Asymmetric dark matter via Leptogenesis

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Work in collaboration with M. Blennow,
B. Dasgupta and N. Rius

Research Interests

- Neutrino phenomenology
  - Measurement of unknown neutrino parameters
  - Phenomenology of models of neutrino masses
  - Non standard neutrino interactions
- Dark Energy
  - Extracting info on the DE eos from SN and BAO
- Dark Matter

Asymmetric DM: Motivation

Baryonic Matter

baryon mass $m_B \sim 938\ \mathrm{MeV}$

matter-antimatter asymmetry:

$$\eta_B = \frac{n_B - n_{\bar{B}}}{n_\gamma} = \frac{n_B}{n_\gamma} = (6.19 \pm 0.15) \cdot 10^{-10}$$ WMAP + BBN

To give $\Omega_B = 0.0455$

Asymmetric DM: Motivation

WIMP Dark Matter

WIMP mass $m_{DM} \sim 1000\,\mathrm{GeV}$

Thermal abundance of heavy weekly interacting particle gives abundance such that:

$\Omega_{DM} = 0.227$ "WIMP Miracle"

$\frac{\Omega_{DM}}{\Omega_B} \approx 5$ but $\frac{n_{DM}}{n_B} \approx 10^{-3}$

are DM and baryon abundances and masses related?

Asymmetric DM

If DM is a Dirac fermion it can have an accidental global symmetry, DM number X, just like B and L in the SM

A DM asymmetry will be stable, like the baryon asymmetry, no need to impose R or KK parity

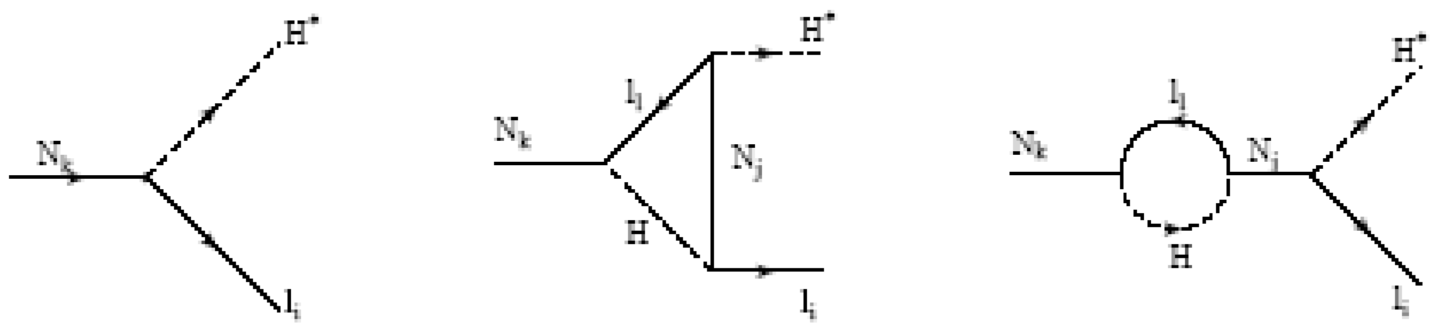
If the DM and baryon asymmetries have the same origin they can be similar, explaining the Ω_B-Ω_{DM} coincidence

typically $m_{DM} \sim 5 \text{ GeV}$

Nussinov 1985; Barr, Chivukula and Farhi 1990; Kaplan 1992; Kuzmin 1997; Kusenko 1999; Kitano and Low 2004 and 2005; Hooper, March-Russell and West 2004; Farrar and Zaharijas 2004 and 2005; Agashe and Servant 2004; Cosme, Lopez Honorez and Tytgat 2005; Suematsu 2005; Banks, Echols and Jones 2006; Page 2007; Nardi, Sannino and Strumia 2009…

Asymmetric DM via Leptogenesis

Decay of Majorana right-handed neutrino N_R produces L asymmetry



M. Fukugita and T. Yanagida 1986

SM sphaleron processes partially convert L into B conserving B-L

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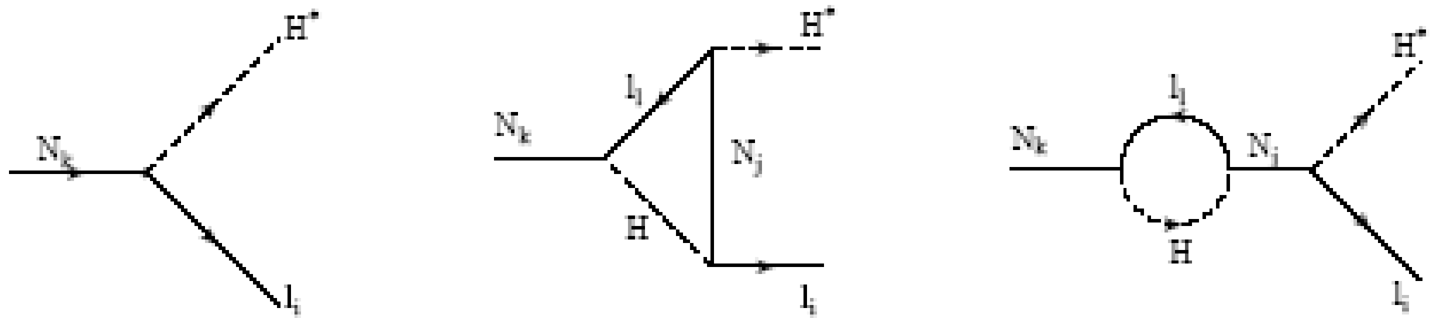

