HIDDeν
Hunting Invisibles: Dark sectors, Dark matter and Neutrinos

GEORG-AUGUST-UNIVERSITÄT GÖTTINGEN IN PUBLICA COMMODA SEIT 1737

University of Goettingen, Institute for Theoretical Physics

FREEZE-IN @ DIRECT DETECTION

Francesco Costa

C. Cosme, **FC**, O. Lebedev, arXiv: 2306.13061
FC, L. Covi, to appear soon

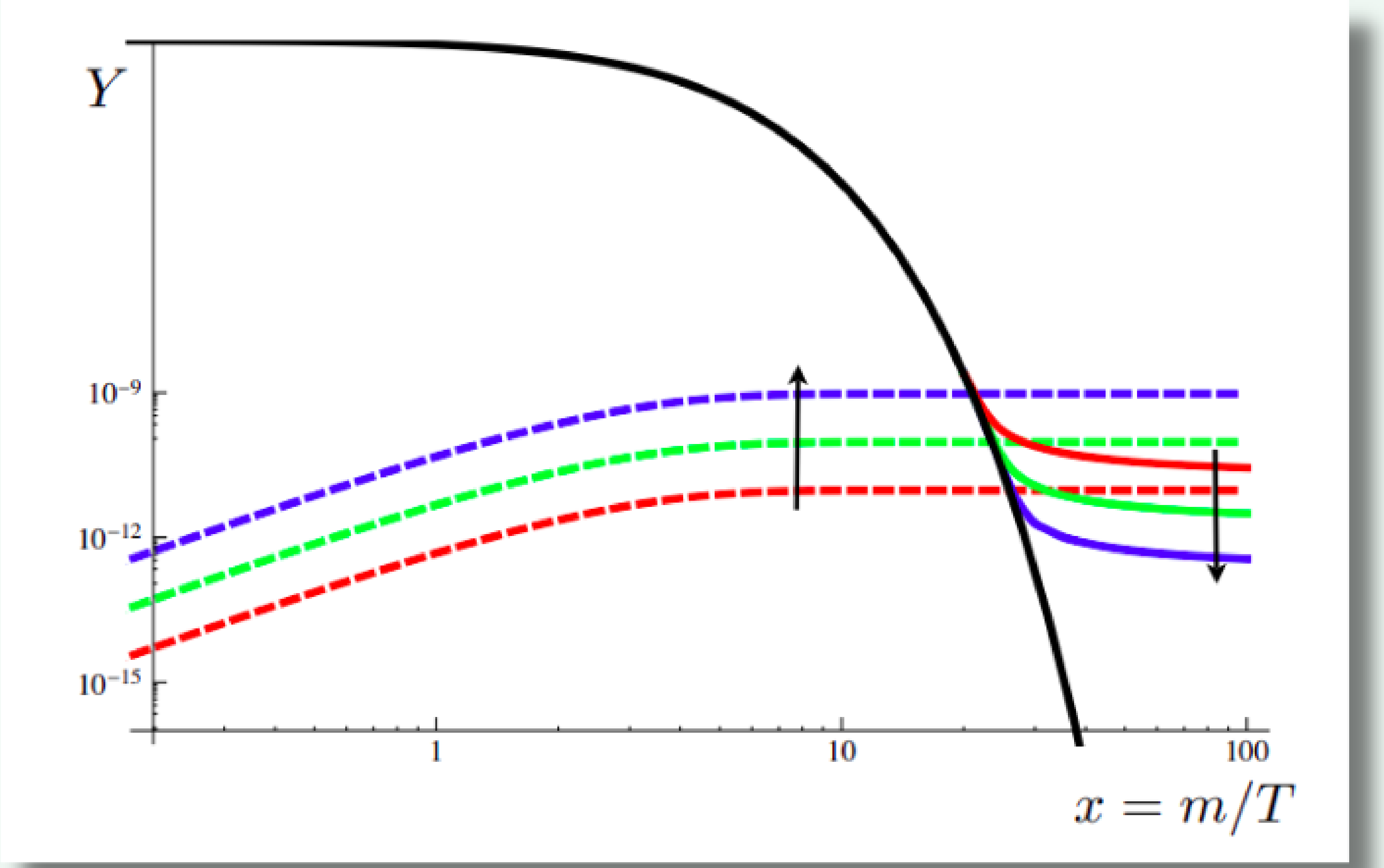
