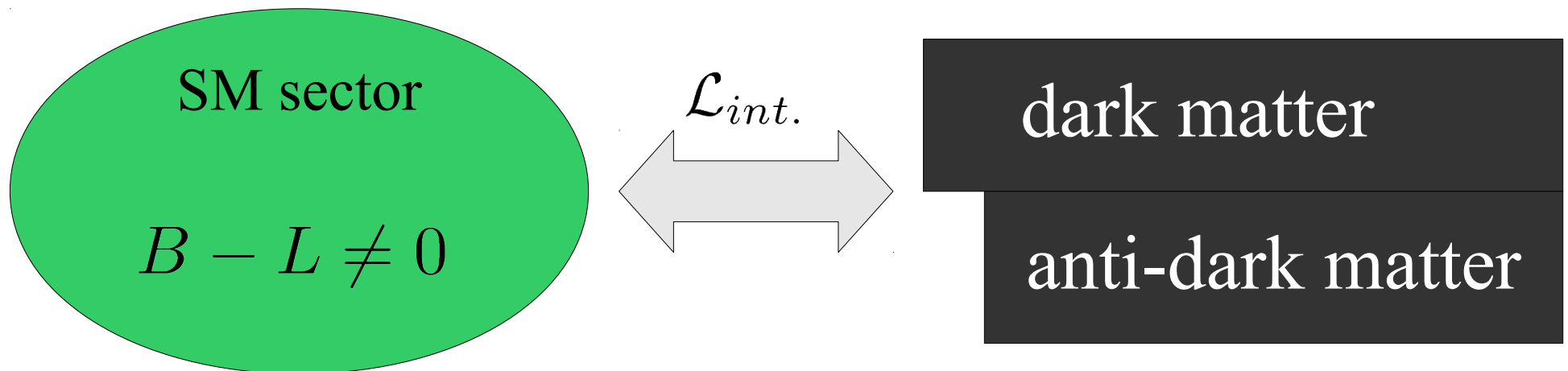What is the origin of the dark matter?

[NASA/WMAP Science Team]

Why the amount of the baryon and the dark matter is closed?

Asymmetric Dark Matter

[Kaplan, Luty and Zurek (2009)]

$$\mathcal{L} = \mathcal{L}_{\mathrm{SM}} + \mathcal{L}_{\mathrm{DM}} + \mathcal{L}_{int.}$$

$\mathcal{L}_{int.}$ enforces the (anti-)dark matter have non-zero **B-L** charge.

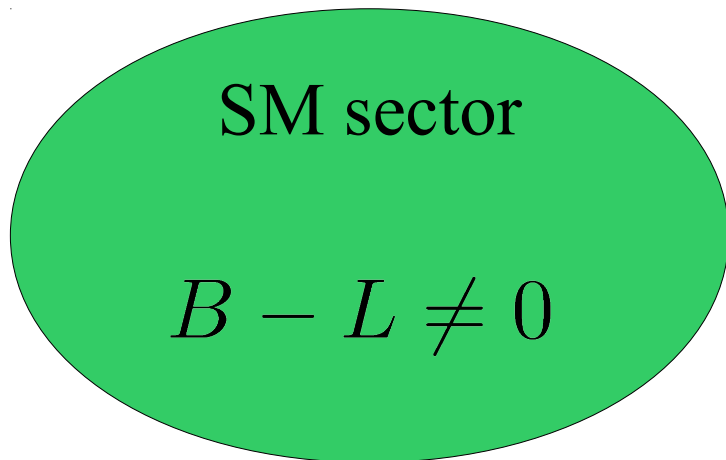The **dark matter** number is generated
by non-zero **B-L** number.

Asymmetric Dark Matter

[Kaplan, Luty and Zurek (2009)]

$$\mathcal{L} = \mathcal{L}_{\text{SM}} + \mathcal{L}_{\text{DM}} + \mathcal{L}_{int.}$$

$\mathcal{L}_{int.}$ enforces the (anti-)dark matter have non-zero **B-L** charge.

dark matter

SM sector

$B - L \neq 0$

annihilated

As the temperature of the universe become low, the dark matter number is fixed.
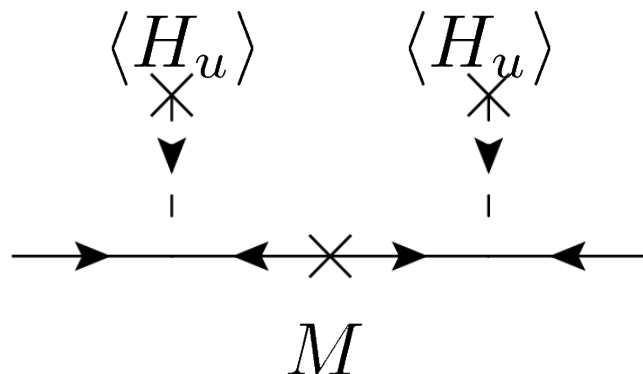
Sneutrino Inflation

