Freeze-in production of FIMP dark matter

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In collaboration with John March-Russell, Lawrence Hall and Karsten Jedamzik

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Freeze-in overview

- Freeze-in is relevant for particles that are feebly coupled

  (Via renormalisable couplings) - λ

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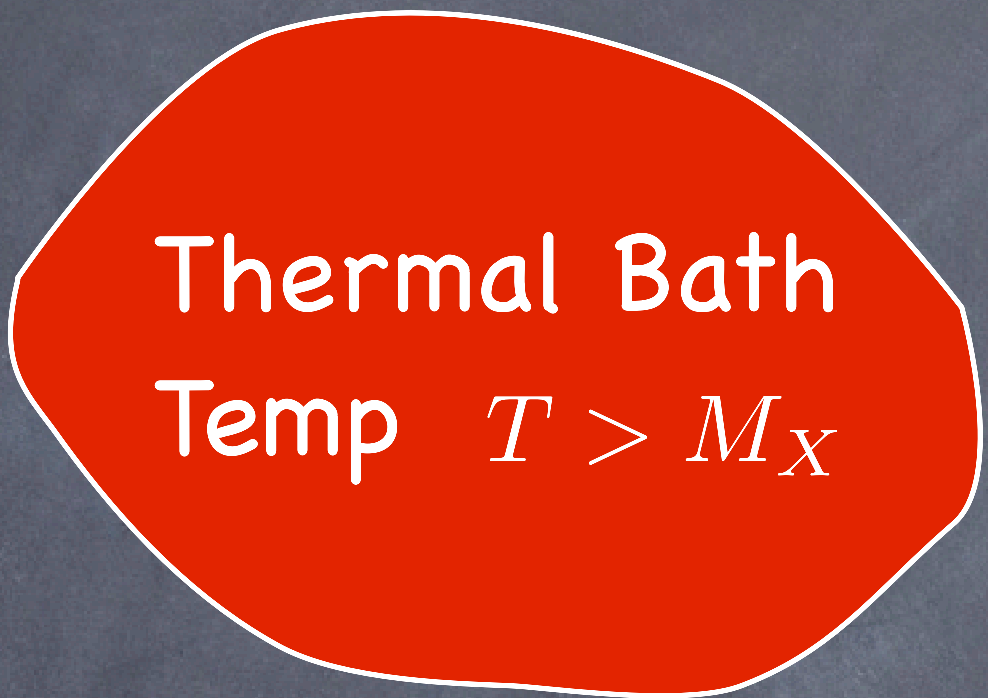

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Thermal Bath

Temp $T > M_X$

X is thermally decoupled and we assume initial abundance negligible

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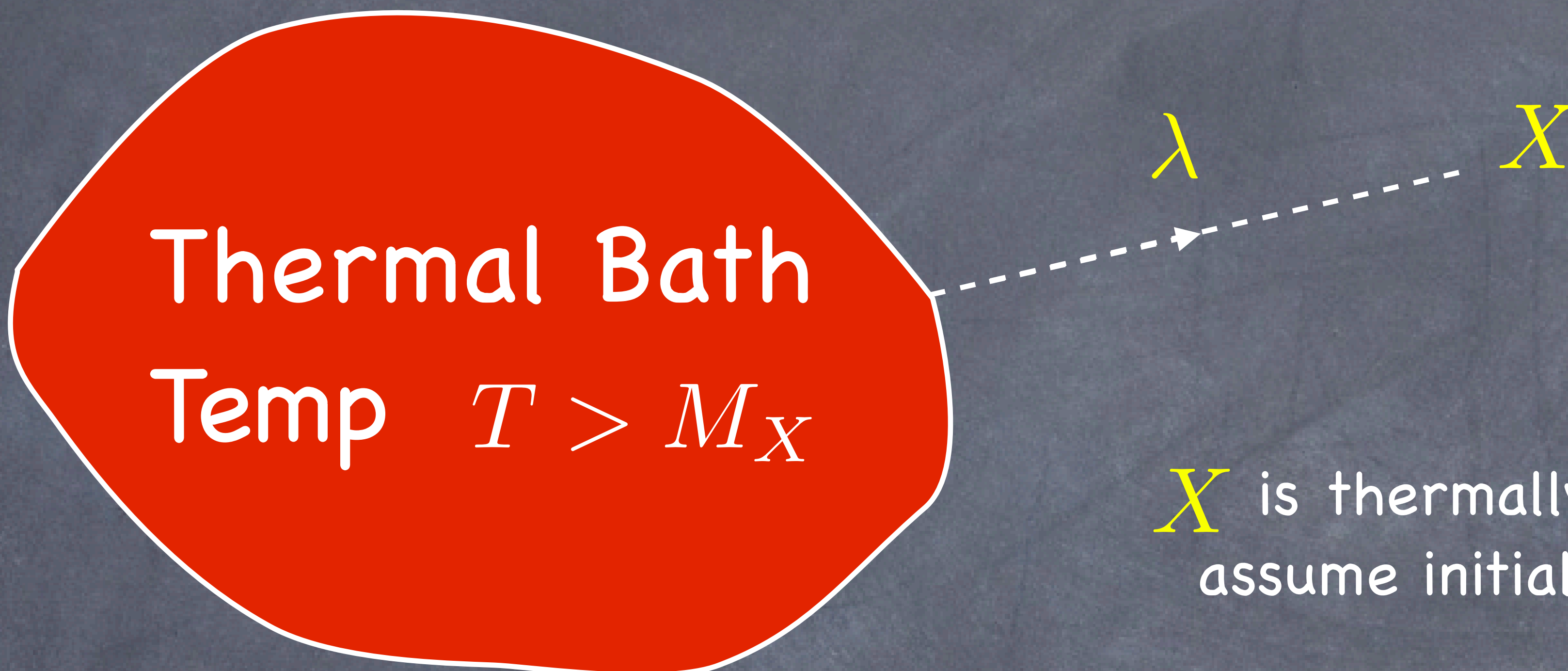