FREEZE-IN

- Out-of-equilibrium
- Dependence on the initial conditions

→ We assume a negligible initial abundance

- Very low couplings

$$\lambda \sim \mathcal{O}(10^{-10})$$



J. McDonald, hep-ph/0106249
L. J. Hall, K. Jedamzik, J. March-Russell, S. M. West, 0911.1120

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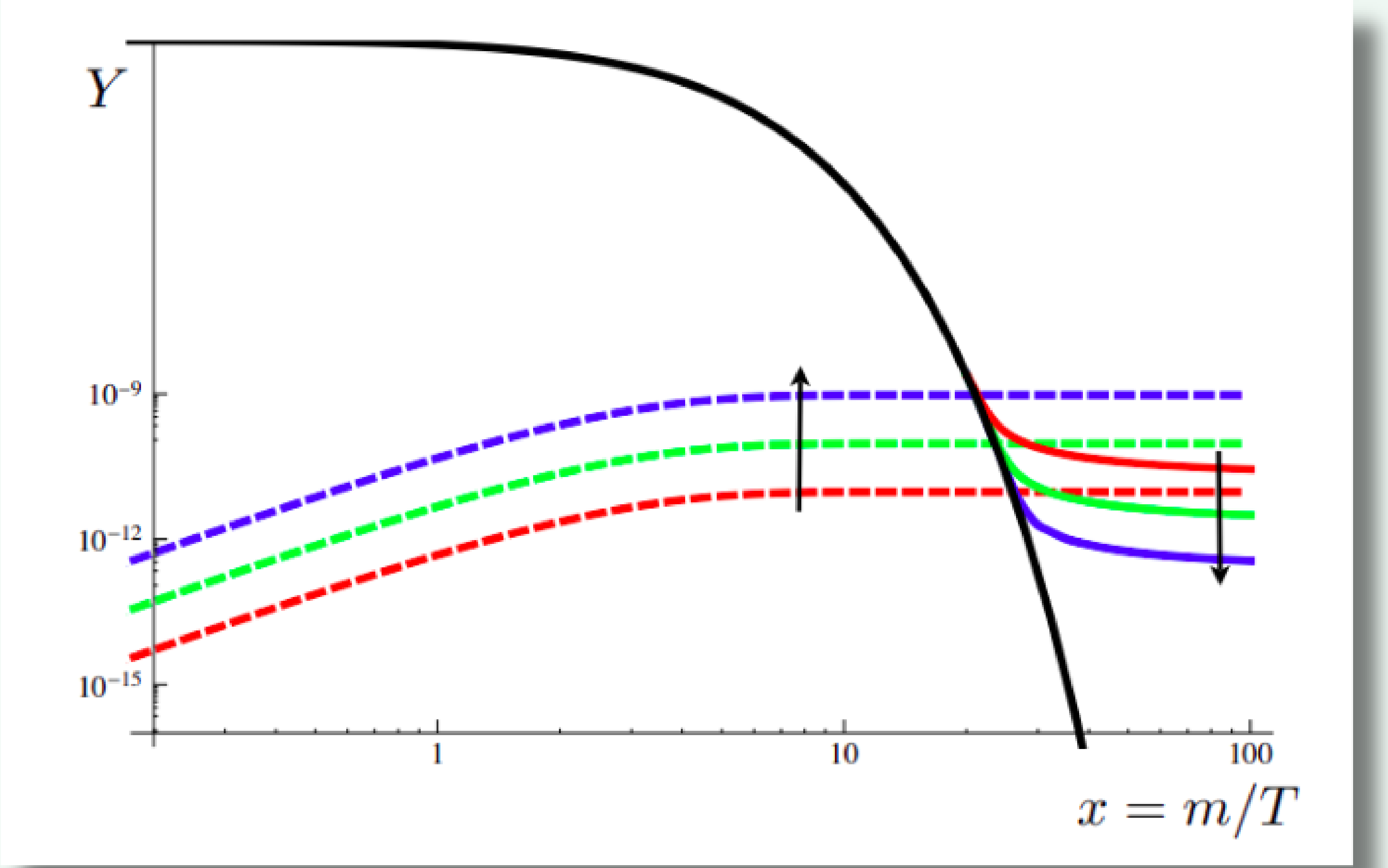