[Murayama, Suzuki, Yanagida and Yokoyama (1993)]

MSSM + Right-handed neutrino & sneutrino

$$W = W_{\text{MSSM}} + y_{ij} N_i L_j H_u + \frac{1}{2} M_i N_i^2$$

Right-handed sneutrino with small Yukawa couplings acts as **the inflaton**!
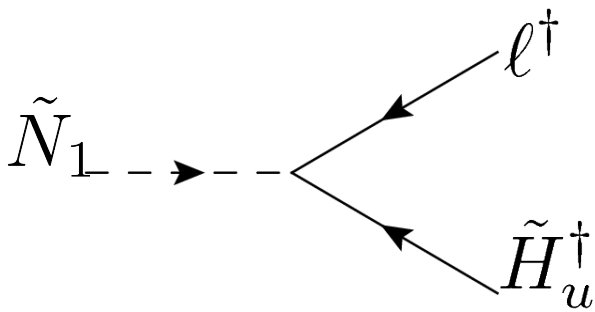
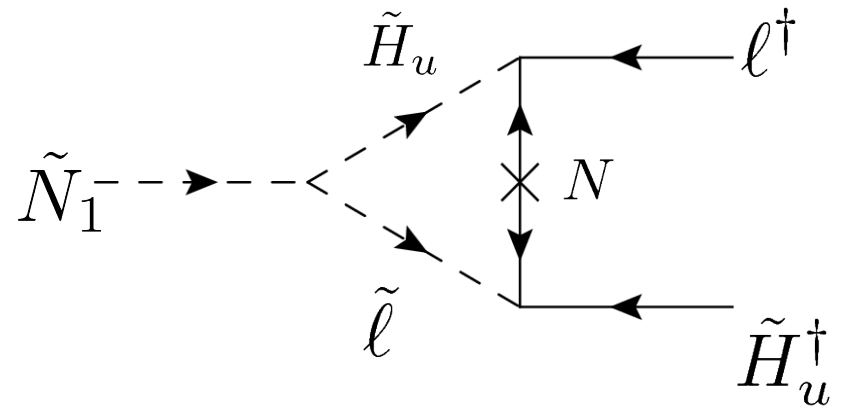The see-saw mechanism leads to **neutrino mass** and **mixing**.

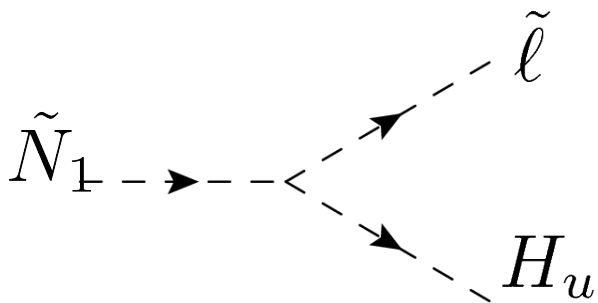# Sneutrino Inflation

Decay of Right-handed Sneutrino

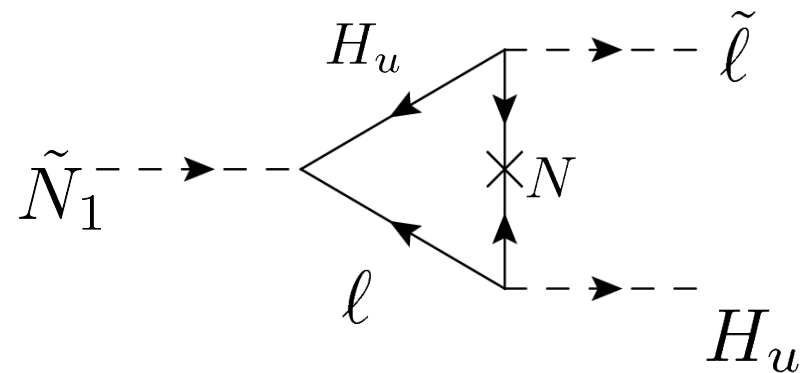$$\tilde{N}_1 \rightarrow \ell^\dagger \tilde{H}_u^\dagger$$

$$\tilde{N}_1 \rightarrow \tilde{\ell} H_u$$

Asymmetric Dark Matter
transmits...

B-L to <u>**dark matter**</u>

Sneutrino inflation
leads to....

