# Asymmetric dark matter @ ILC


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Among several experiments, the ILC will be the most sensitive one to test the Asymmetric dark matter scenario.

# BSM evidences & DM stability

**Experiments**

Higgs (126GeV)
No BSM signals
Standard cosmos

→

**Clear evidences for BSM**

Neutrino masses & mixings
Baryon asymmetry of Universe
Existence of dark matter

**1st & 2nd evidences**

First two evidences can be simultaneously explained by introducing heavy right-handed neutrinos. (Seesaw mechanism & Leptogenesis)

↓

Existence of $U(1)_{B-L}$ gauge symmetry broken at some high scale!

**3rd evidence**

What is the dark matter? → DM will be a neutral stable particle.

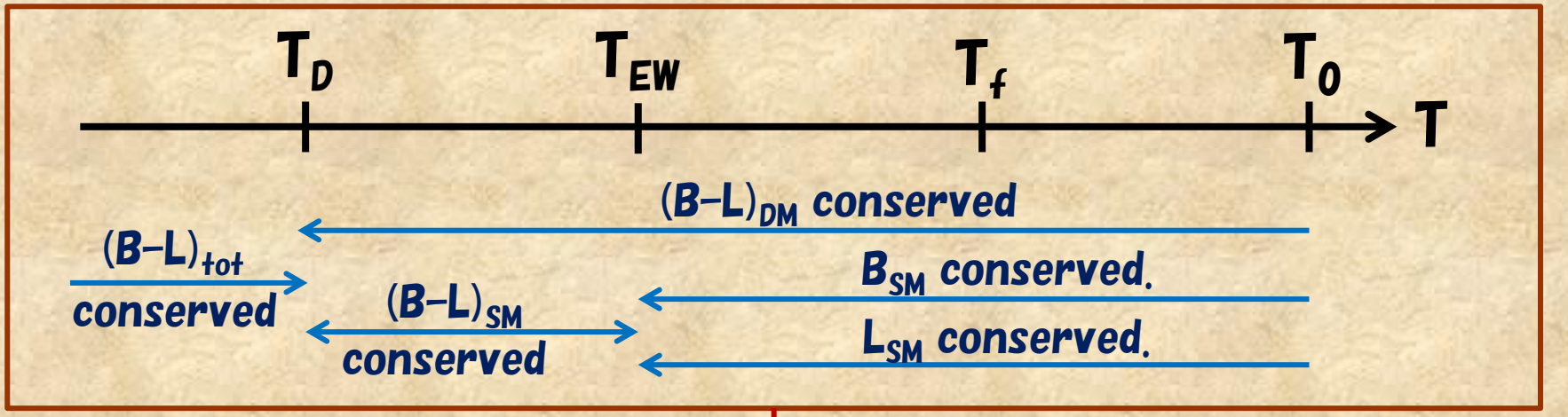
But why is it stable? → Because of a Residual symmetry of $U(1)_{B-L}$.

↓

Since the SM involves only B-L odd fermions & B-L even bosons,

a new fermion w/ even B-L or a new boson w/ odd B-L is stable!
It is also OK to consider a new particle with fractional B-L charge.

# DM carrying B−L charge = ADM




From detailed balance among chemical potentials of SM particles and DM

$$\frac{(\mathrm{B}-\mathrm{L})_{\mathrm{SM}}}{(\mathrm{B}-\mathrm{L})_{\mathrm{DM}}} = \frac{79}{22\,Q_{\mathrm{DM}}^2} \quad \Rightarrow \quad m_{\mathrm{DM}} = \frac{30}{97}\frac{79}{22}\frac{\Omega_{\mathrm{DM}}}{\Omega_b}\frac{m_N}{Q_{\mathrm{DM}}} \simeq \frac{5.7\,\mathrm{GeV}}{Q_{\mathrm{DM}}}$$

This result **does not depend on** the details of ADM interactions!

**Scalar ADM particle**

**Severely constrained** by old neutron star observations.
∵ ADM has $|\phi|^2|H|^2$ interaction.

**Fermionic ADM particle**

No renormalizable interaction.
→ Introduce a light particle.
→ **Affecting low energy phys.**

# Minimal model for the fermionic ADM

$$\mathcal{L} = i\overline{\chi}\left(\partial\!\!\!/ - m_\chi\right)\chi + \frac{1}{2}\left[(\partial\phi')^2 - m_{\phi'}^2\phi'^2\right] - \kappa\,\overline{\chi}\chi\phi' - V(H',\phi')$$

$$h = (\cos\alpha)\,h' - (\sin\alpha)\,\phi' \quad \& \quad \phi = (\sin\alpha)\,h' + (\cos\alpha)\,\phi'$$

Phenomenologically important parameters are the following:

