New Production Mechanism for KeV Sterile Neutrino Dark Matter

IMPRS
PTFS

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MPIK, Heidelberg
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paper in arXiv: 1305.XXXX

MAX-PLANCK-INSTITUT FÜR KERNPHYSIK

Outline

- KeV Sterile Neutrino Dark Matter
- Freeze-In Mechanism
- Decay of Frozen-In FIMP
  (≠ Frozen-Out WIMP)
  into KeV Sterile Neutrino
- Results
- Summary

KeV Sterile Neutrino Dark Matter: Introduction

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Standard Model

Neutrinos massless:
no right-handed neutrino,
lepton number conserved

Dark Matter: „stable“,
electrically neutral, Weakly
Interacting Massive Particle ?

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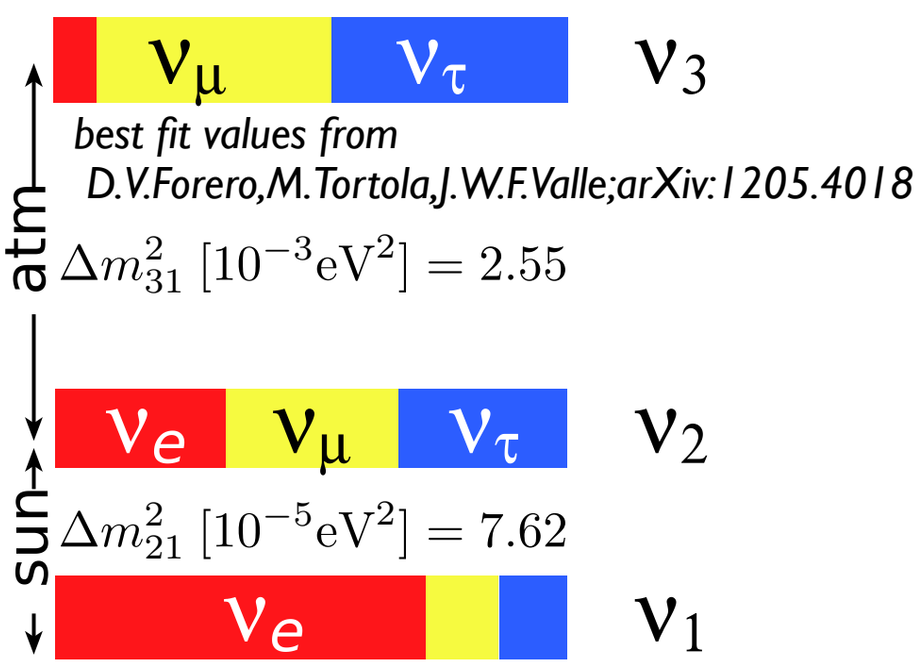

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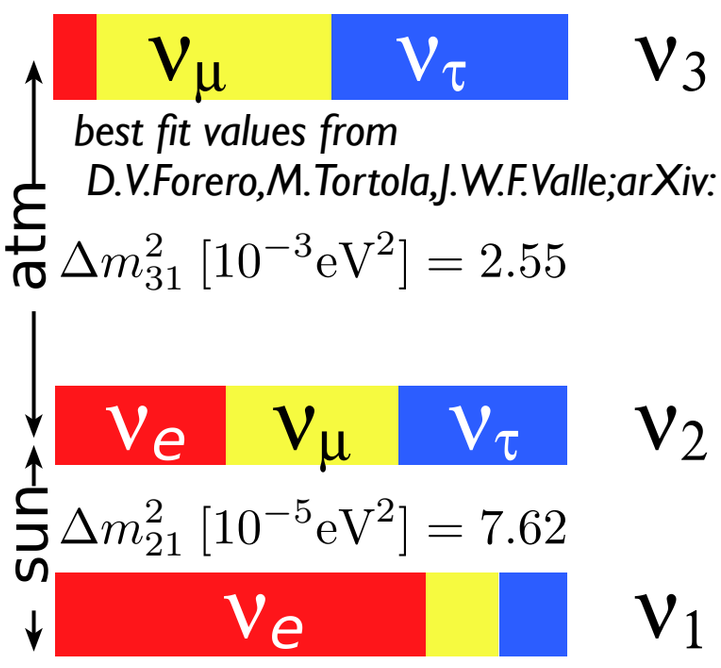

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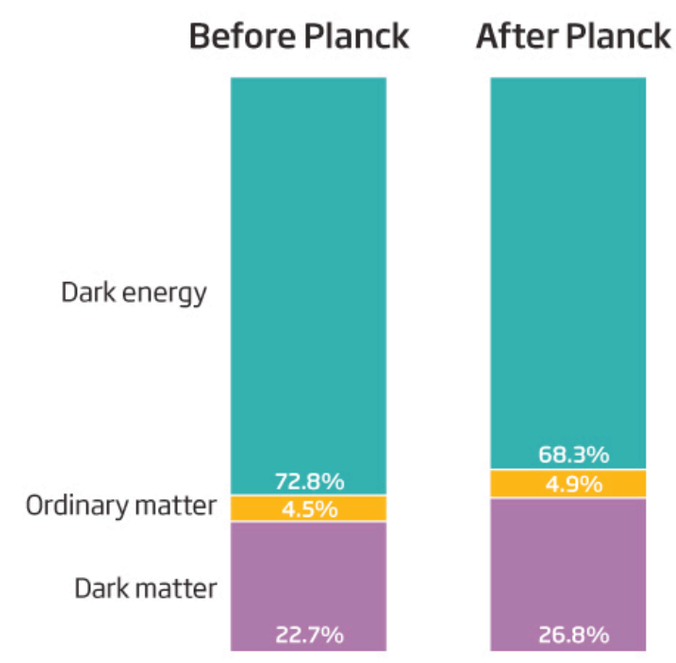
Planck cosmic recipe



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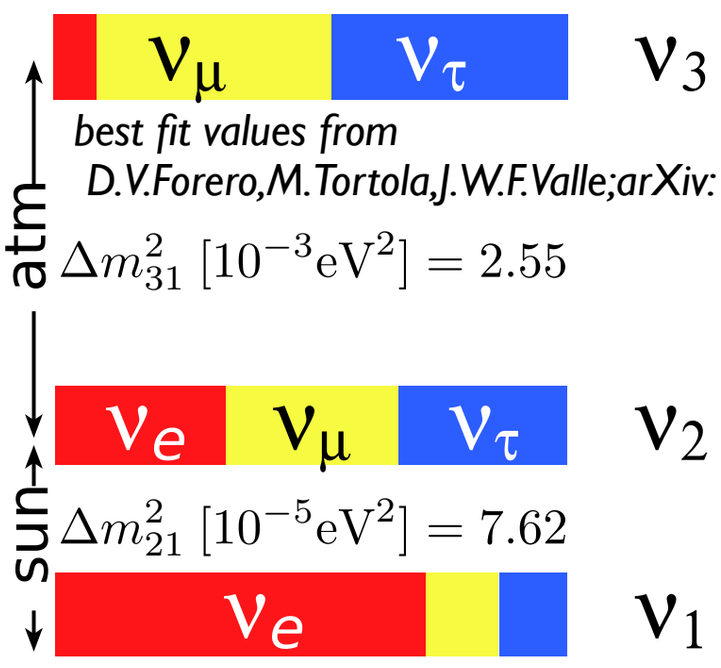

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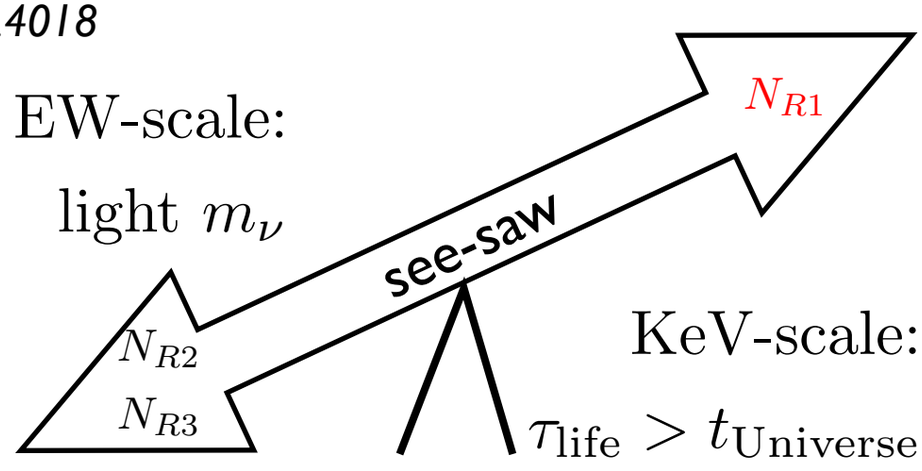

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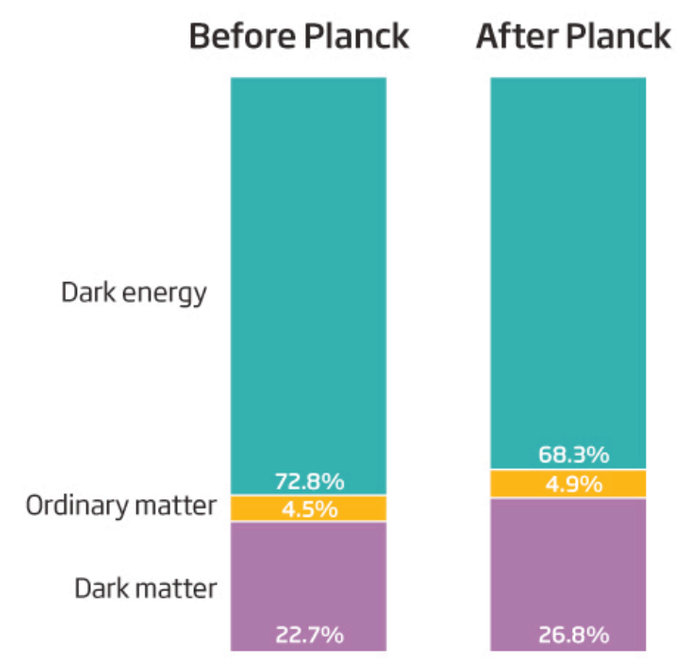

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F. Bezrukov, H. Hettmansperger and M. Lindner, Phys.Rev. D81 (2010) 085032

(thermal relic only if charged under extended gauge group)