Inflation
Neutrino mass & mixing
B-L **number asymmetry**

Can we combine
"**Asymmetric Dark Matter**" and
"**Sneutrino Inflation**" successfully ?

$$\begin{cases} n_B/s \simeq 8 \times 10^{-11} \\ \Omega_{DM}/\Omega_B \simeq 5 \end{cases}$$

Our setup

NMSSM (MSSM+singlet)

+ right-handed neutrino & sneutrino

+ dark matter & anti-dark matter

$X, \bar{X}$: (anti-) Dark matter

S : Singlet in NMSSM

$$W = W_{\mathrm{NMSSM}} + \lambda S H_u H_d + \kappa' S X \bar{X}$$

$$+ \frac{M}{2} N_i^2 + y_{ij} N_i L_j H_u + \frac{\kappa_i}{2} N_i \bar{X}^2$$

$$+ m_X X \bar{X}$$

Our setup

NMSSM (MSSM+singlet)

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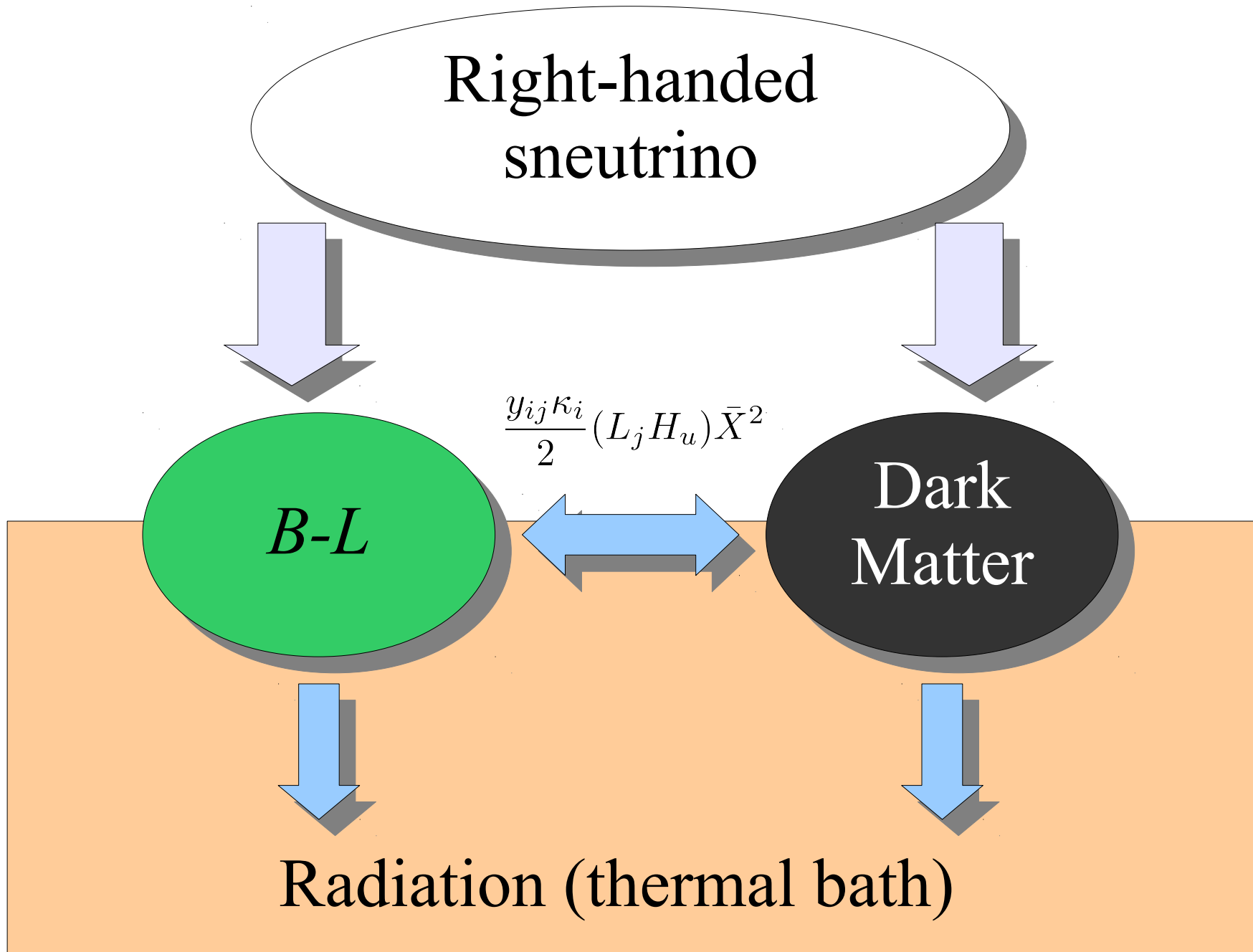
Dark Matter annihilation