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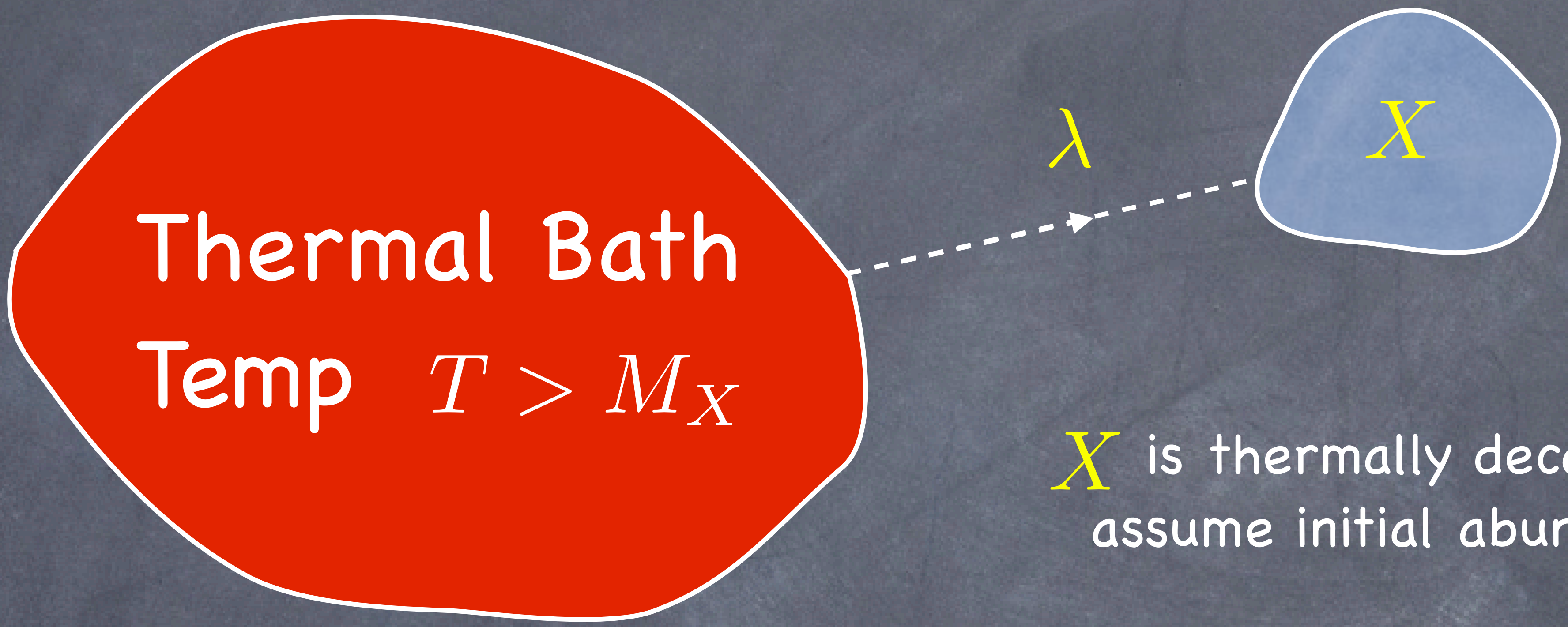

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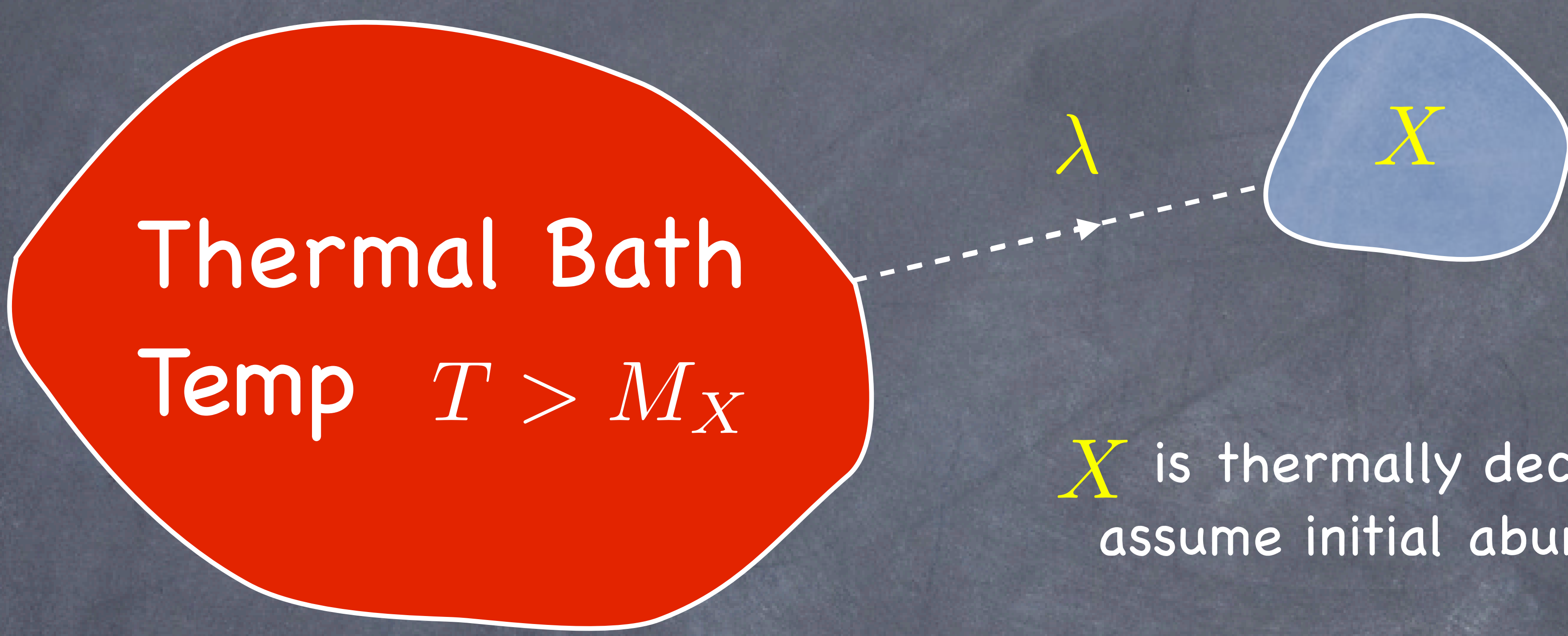