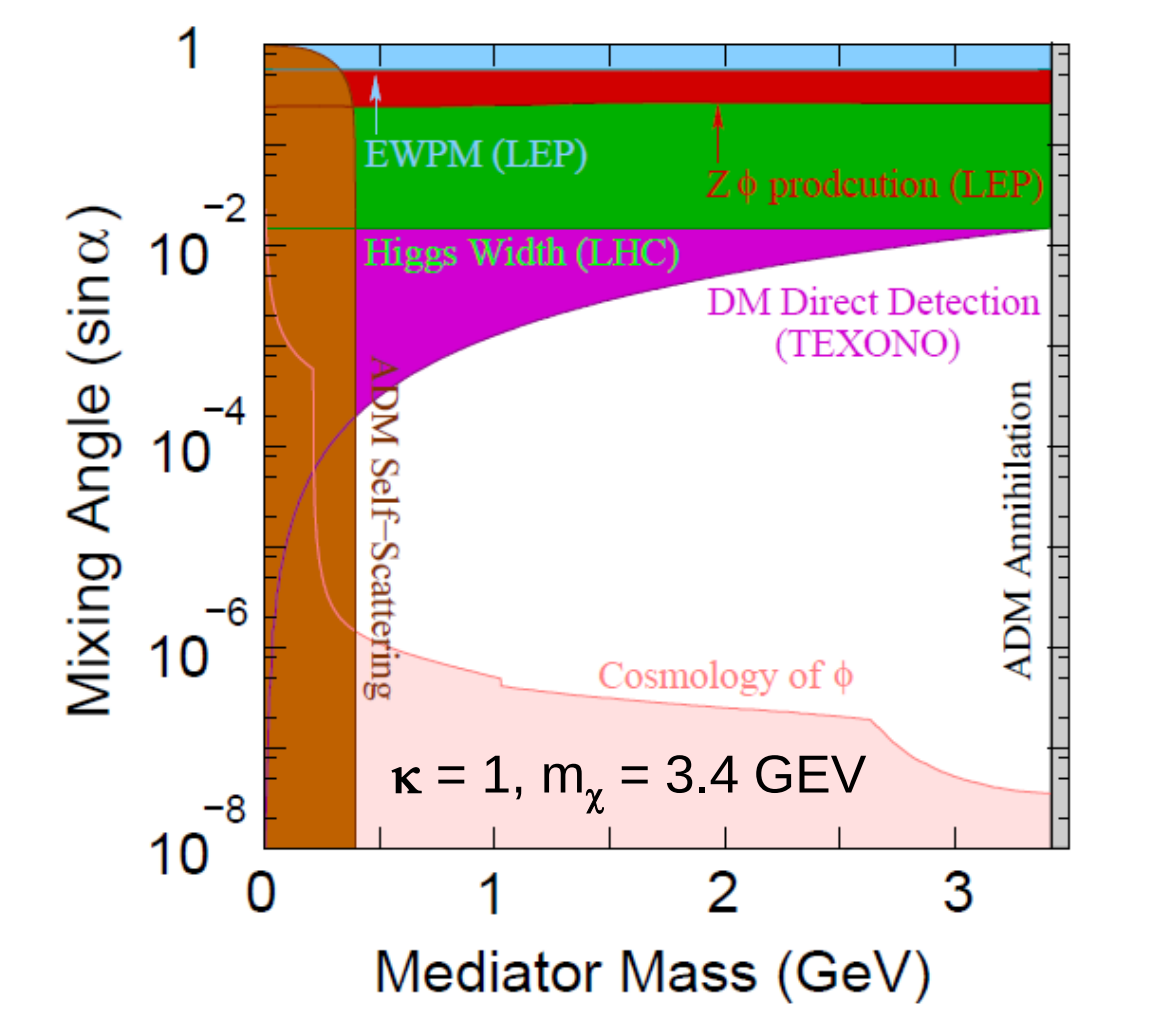
① **ADM mass($m_\chi$):**
As sample point, **3.4GeV**, (which is corresponding to $Q_{DM} = 5/3$)

② **Mediator mass ($m_\phi$):**
Focusing on the parameter region $m_\chi > m_\phi$, where $\chi\chi \to \phi\phi$ dominates annihilation between dark and anti-dark matters.

③ **ADM coupling ($\kappa$):**
In order to eliminate the symmetric component of the ADM, $\kappa > 0.1$ for $m_\chi = 3.4$ GeV, we take $\kappa = 1$ as a sample point.