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Cant couple 5 GeV DM to SM sphalerons we need new sphalerons

Asymmetric DM via Leptogenesis

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$SU(2)_H$ is a horizontal chiral symmetry that provides new sphalerons

$SU(2)_H$ doublets:

$$\begin{pmatrix} \mu \\ e \end{pmatrix}_R \quad \begin{pmatrix} s \\ d \end{pmatrix}_R \quad \begin{pmatrix} c \\ u \end{pmatrix}_R \quad \begin{pmatrix} x_2 \\ x_1 \end{pmatrix}_R$$

N_R and x_L are singlets to prevent the Witten anomaly

Asymmetric DM via Leptogenesis

N_R is a gauge singlet → Seesaw model and L generation in its decay

$SU(2)_L$ sphalerons violate B, L and X in the direction: $\Delta B = \Delta L$, $\Delta X = 0$
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Symmetric DM component from thermal freeze out form
"dark mesons" below the $SU(3)_{DC}$ phase transition which decay into SM particles via the $SU(2)_H$ interaction

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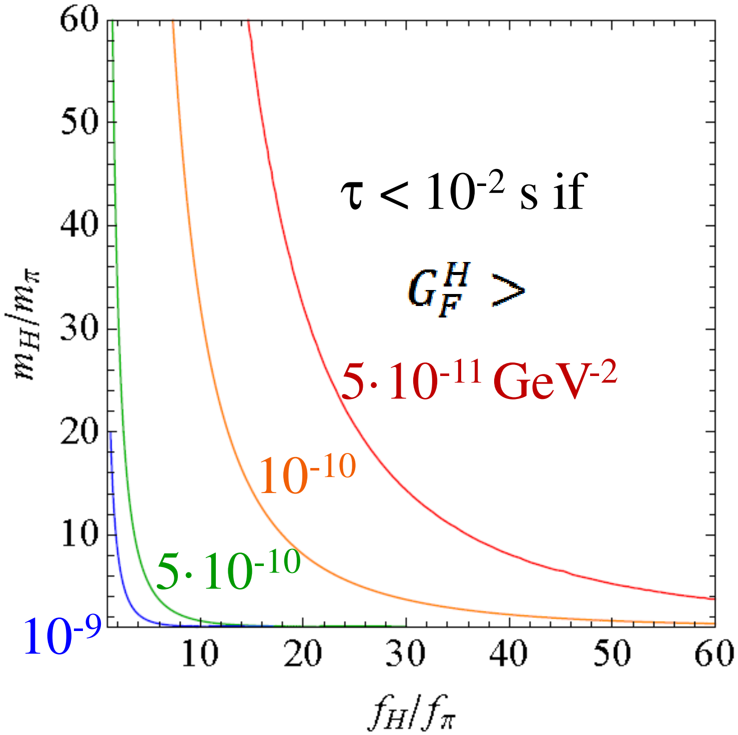
Too weak to decay before BBN, need to break the symmetry in stages or to couple mainly to 2nd and 3rd generations

Breaking the symmetry in stages

If $SU(2)_H$ symmetry broken by vev of scalar triplet along σ_3 a flavour-conserving Z′ remains massless (like Georgi-Glashow model)

Milder constraints on the mass of the Z′ → can mediate "dark mesons" decay before BBN