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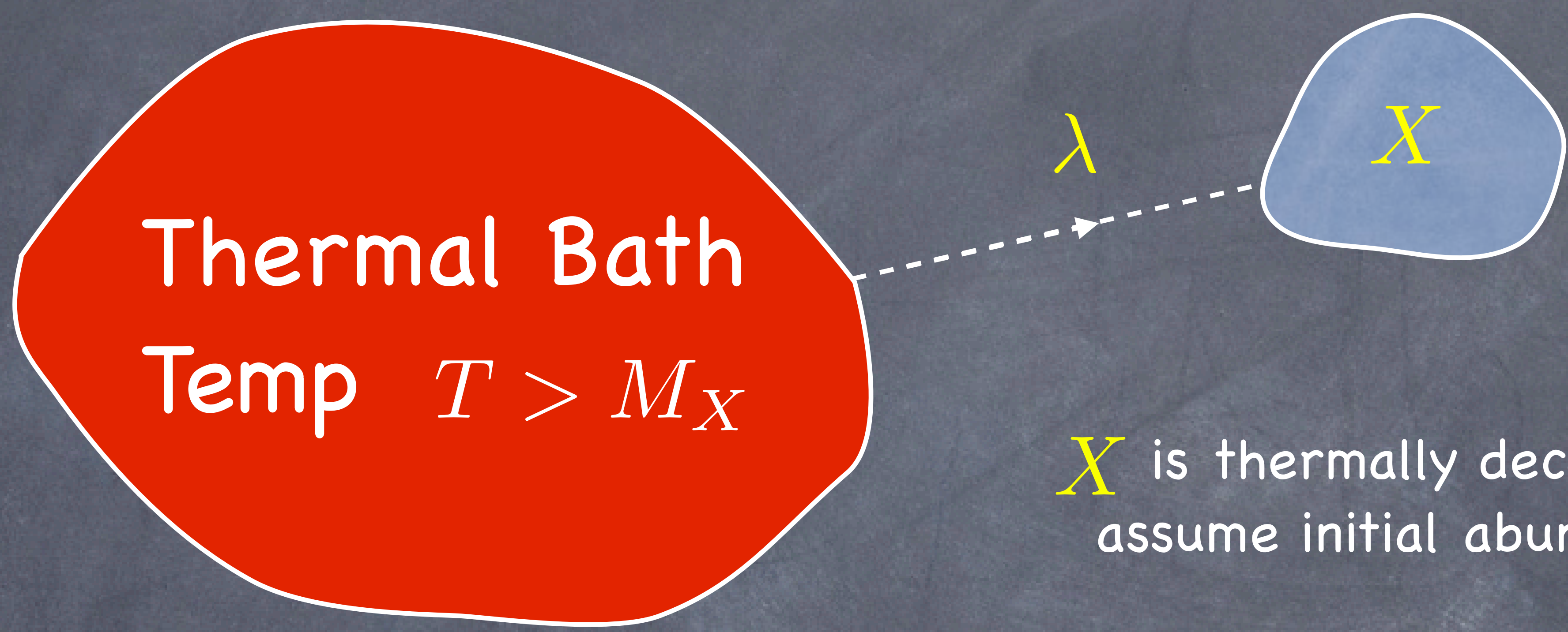

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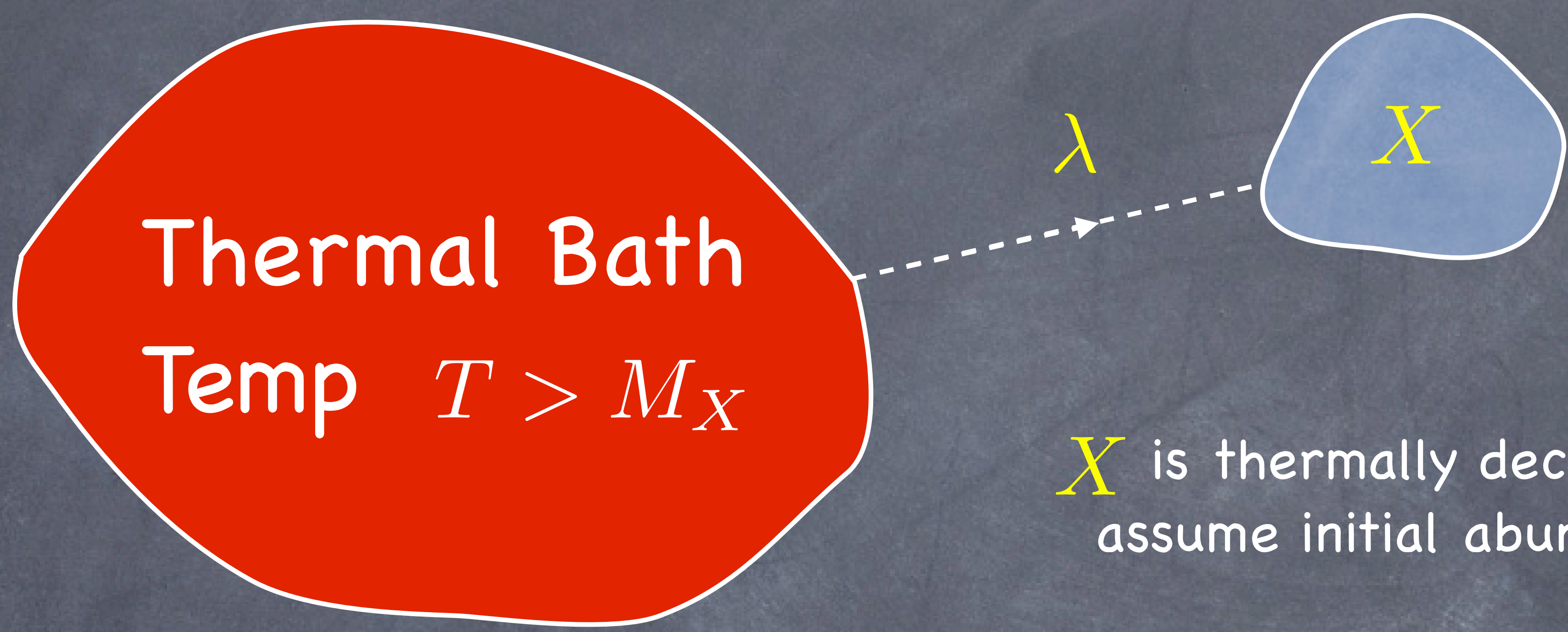