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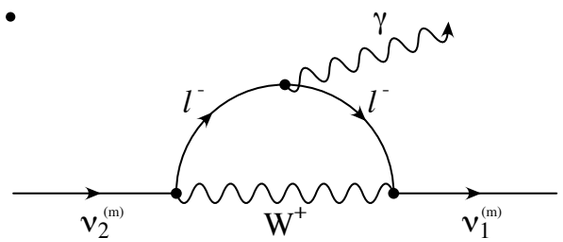

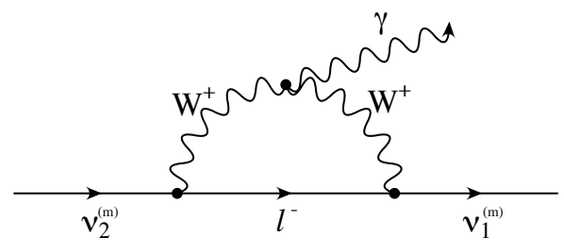

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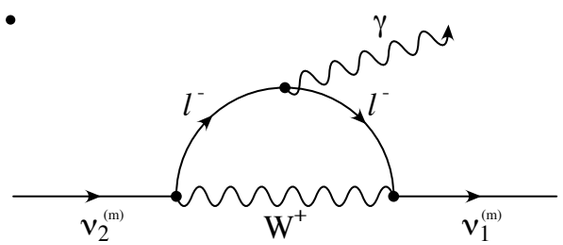

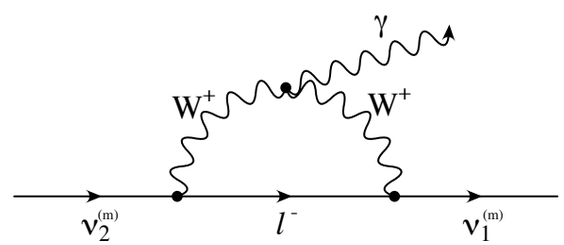

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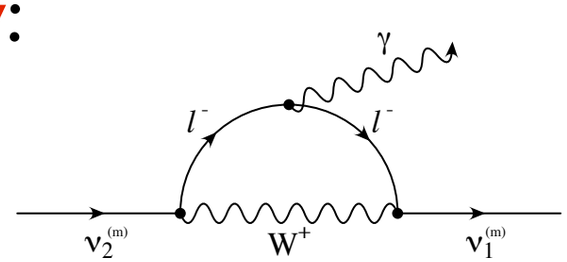

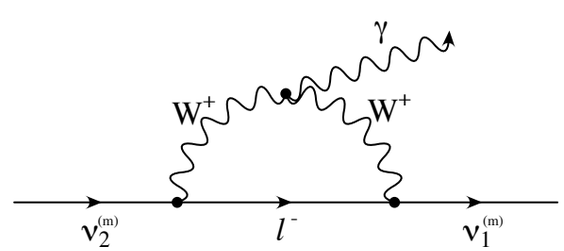

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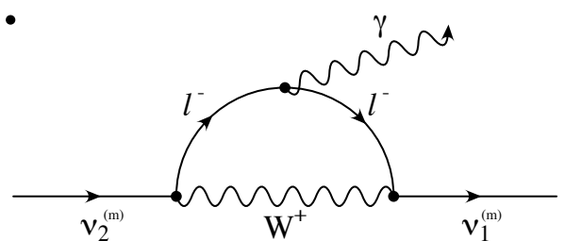

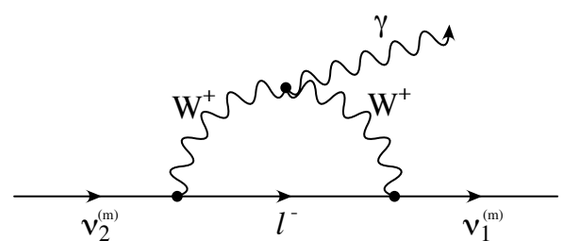

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M. Laine and M. Shaposhnikov, JCAP 6 31 (2008)

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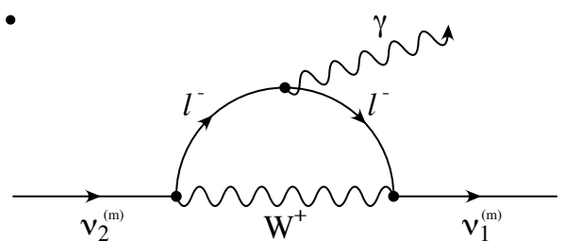

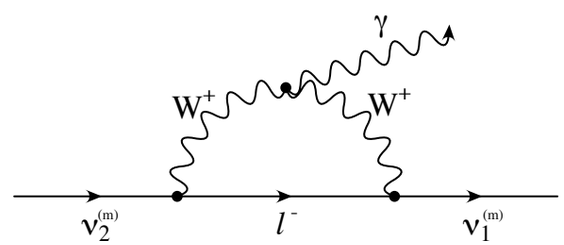

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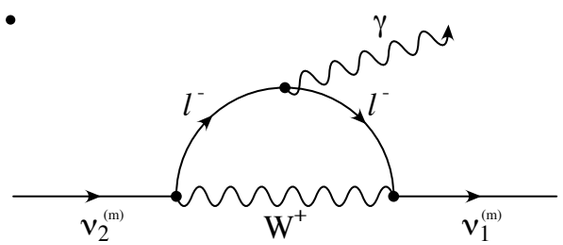

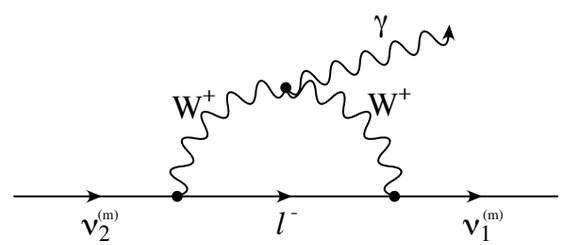

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WDM erases structures on scales smaller than its free streaming horizon $\lambda_{\rm FS}$.

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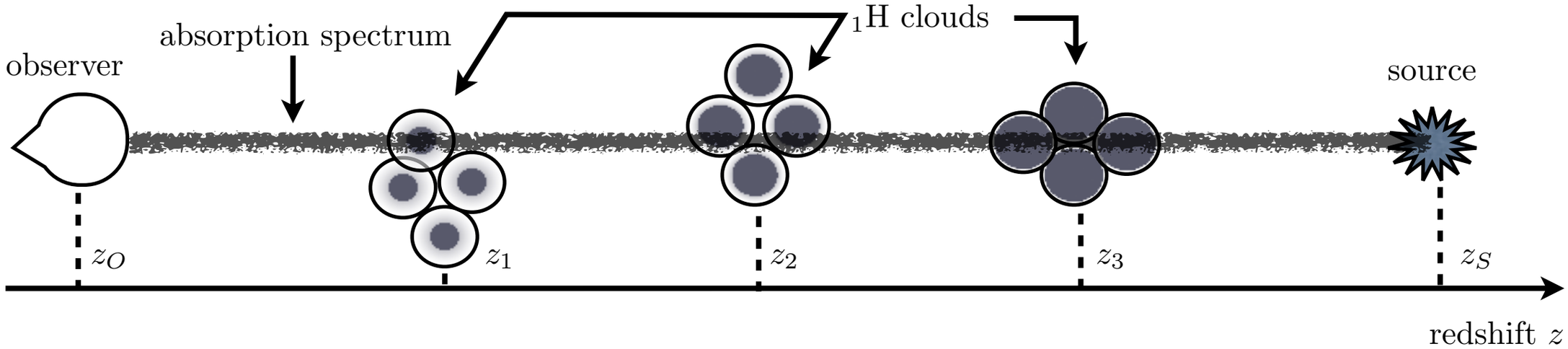

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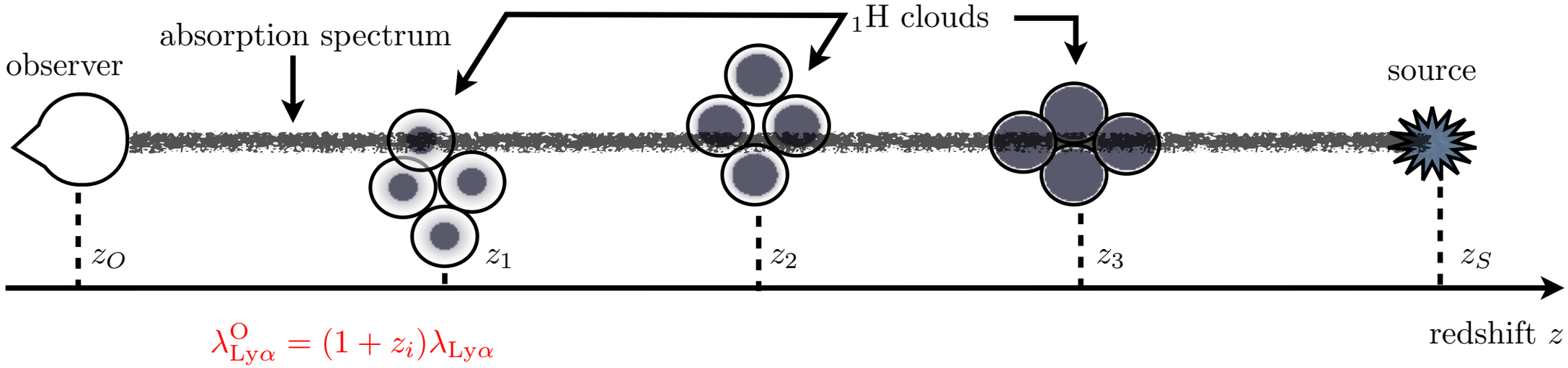

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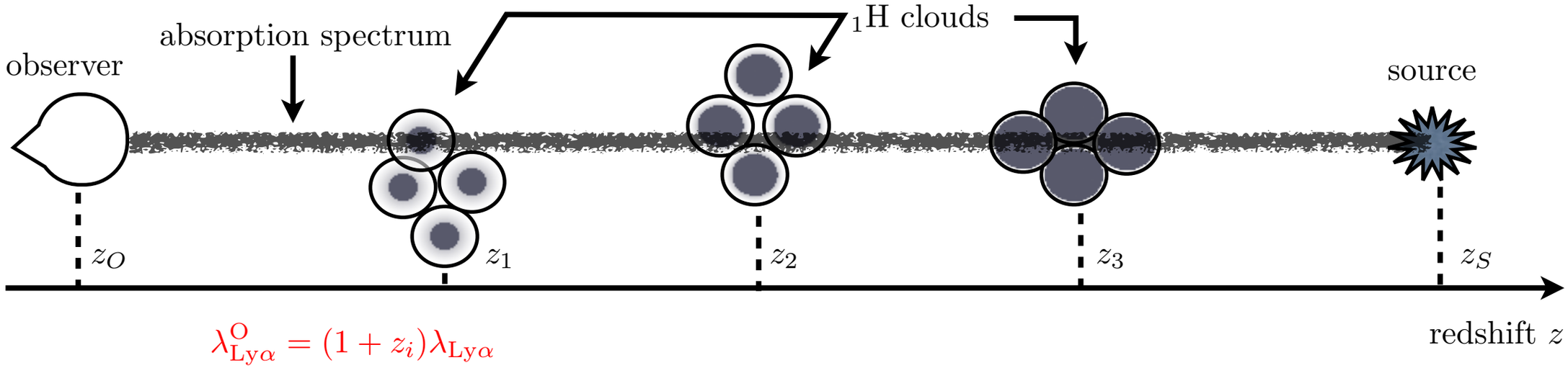