④ **Mixing ($\sin\alpha$):** Controlling between ADM and SM sectors

# Current Limits on the Fermionic ADM

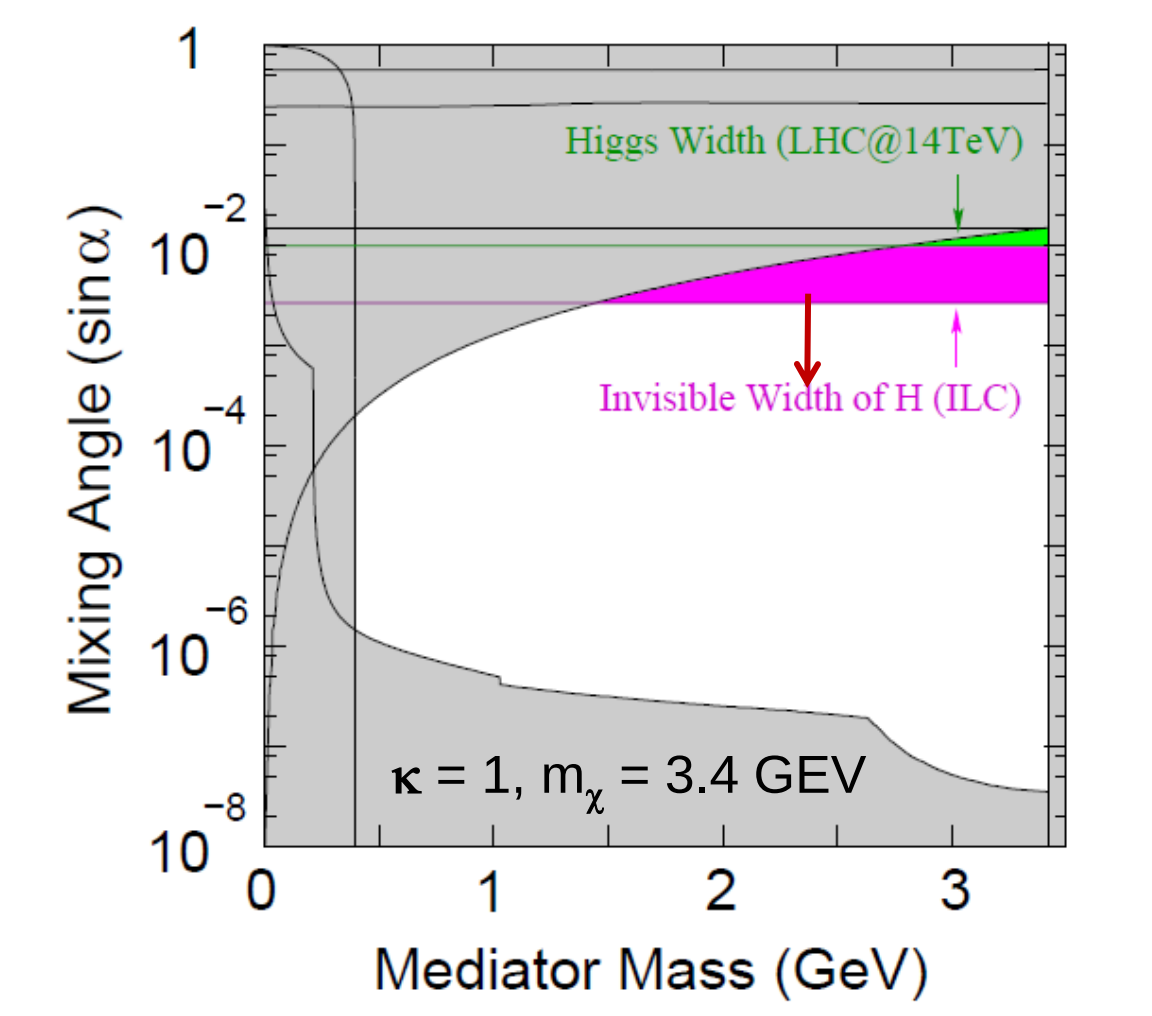



DM direct detection (TEXONO) gives the most sever limit on sin $\alpha$.

Theoretically, sin $\alpha$ is expected to be $O(m_\phi/m_h) = 10^{-2} - 10^{-3}$ .

# Future Prospects on the Fermionic ADM






**Higgs invisible width search at the ILC will be the most sensitive one.**
**(0.7% accuracy on the invisible branching ratio! [Ishikawa's talk])**

# Summary

- **B-L charged DM** is interesting for its stability is guaranteed by a residual symmetry of $U(1)_{B-L}$. The dark matter is nothing but the Asymmetric DM!

- Fermionic ADM requires the introduction of **a light mediator**, which affects various low energy physics. In the minimal model, the mediator is the scalar.

- Currently, the DM direct detection gives the most sever limit on its model parameter space. In future, searching **the invisible branching ratio of the higgs boson** at the international linear collider (ILC) will be the most sensitive experiment to explore the ADM.