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opposite to Freeze-out...

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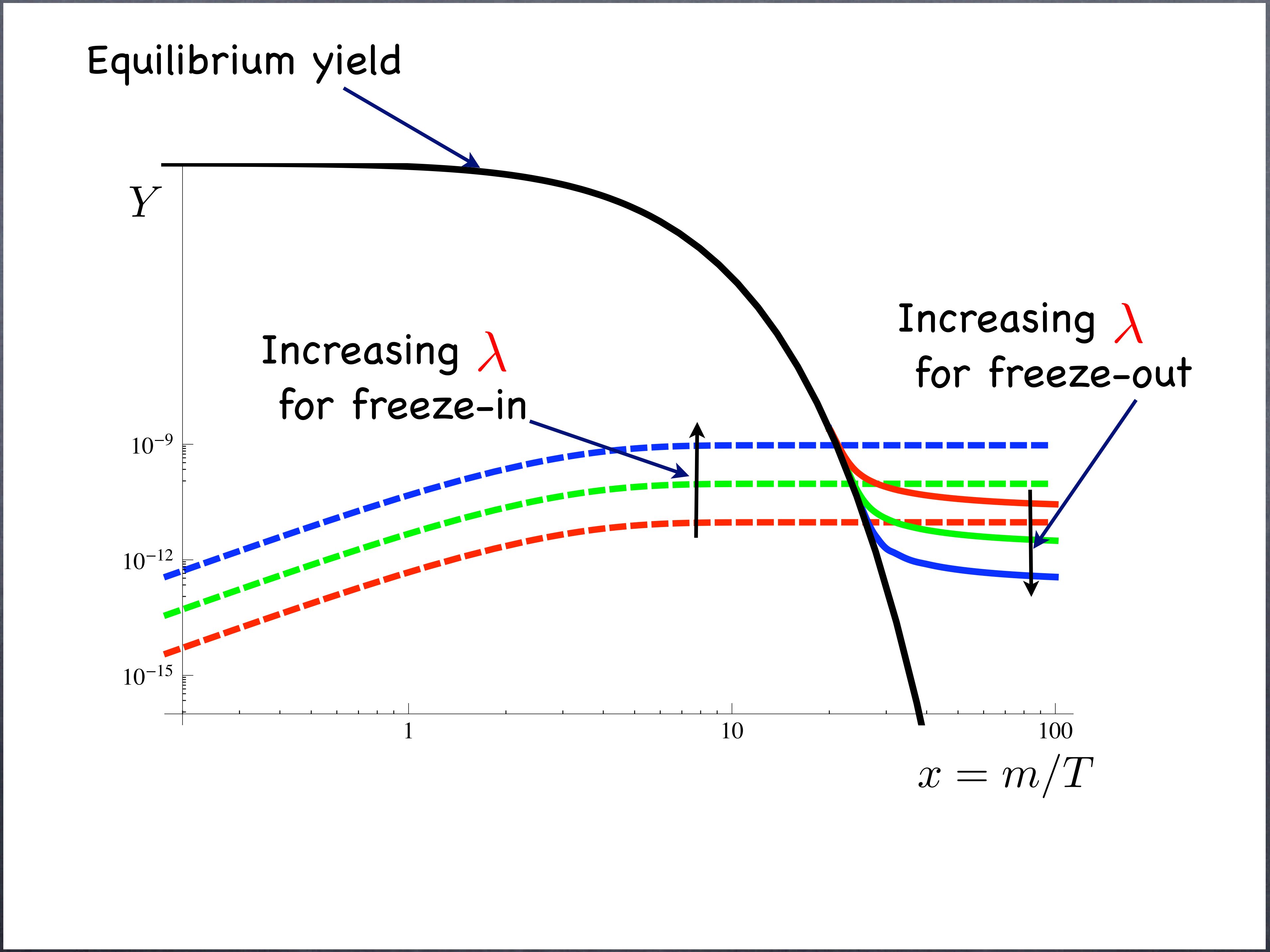