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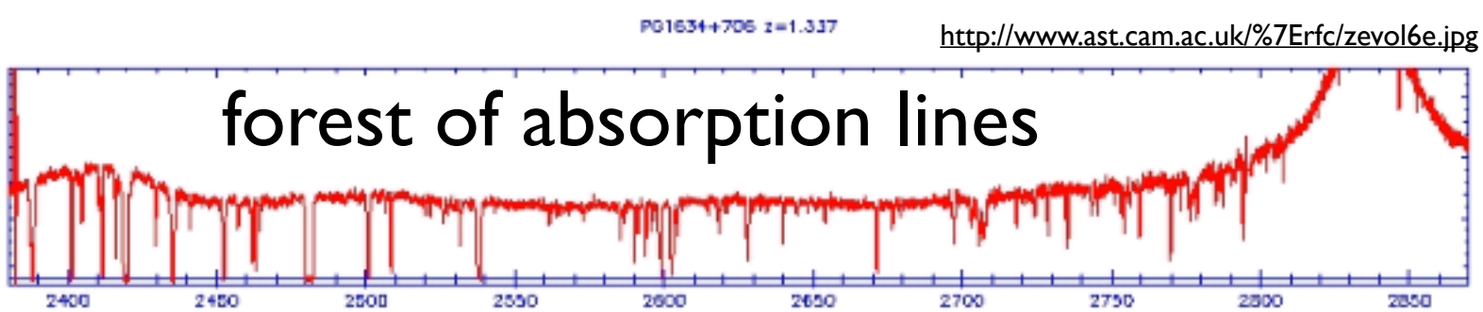

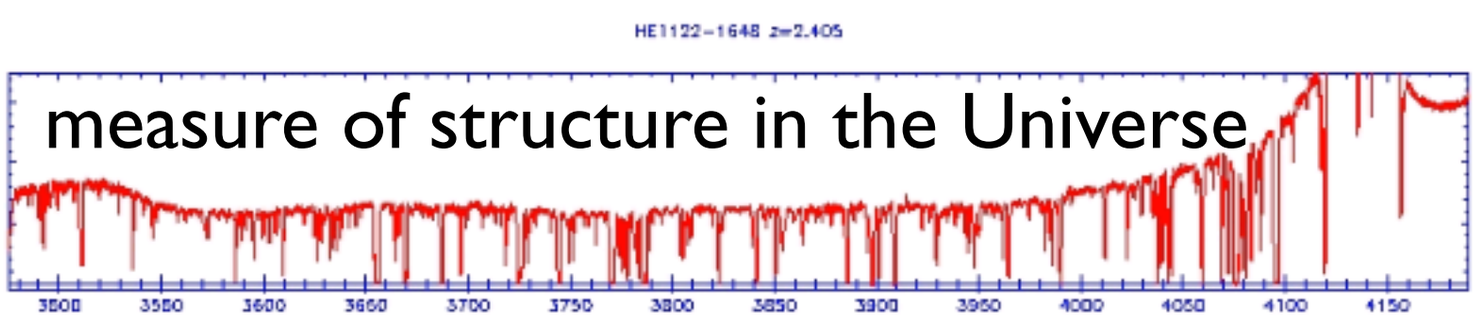

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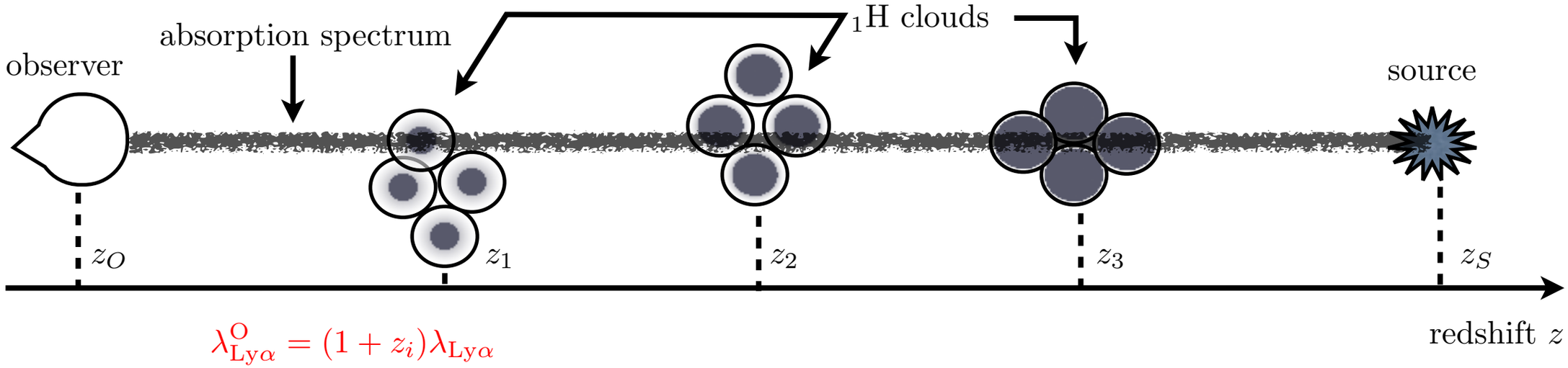

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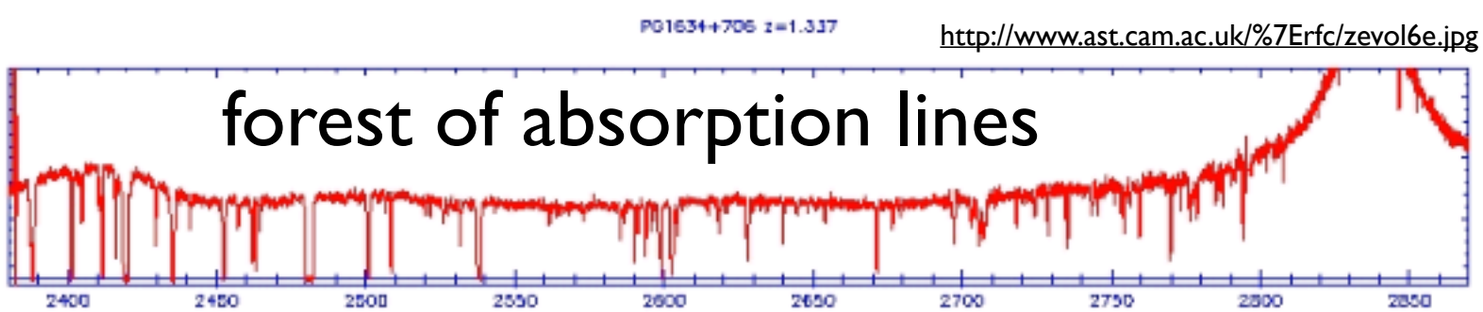
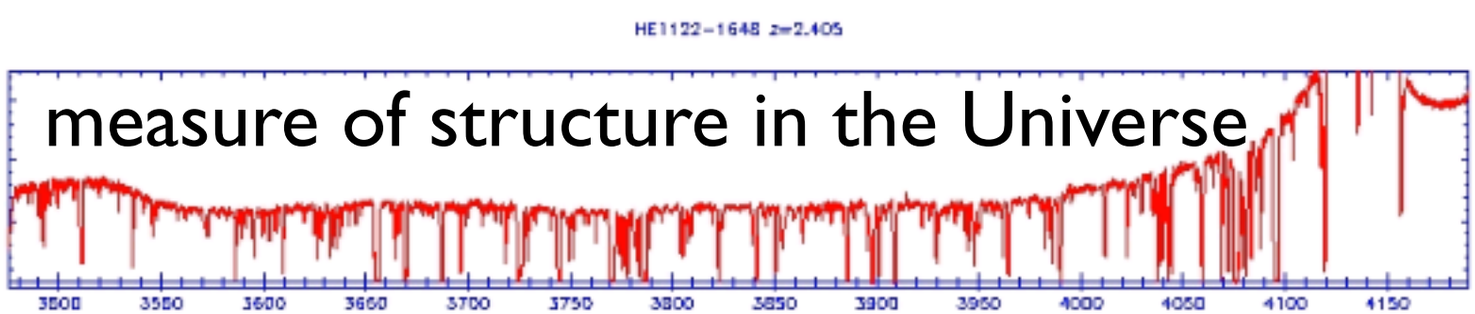


warmer WDM, larger λ_{FS}



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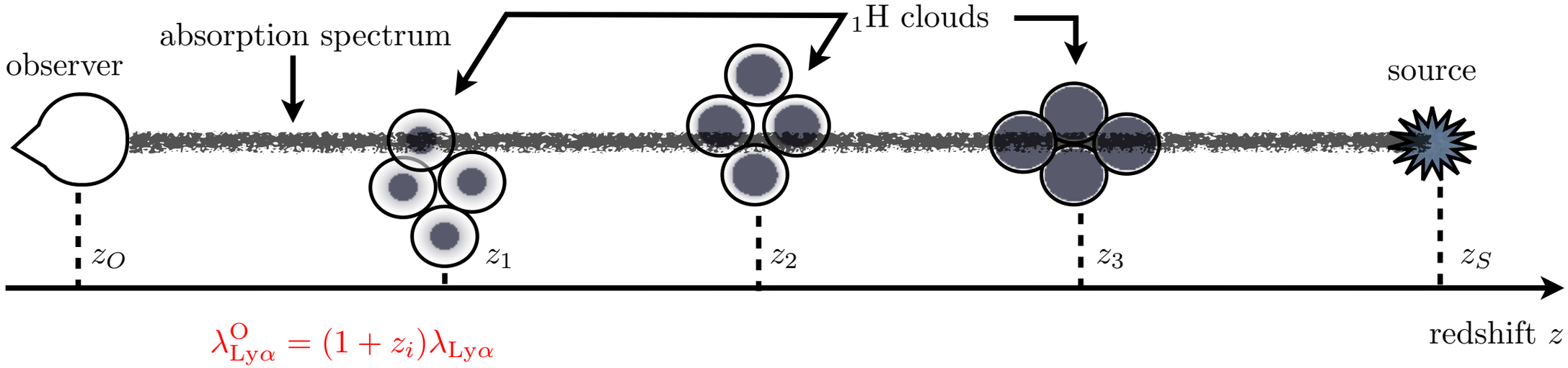