$$+ \frac{M}{2} N_i^2 + y_{ij} N_i L_j H_u + \frac{\kappa_i}{2} N_i \bar{X}^2$$
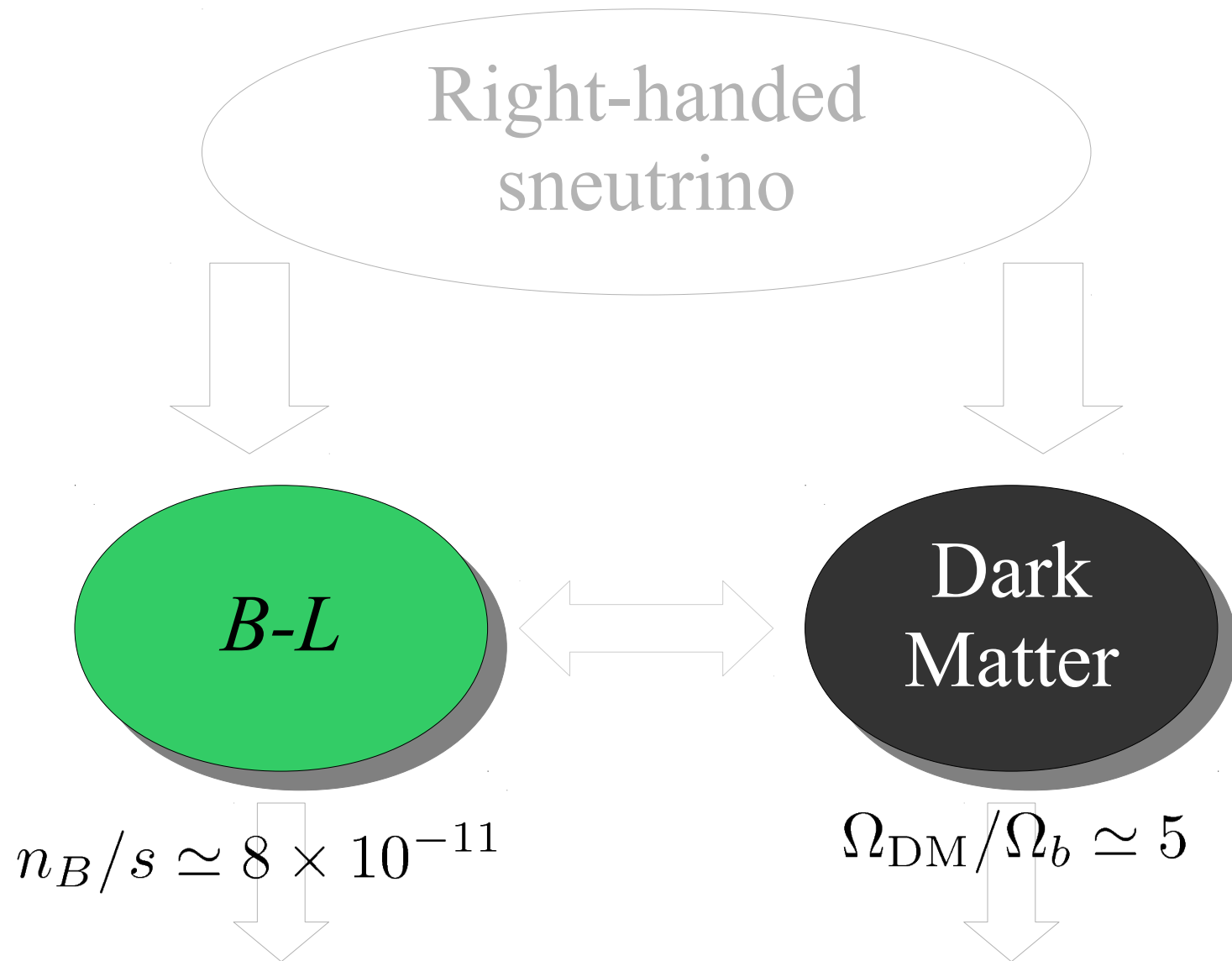
$$+ m_X X \bar{X}$$