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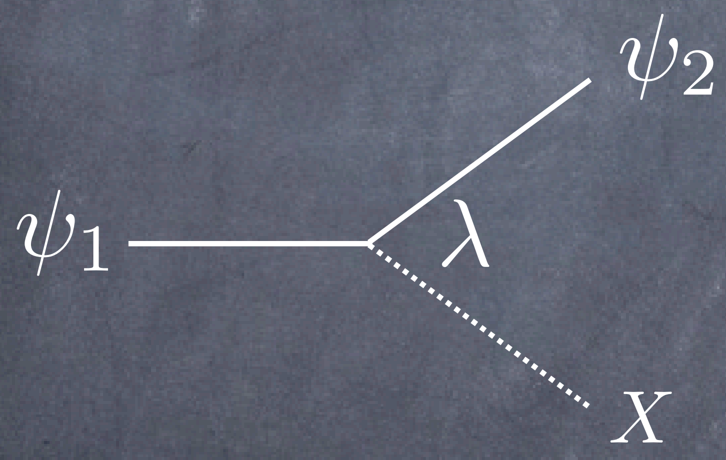

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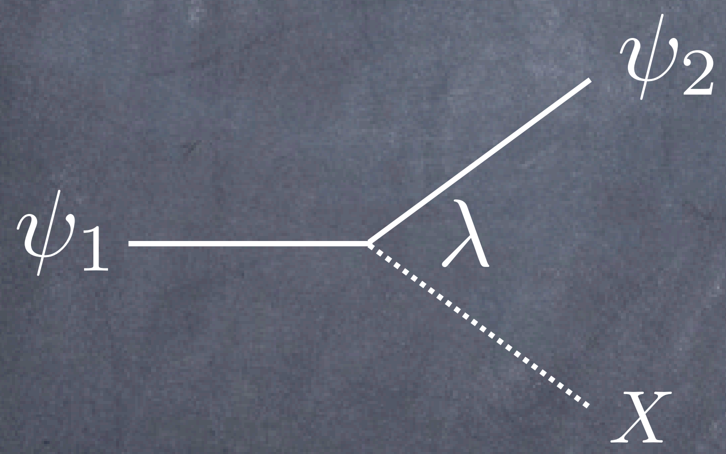

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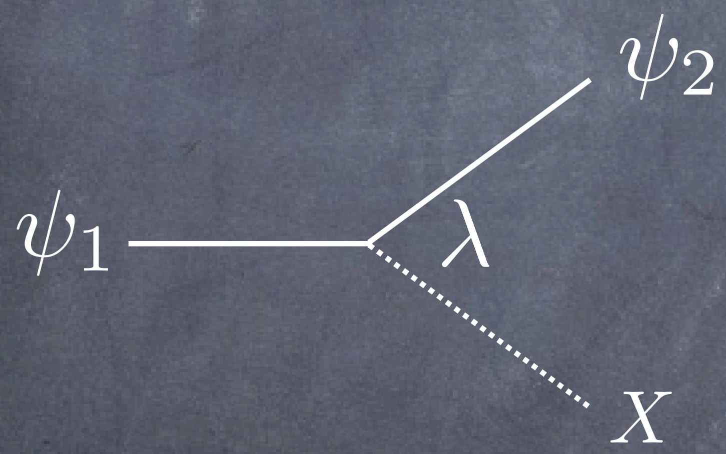

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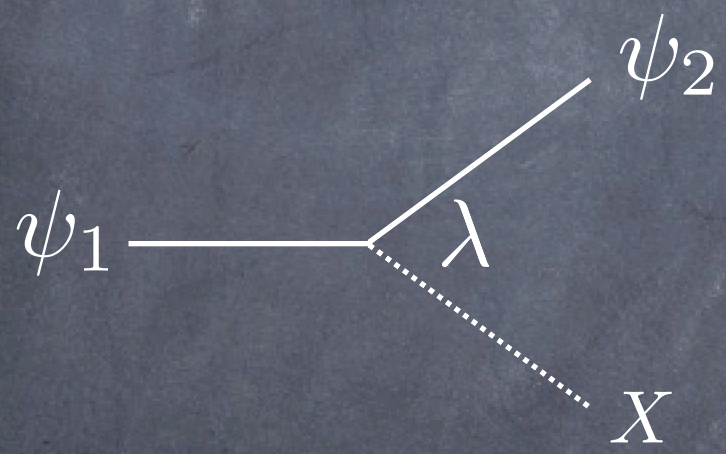

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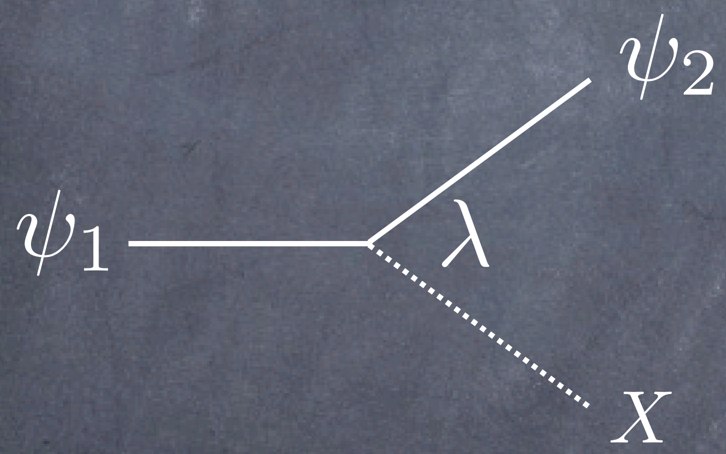

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- Lifetime of LOSP is long - signals at LHC, BBN...