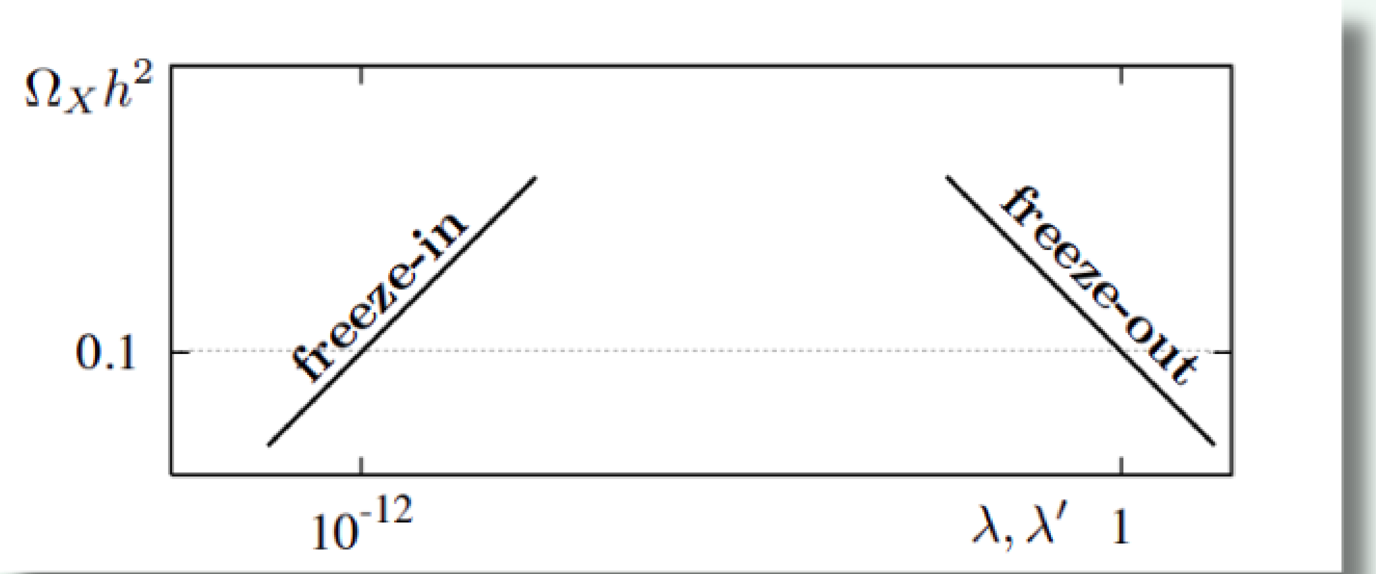

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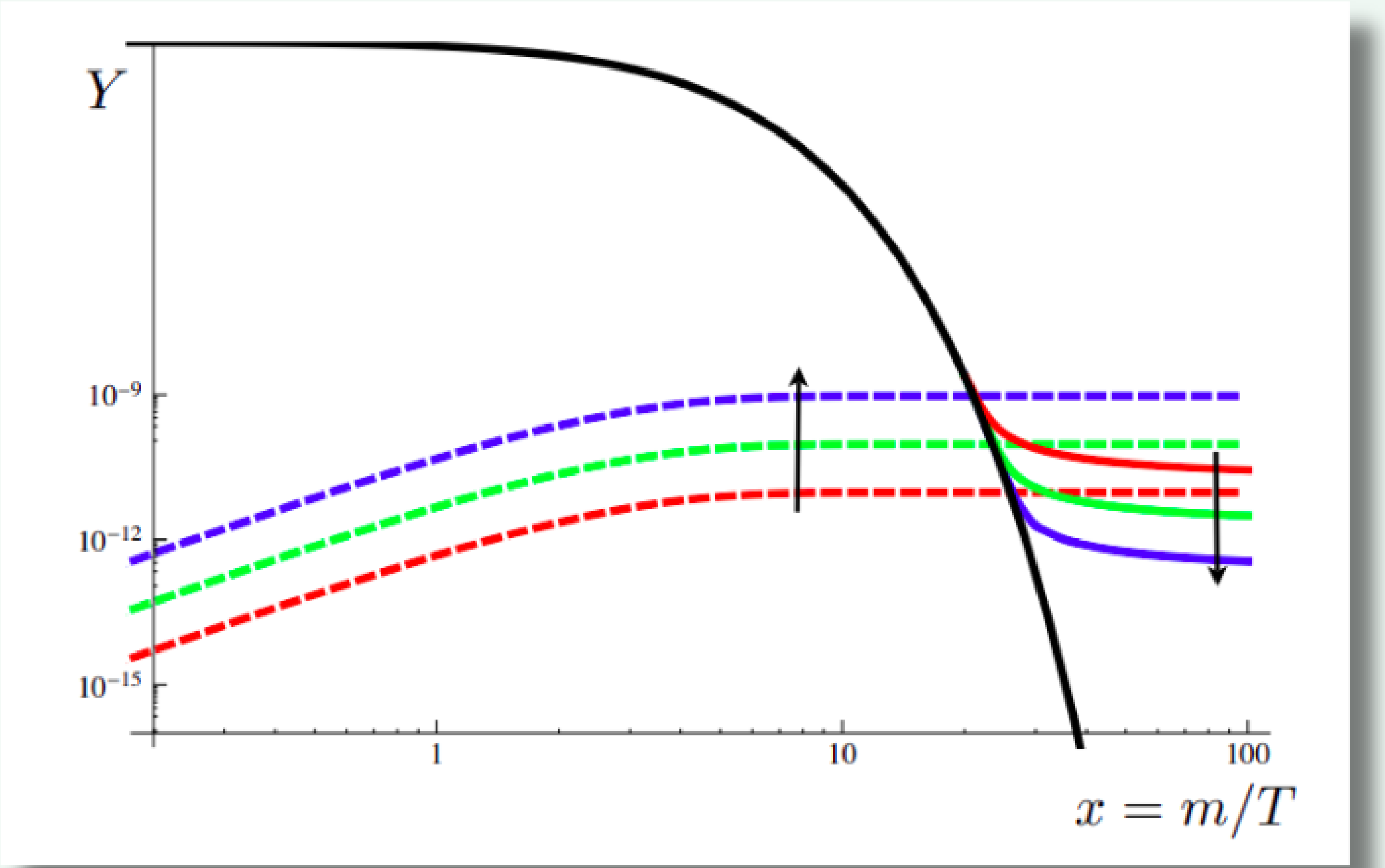