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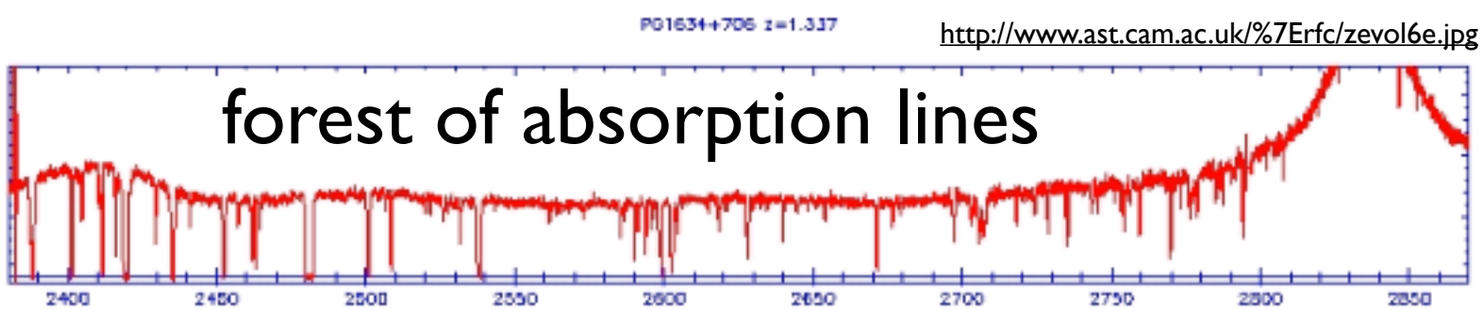

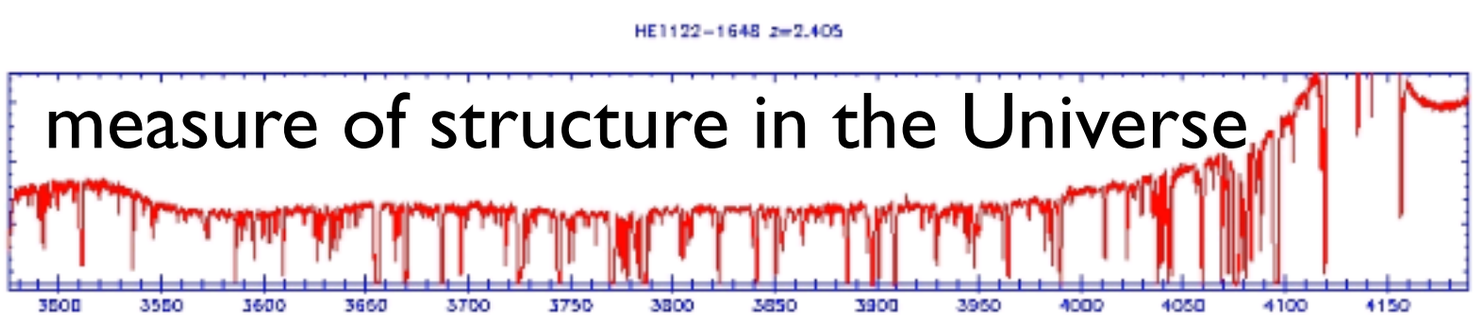

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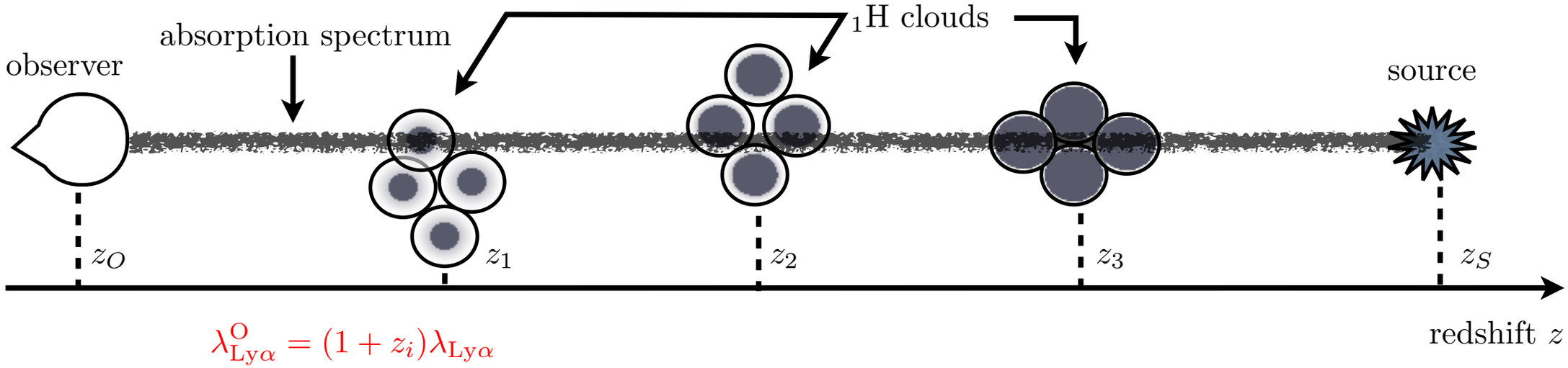

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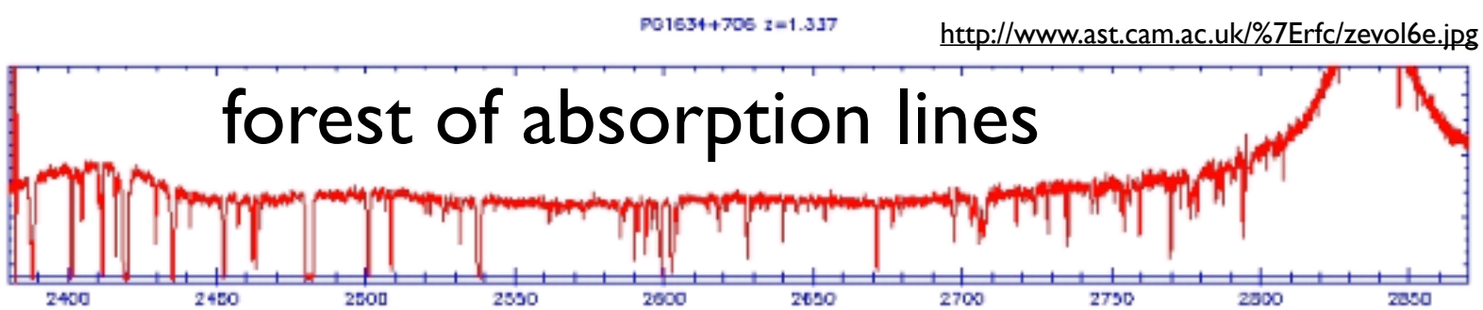

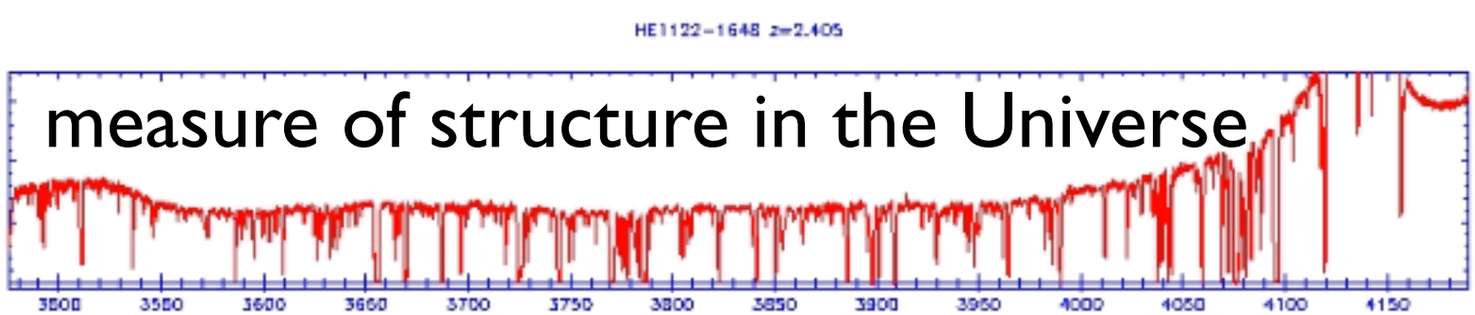

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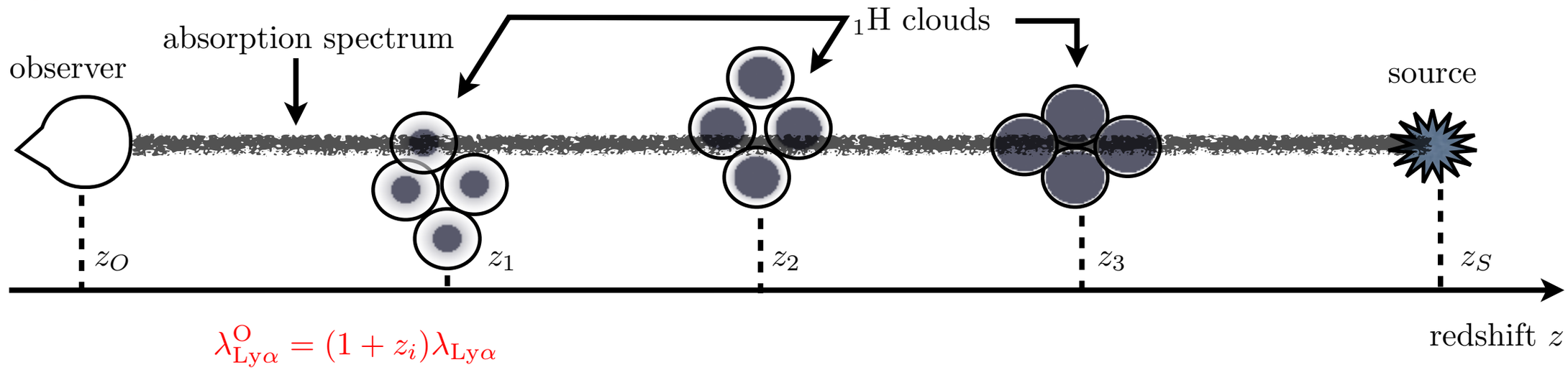