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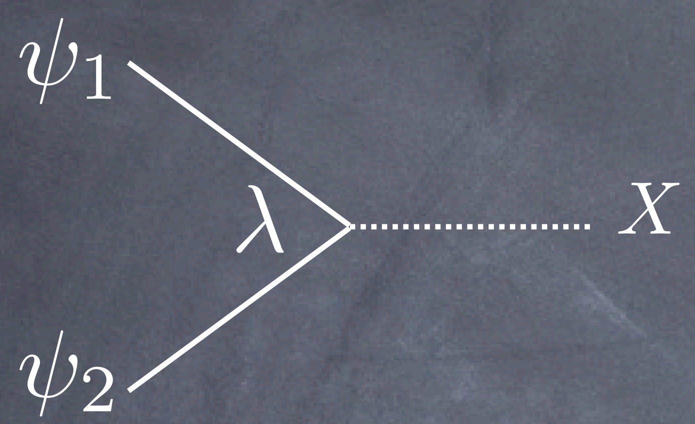

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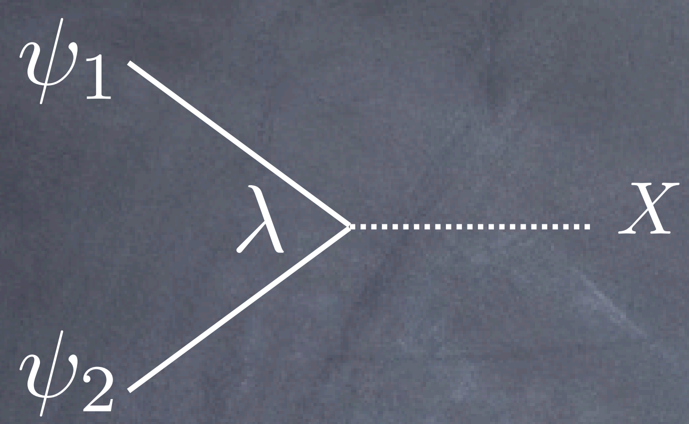

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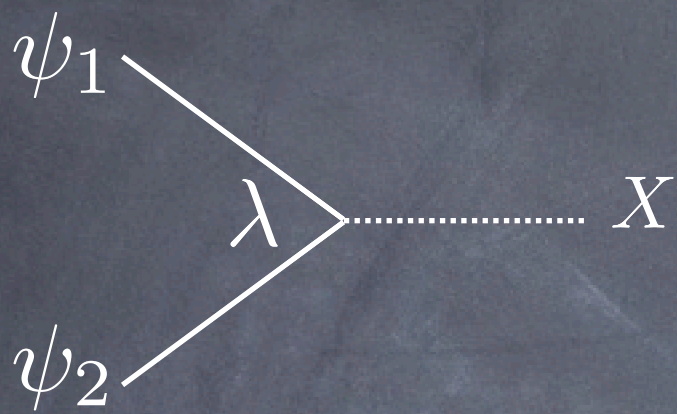

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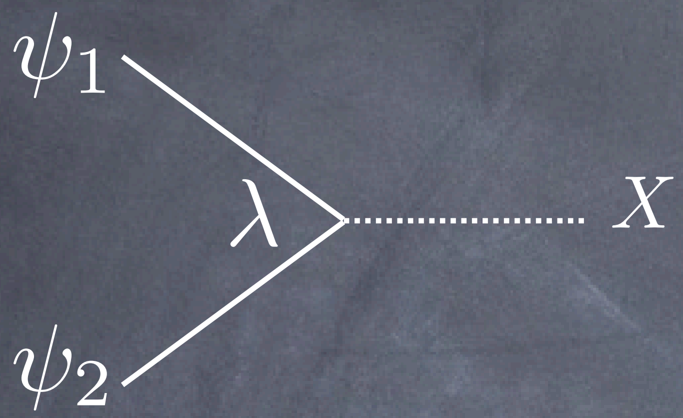

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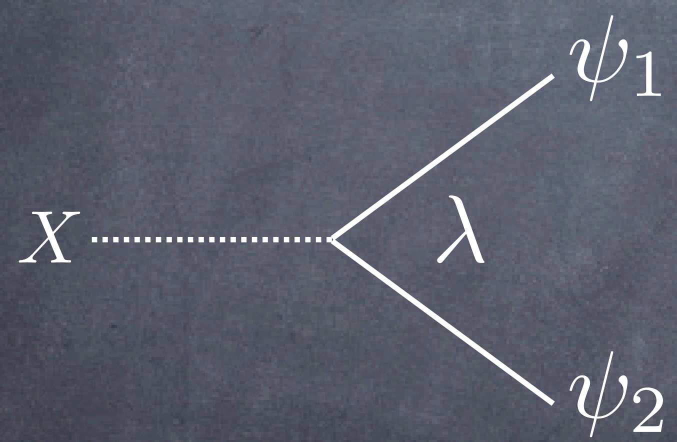

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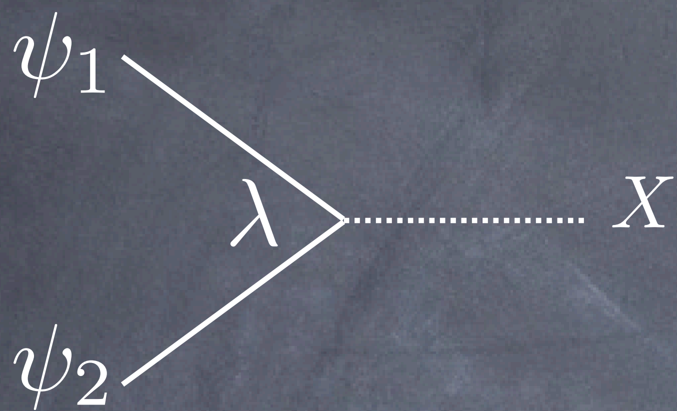

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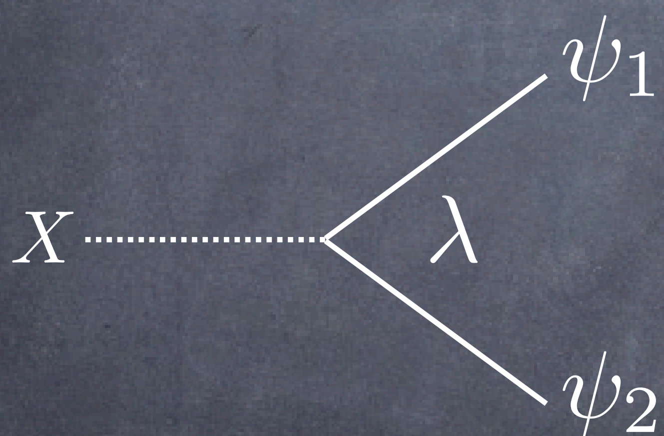