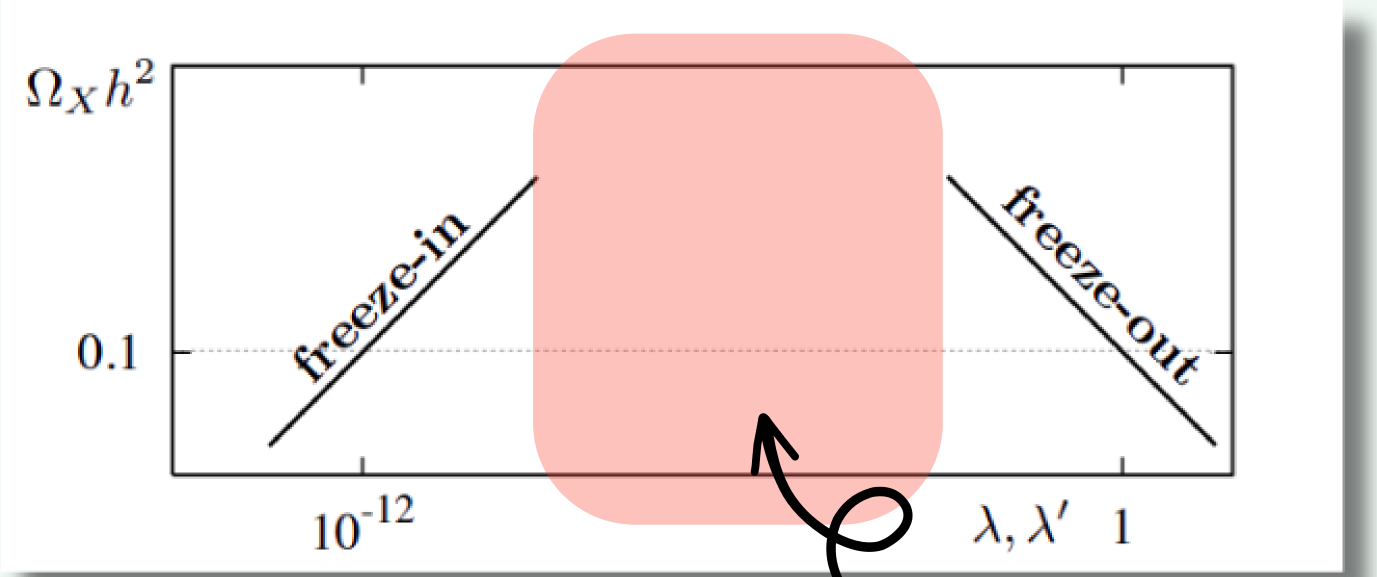

overproduction

J. McDonald, hep-ph/0106249
L. J. Hall, K. Jedamzik, J. March-Russell, S. M. West, 0911.1120

GRAVITATIONAL PARTICLES PRODUCTION

s is the scalar DM particle

QUANTUM GRAVITY OPERATORS

$$C\frac{\phi^4 s^2}{M_{\rm Pl}^2}$$

O. Lebedev, 2210.02293
Y. Ema, R. Jinno, K. Mukaida, K. Nakayama, 1502.02475

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$\Omega_s h^2 \lesssim 0.1$

$$\Delta_{\rm NR} \gtrsim 10^{17} C^2 \frac{m_s}{\rm GeV}$$