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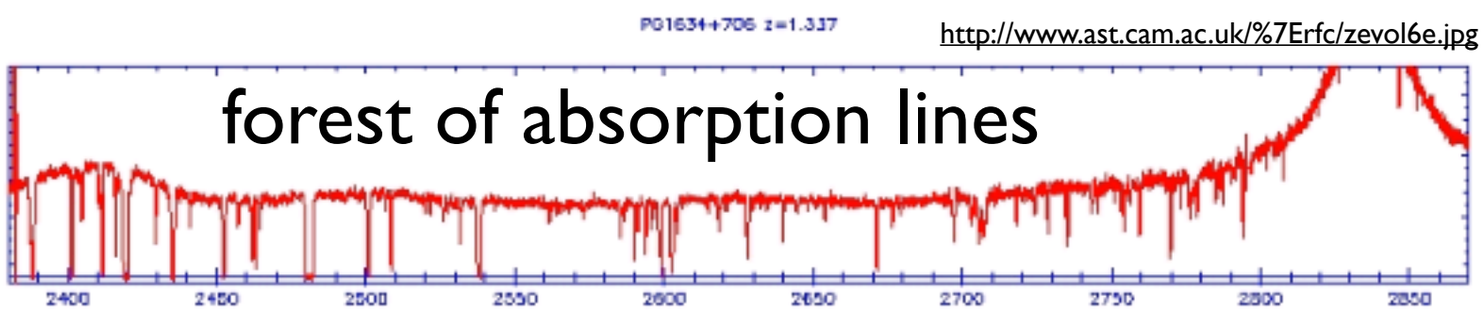

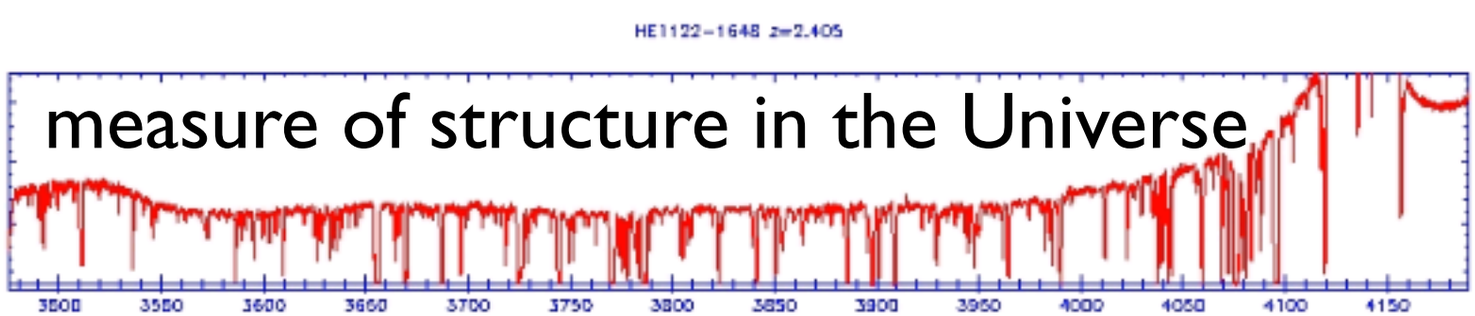

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A. Boyarsky et al., Phys.Rev.Lett. 102 (2009) 201304

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KeV Sterile Neutrino Dark Matter: New Production Mechanism

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Freeze-In Mechanism

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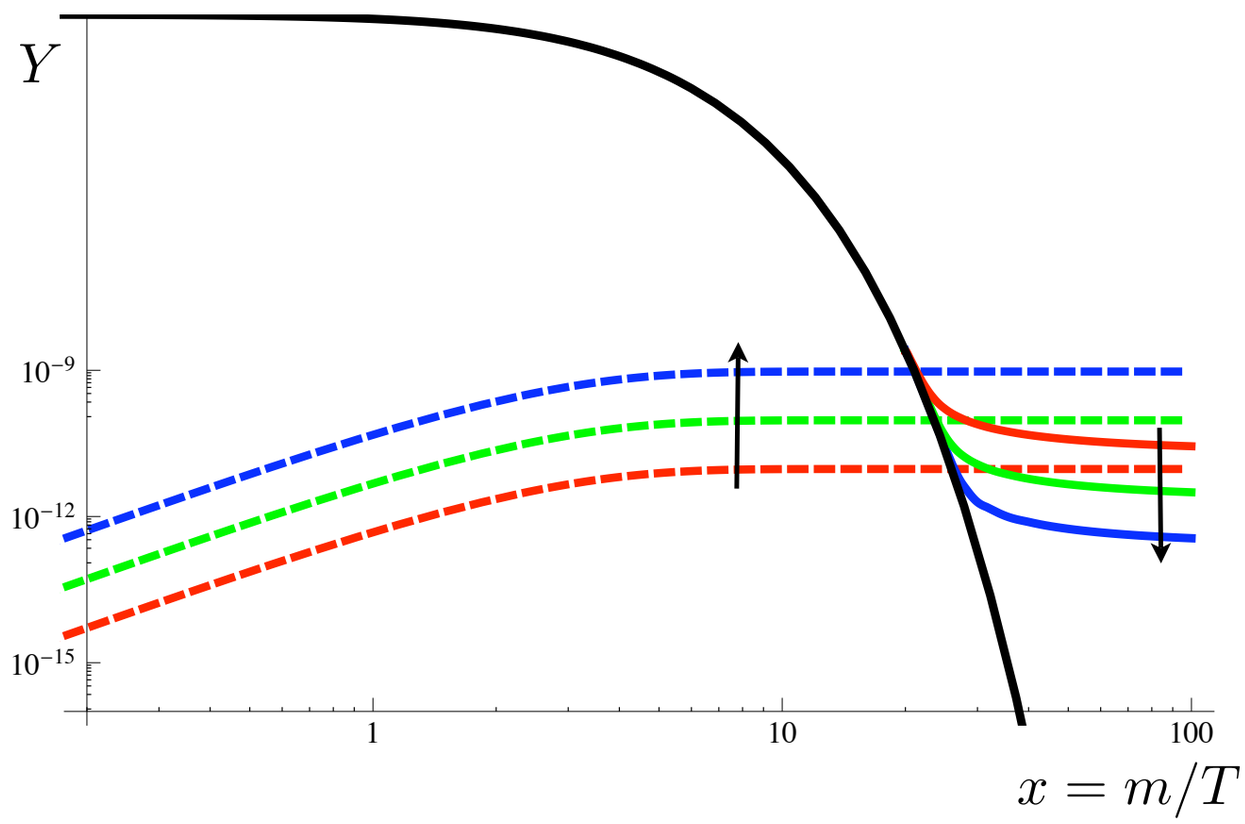
L. J. Hall et al., JHEP 1003 (2010) 080



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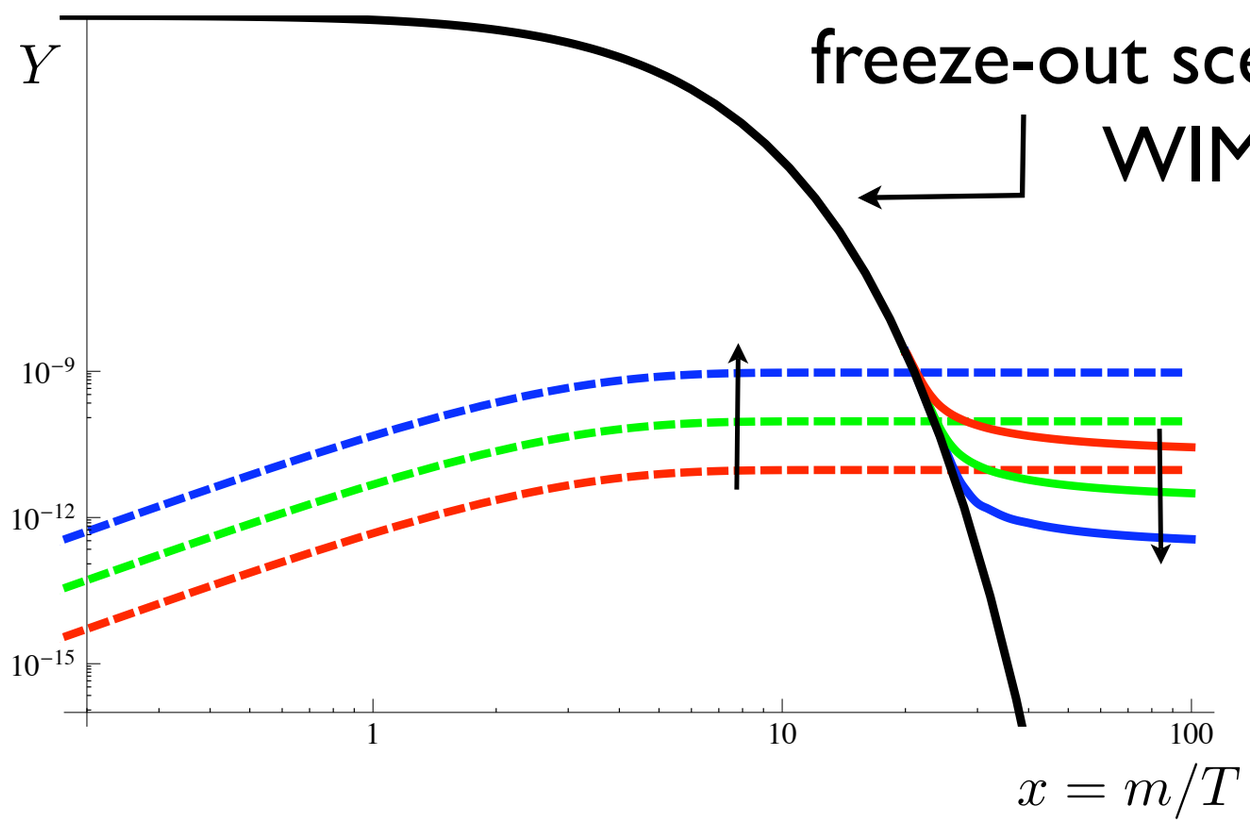