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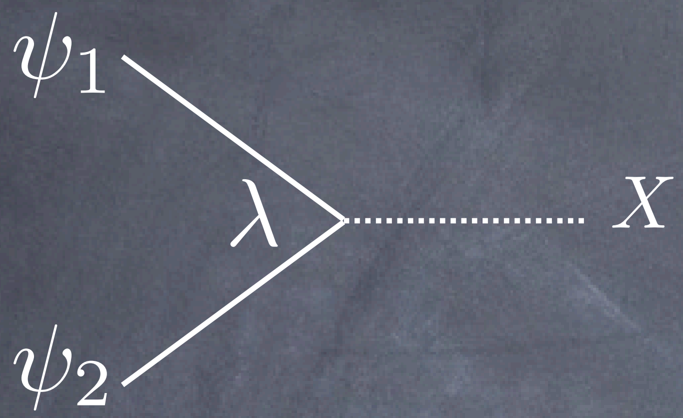

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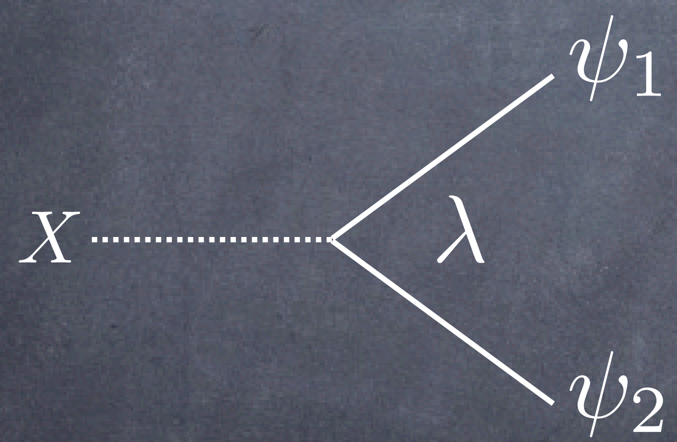

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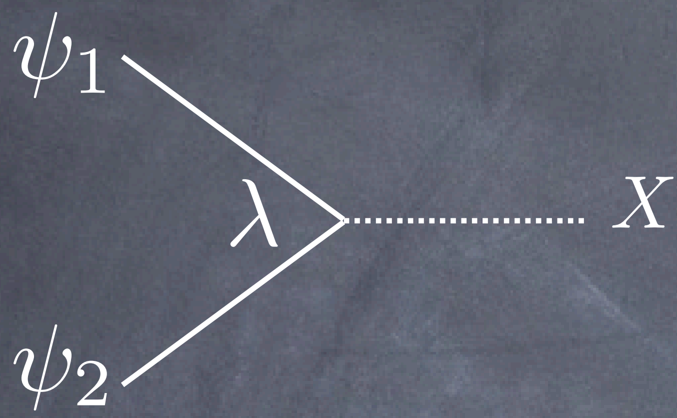

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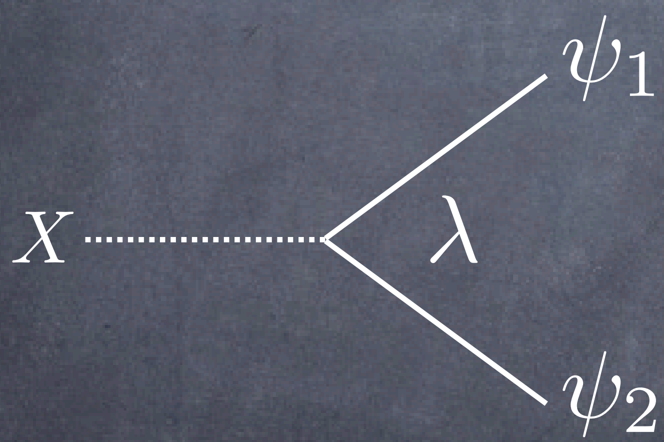

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- X lifetime can be long - implications for BBN, indirect DM detection

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- FIMPs from kinetic mixing: hidden sector particles coupling to the MSSM via mixing of $U(1)_Y$ and hidden U(1) tiny mixing tiny coupling

- Others...

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- Enhanced indirect and direct detection: Relic abundance and DM annihilation cross section no longer related. Freeze-in dominantly produces DM abundance annihilation cross section must be large - freeze-out abundance is small

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Much more to come...