Lower bound on the matter dominated epoch in order to avoid overproduction of DM

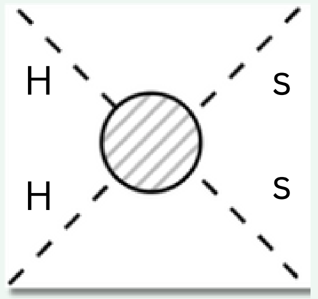
O. Lebedev, 2210.02293
Y. Ema, R. Jinno, K. Mukaida, K. Nakayama, 1502.02475

WHAT HAPPENS AT LOW TR?

t

Higgs portal

$$\mathcal{L} \supset \frac{1}{2}\lambda_{hs} s^2 H^\dagger H$$



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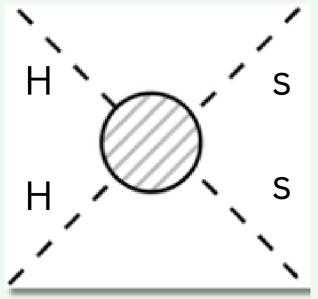
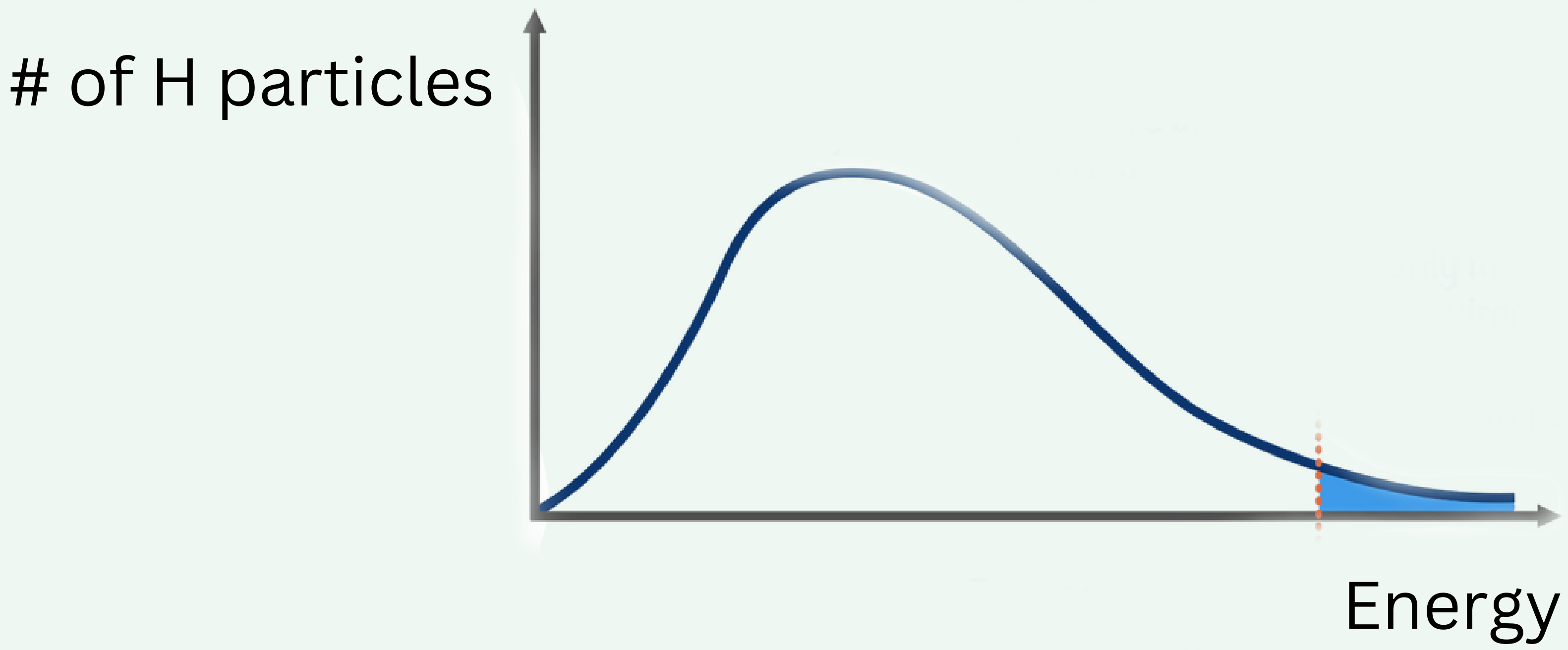