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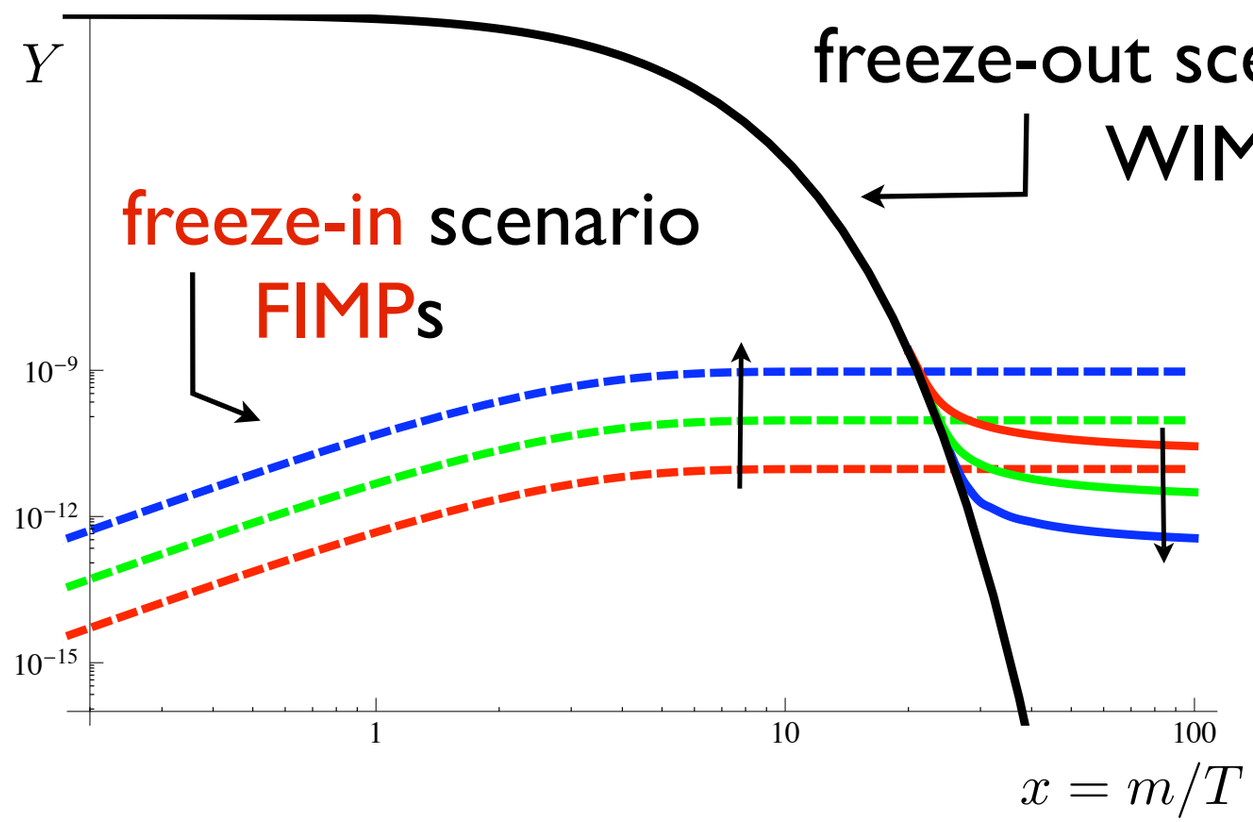

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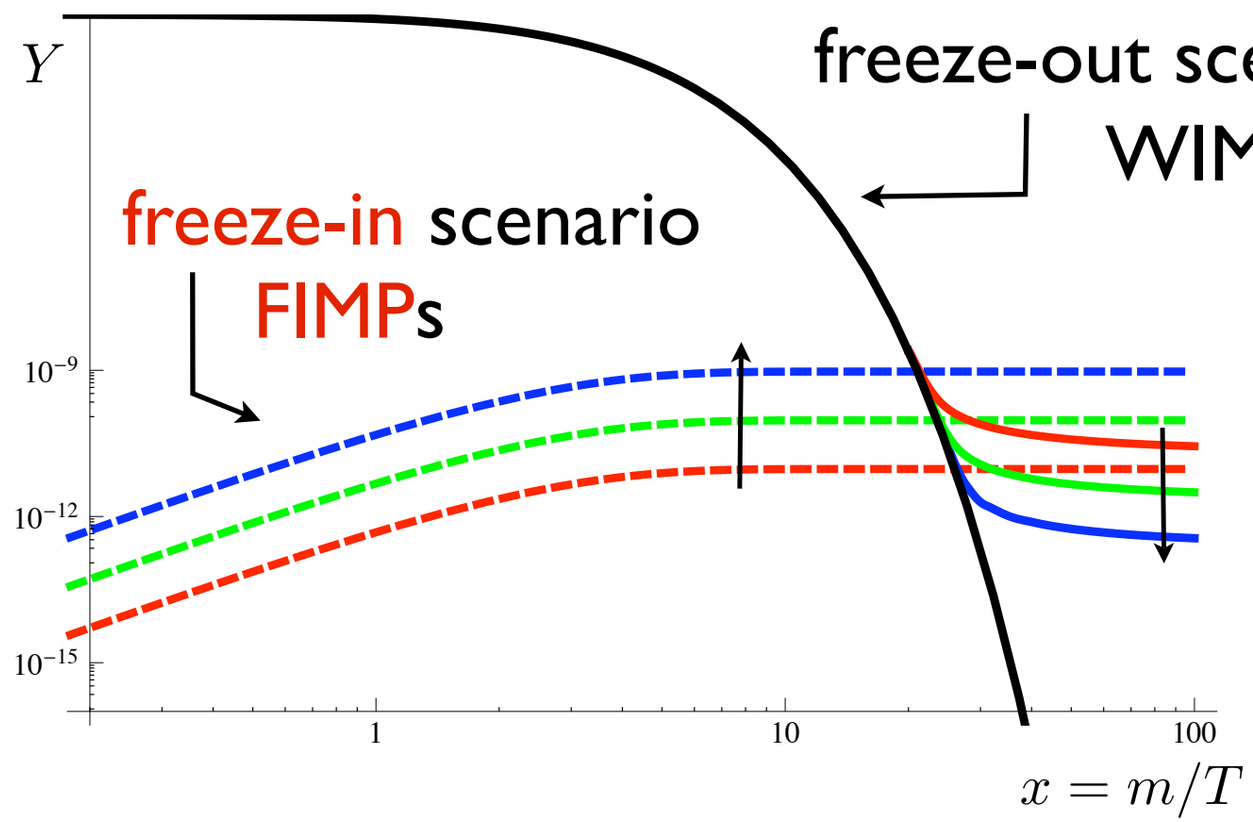

general features:

- initial abundance Y negligibly small (assumption)
- particle itself is never in thermal equilibrium
- feebly coupling constants $\lambda \ll 10^{-6}$ (Feebly Interacting Massive Particle)
- abundance Y increases with increasing coupling constants

Decay of Frozen-In FIMP into KeV sterile Neutrino: Model

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our model:

$$\mathcal{L} = i\overline{N}_{Ra}\partial\!\!\!/ N_{Ra} + \frac{1}{2}\partial_\mu S \partial^\mu S - \frac{(y_M)_a}{2} S\, \overline{N}^c_{Ra} N_{Ra} + \text{ h.c.}$$

$$- \mathcal{V}_{\text{scalar}} + \mathcal{L}_\nu + \mathcal{L}_{\text{SM}}$$

$$\mathcal{V}_{\text{scalar}} = -\mu_H^2 H^\dagger H - \frac{1}{2}\mu_S^2 S^2 + \lambda_H (H^\dagger H)^2 + \frac{1}{4}\lambda_S S^4 + 2\lambda (H^\dagger H) S^2$$

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decay width: $\Gamma\left(\sigma \to N_{R1} N_{R1}\right) = \frac{(y_M)_1^2}{16\pi} m_\sigma \left[1 - \frac{4 m_{N_{R1}}^2}{m_\sigma^2}\right]$

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inverse decay neglected

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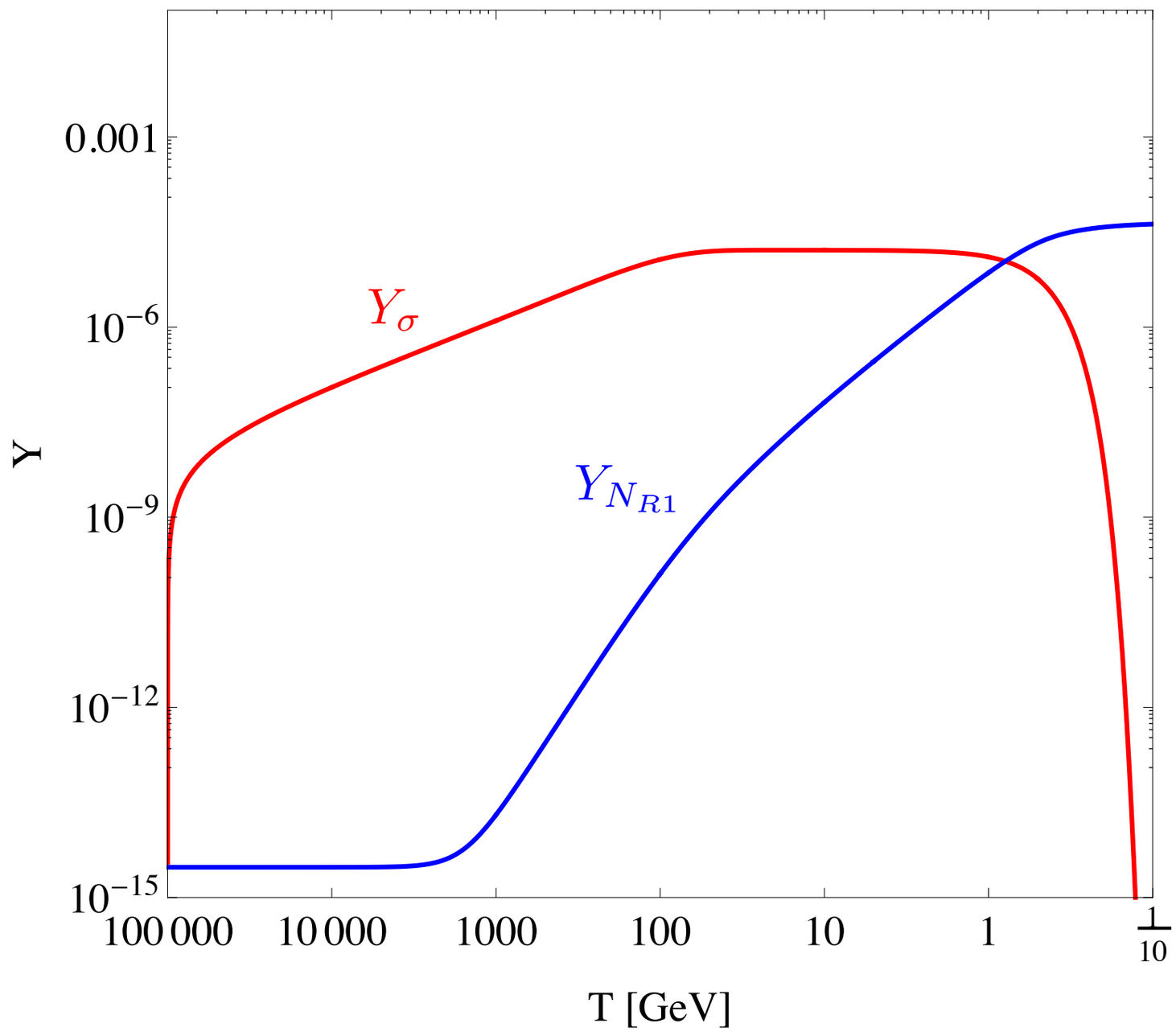