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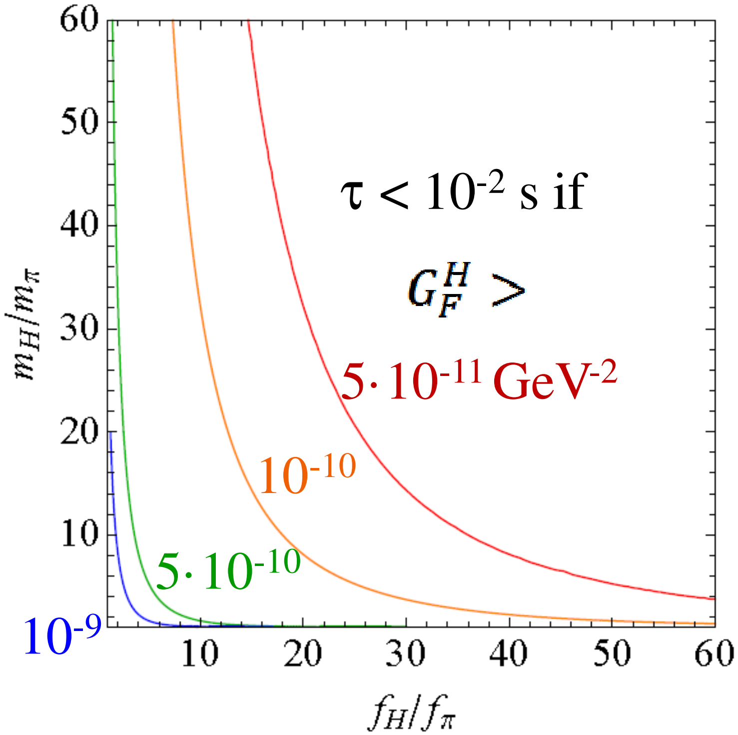
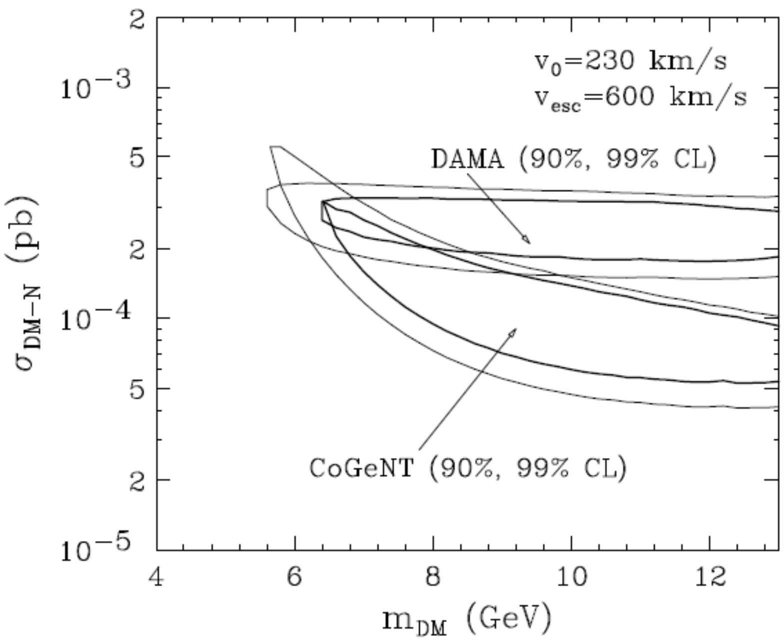


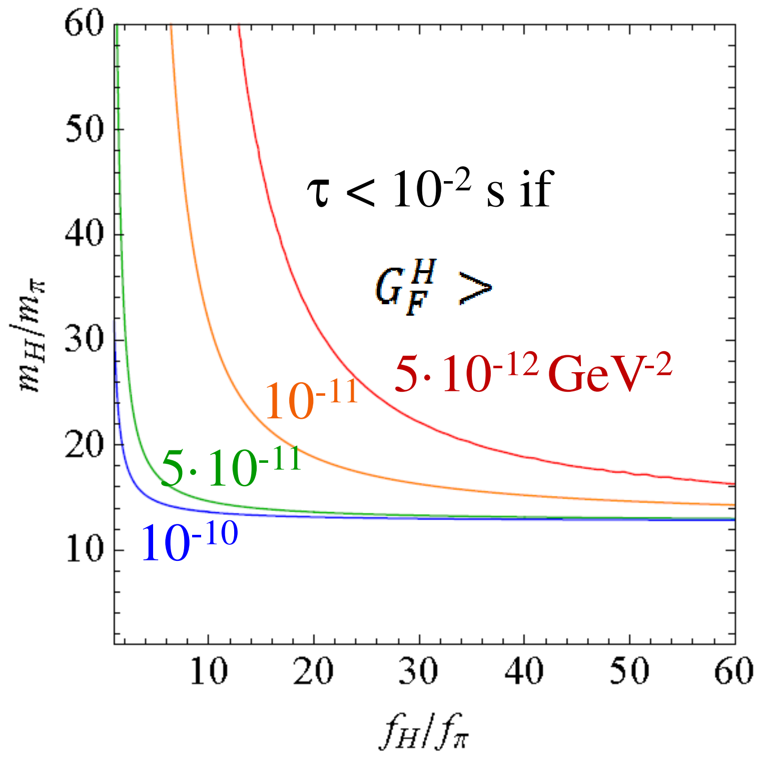


D. Hooper et al
arXiv:1007.1005

Requires $G_F^H \approx 10^{-7}$GeV^{-2}
tension with LEP bounds

Coupling to 2nd and 3rd generations

If $SU(2)_H$ interaction involves mainly 2nd and 3rd generations constraints are weaker



Also provides a new source of mixing an CP violation in the B_s system that can accommodate the Tevatron dimuon anomaly with

$$G_F^H \approx 7 \cdot 10^{-11} \text{ GeV}^{-2}$$

S. C. Park, J. Shu, K. Wang and T. Yanagida arXiv:1008.4445

Conclusions and Outlook

- Extending the SM with N_R and DM fermions + $SU(2)_H \times SU(3)_{DC}$ induces asymmetric DM via leptogenesis
  - DM is stable without additional parities
  - DM mass and abundance similar to baryons
- A flavour-conserving Z′ remnant of $SU(2)_H$ can have low mass and lead to signals at colliders or direct detection experiments
- If $SU(2)_H$ couples mainly to the 2nd and 3rd generations it can accommodate the Tevatron dimuon anomaly
- Can the $SU(2)_H$ symmetry breaking help with the flavour puzzle?