$m_H < m_s \ \& \ T_R < m_s$



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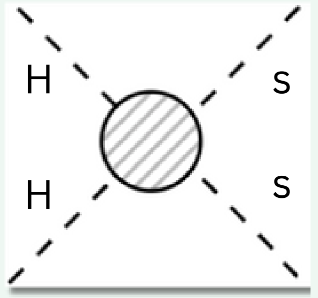

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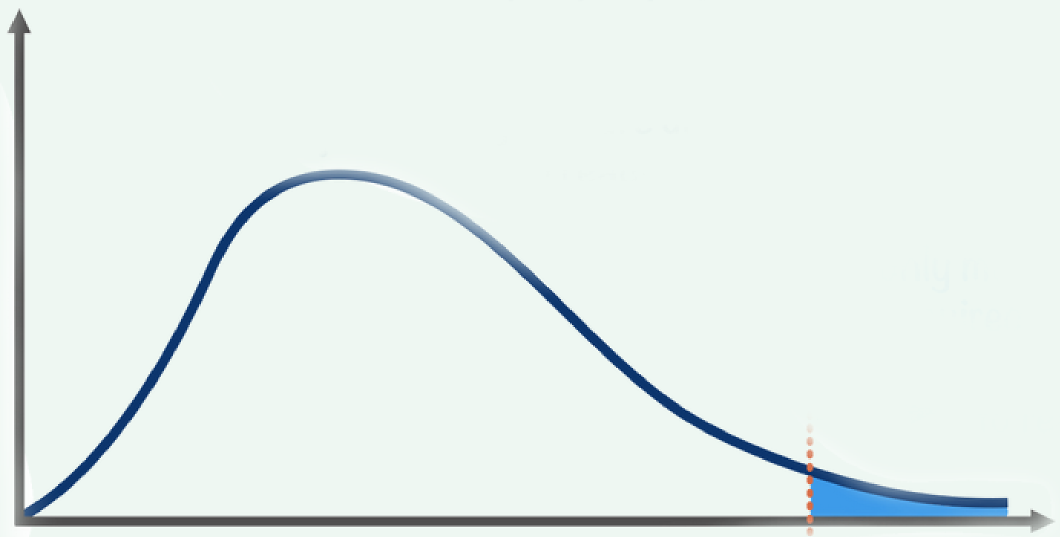

$$\Gamma(h_i h_i \to ss) \simeq \frac{\lambda_{hs}^2 T^3 m_s}{2^7 \pi^4} e^{-2m_s/T}$$