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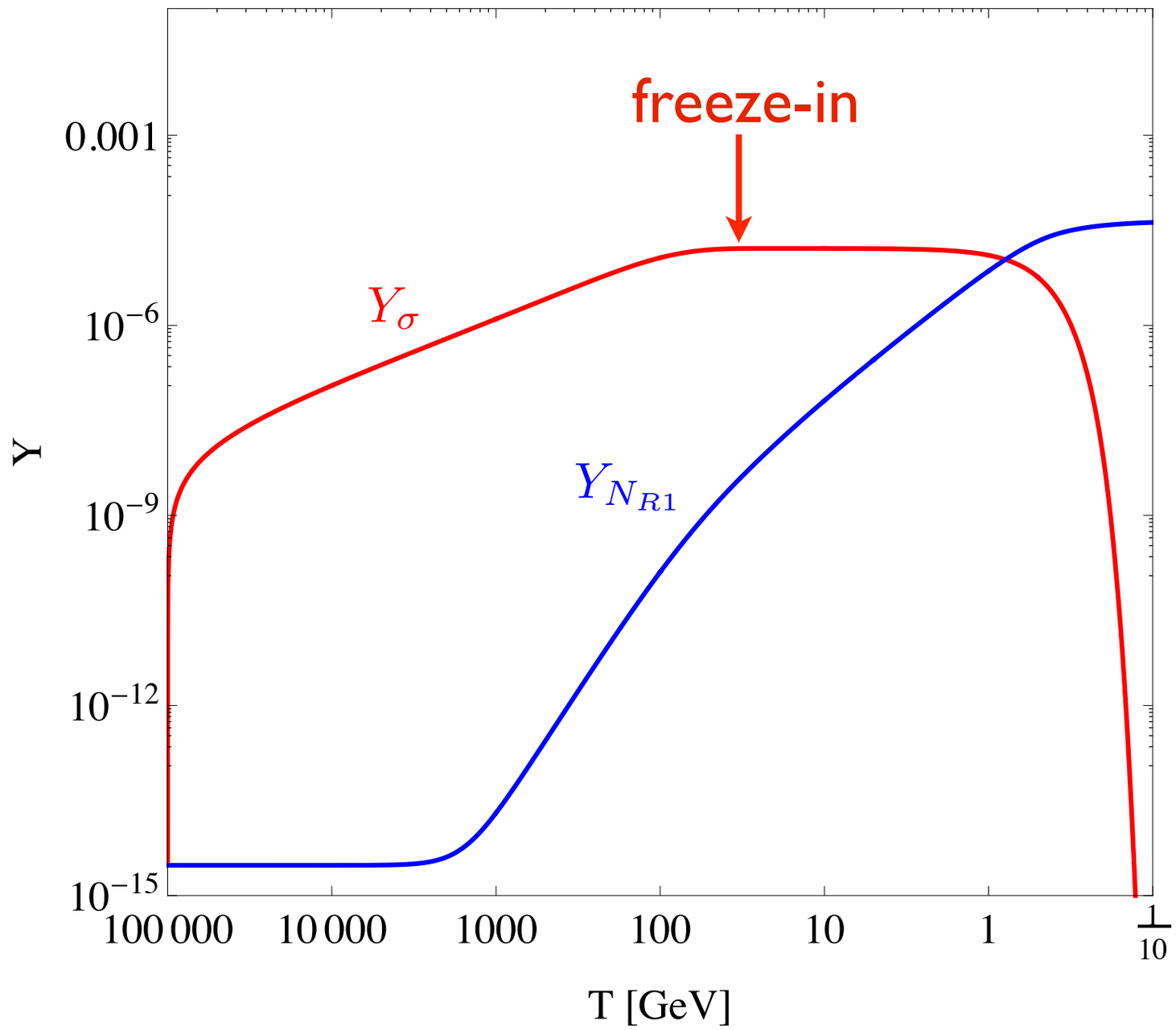

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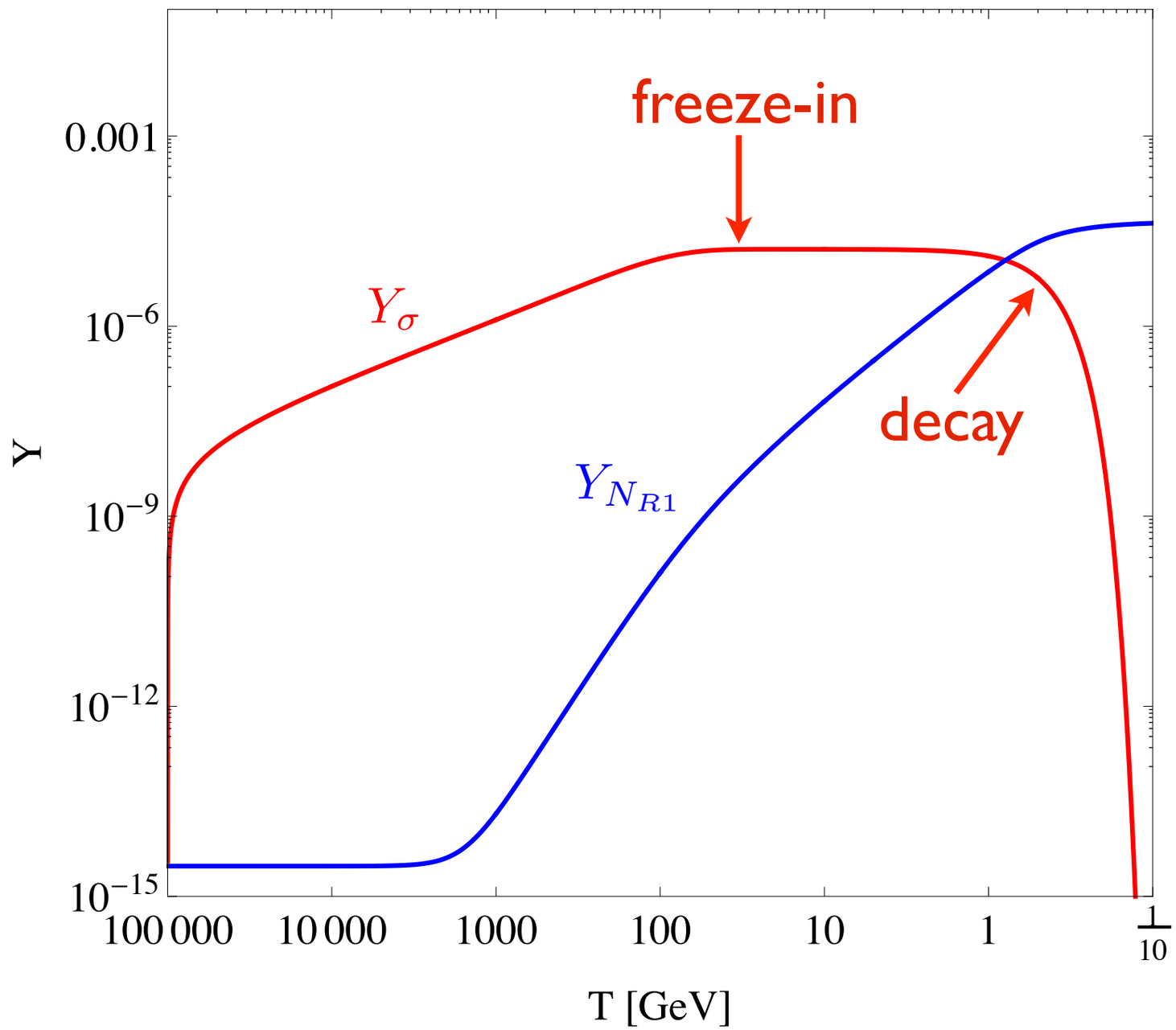