$$\boxed{\frac{y_{ij}\kappa_i}{2} (L_j H_u) \bar{X}^2}$$

Dark matter production

Thermal history of the Universe in our model

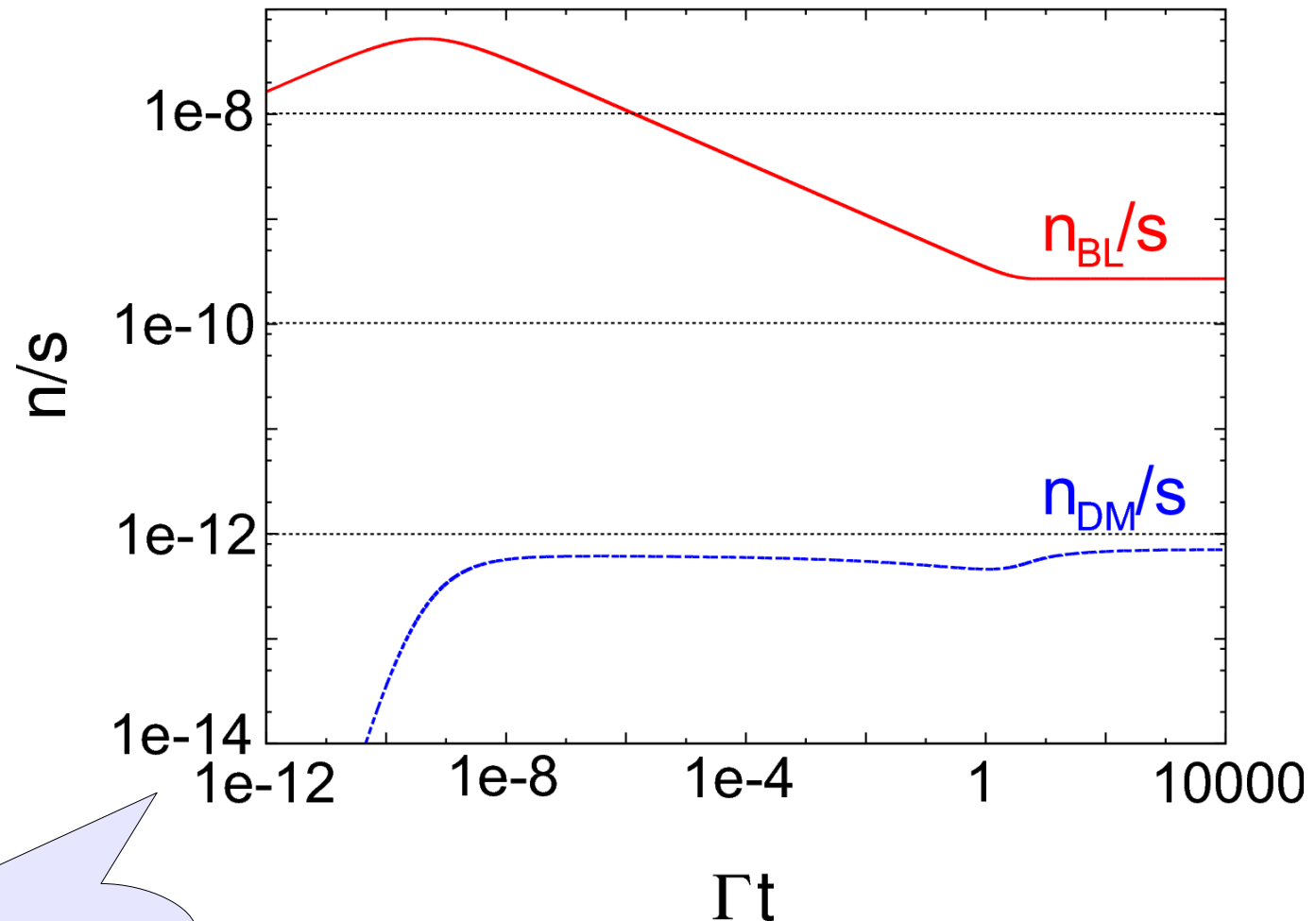# Thermal history of the Universe in our model

Thermal history of the Universe in our model

$M = 10^{13} \text{ GeV}$
$T_{\text{RH}} = 2 \times 10^{10} \text{ GeV}$

$\epsilon_{BL} = 1.0 \times 10^{-7}$
$\epsilon_{DM} = 0$

$y_{33} = 0.14$
$\kappa_3 = 0.70$

$m_X = 550 \text{ GeV}$

$\Omega_{DM}/\Omega_B = 5$

N. Haba, S. Matsumoto and RS [arXiv : hep-ph/1101.5679]

Conclusion

The dark matter density today is close to the baryon density. This facts suggests they have **a common origin**.

We have constructed the model which can realize **inflation** and **appropriate relic abundance** of **baryon** and **dark matter** simultaneously.