Freeze-in vs Freeze-out

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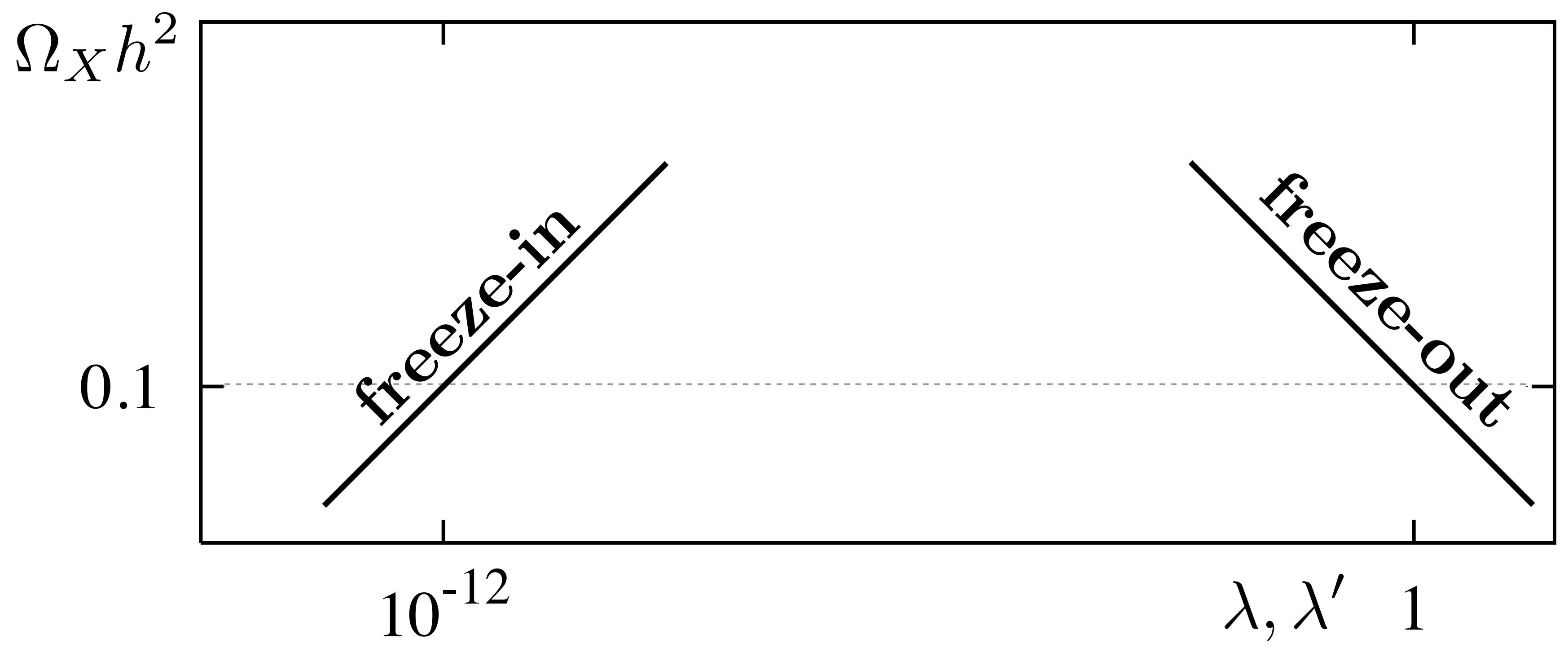

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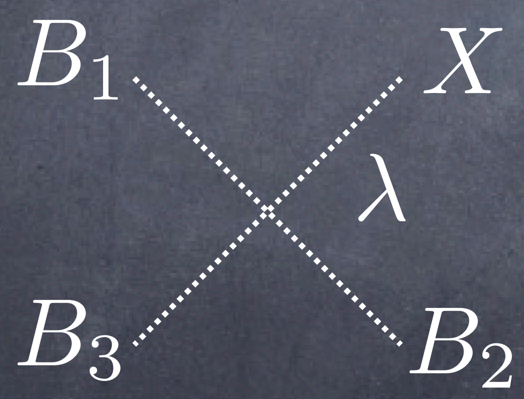

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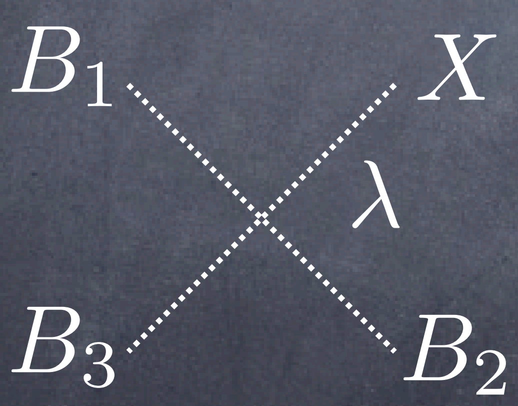

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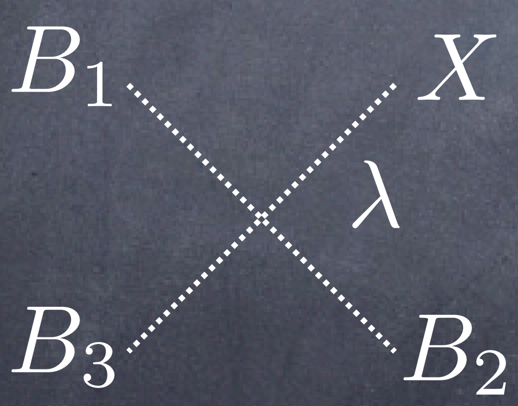


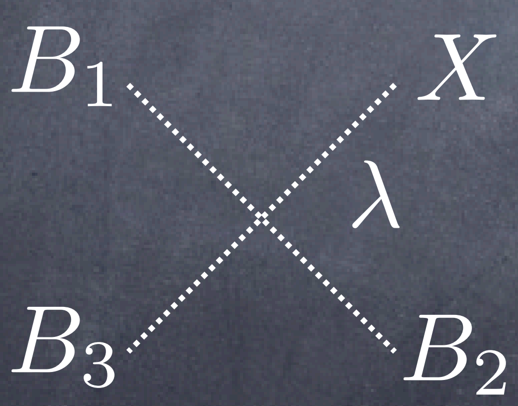
$$\Omega h^2_X \approx 1.01 \times 10^{21} \lambda^2$$

Example Model II

- Many applications and variations of the Freeze-in mechanism
- Assume FIMP is lightest particle carrying some stabilising symmetry - FIMP is the DM
- Consider quartic coupling of FIMP with three bath scalars

$$\mathcal{L}_Q = \lambda X B_1 B_2 B_3$$

Assuming
$m_x \gg m_{B_1}, m_{B_2}, m_{B_3}$



$$\Omega h^2_X \approx 1.01 \times 10^{21} \lambda^2$$

For correct DM abundance $\Rightarrow \lambda \sim 10^{-11}$

- NOTE: Abundance in this case is independent of the FIMP mass