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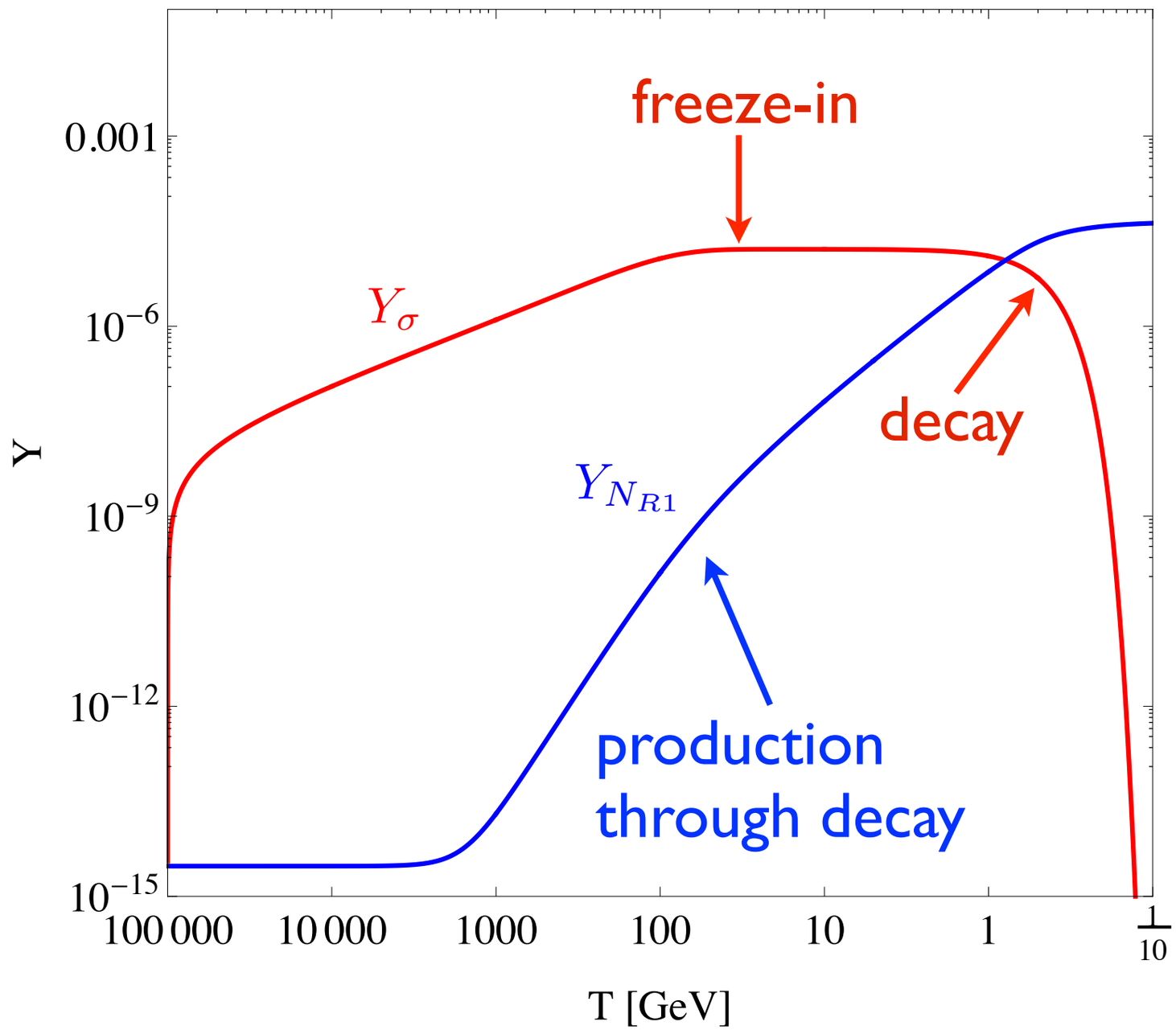

Decay of Frozen-In FIMP into KeV sterile Neutrino: Free Streaming

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free streaming horizon: comoving distance traveled by a freely moving particle

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Results:

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Come to an end!

Don’t miss the bus 39 down to Bismarck Platz!

Results: Higgs Portal

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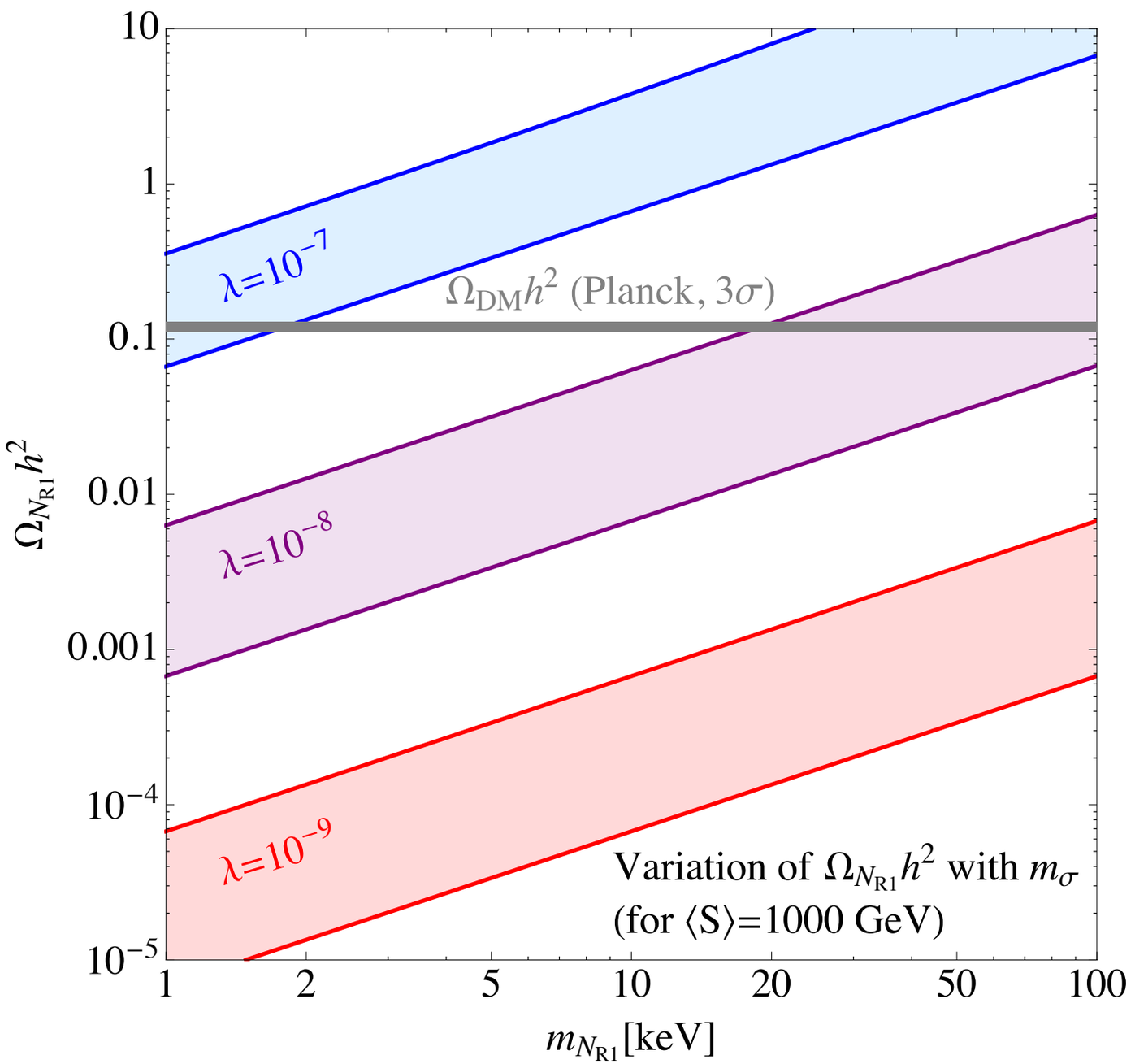

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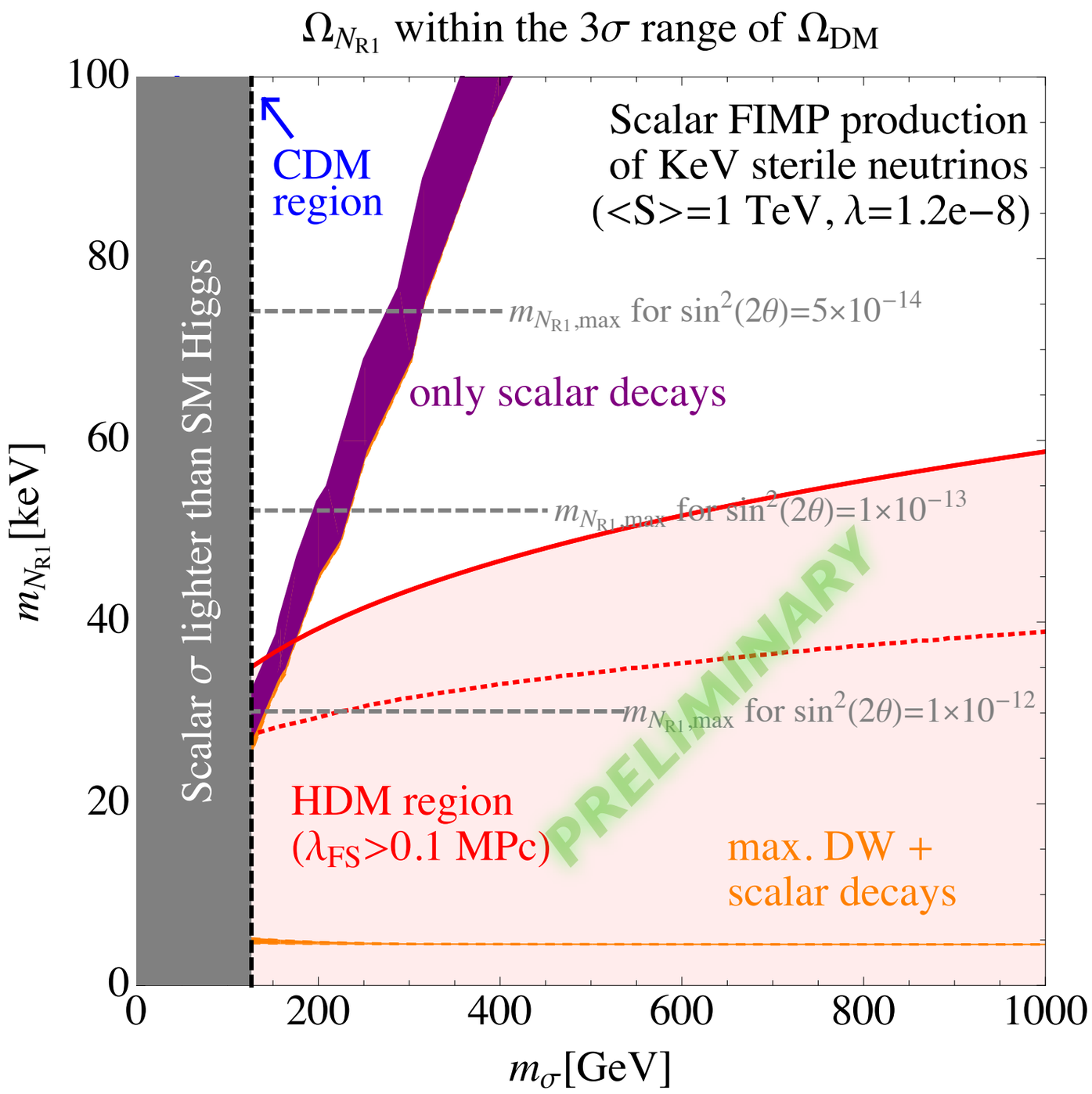

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Other well studied and successful non-thermal mechanism is production through decay of frozen-out scalar.

We have analysed the decay of a frozen-in FIMP as a new production mechanism.

Our new production mechansim opens up a new region in the allowed parameter space.

Thanks !