The rate of production is Boltzmann suppressed

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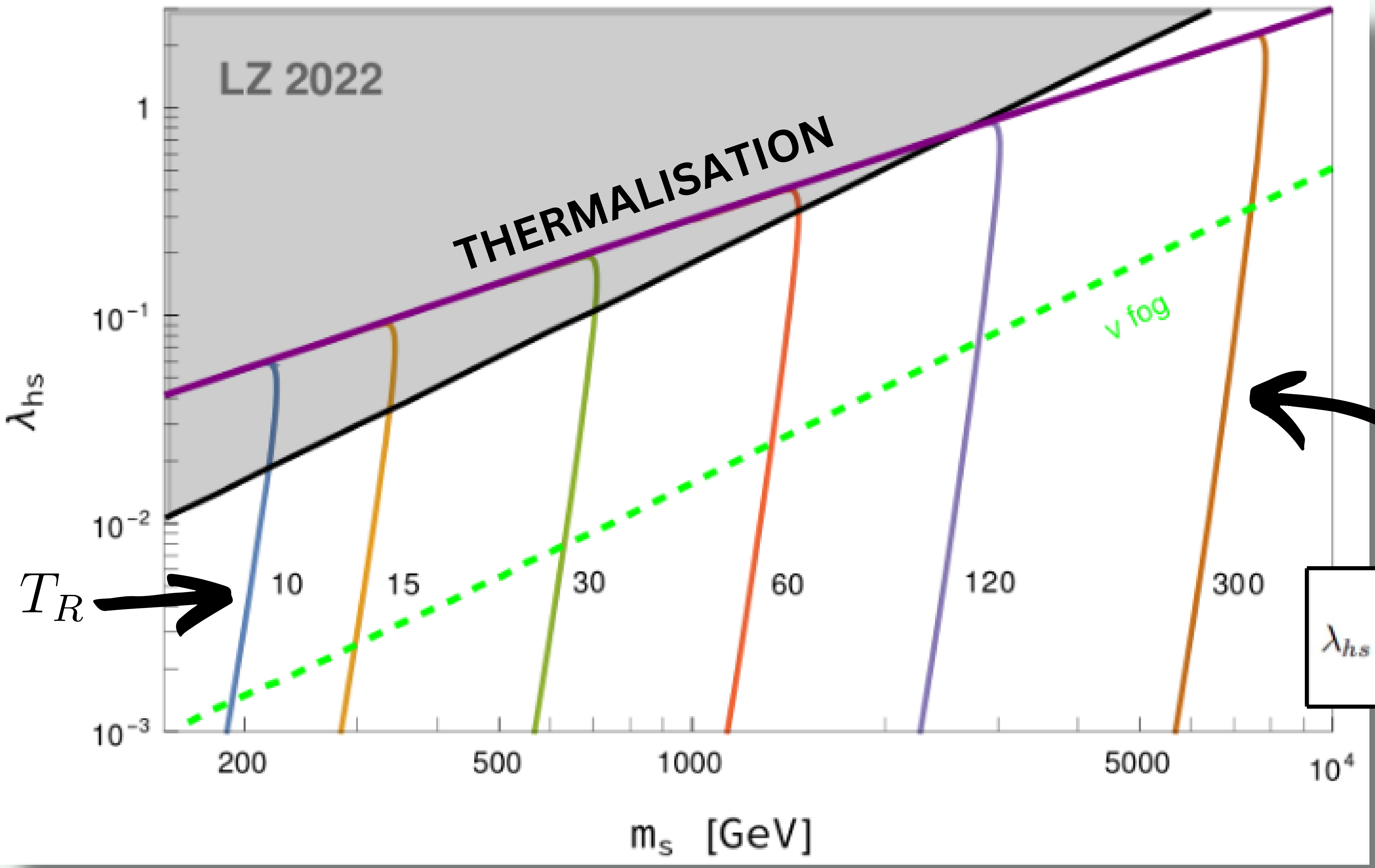
DIRECT DETECTION



$$\lambda_{hs} \simeq 3 \times 10^{-11} \, e^{m_s/T_R} \sqrt{\frac{T_R}{m_s}}$$

TAKE HOME MESSAGE

EARLY UNIVERSE EFFICIENT
GRAVITATIONAL PRODUCTION

NEED FOR A "LONG" MATTER DOMINATED EPOCH AND **LOW REHEATING TEMPERATURE** TO AVOID OVEPRODUCTION

BOLTZMANN SUPPRESSED PRODUCTION RATE AND POSSIBLE **DIRECT DETECTION SIGNATURES**

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THANK YOU

Francesco Costa

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University of Goettingen

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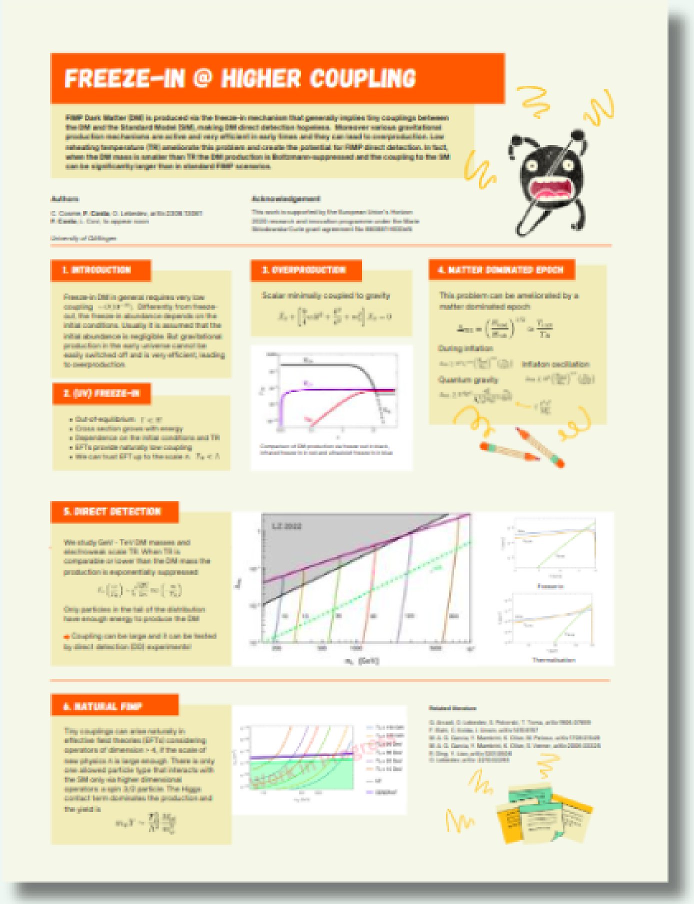

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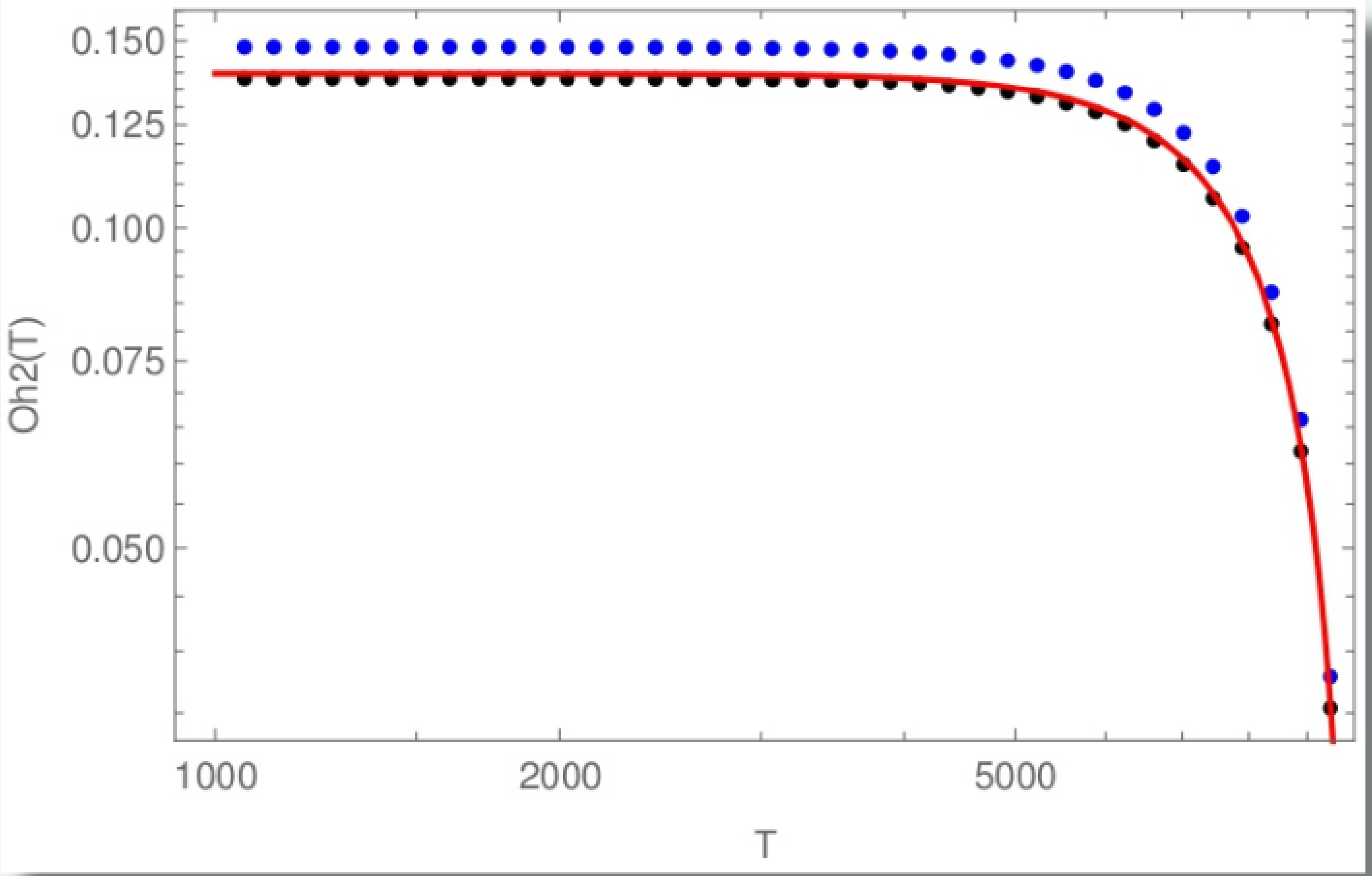
More info on my poster and on arXiv: 2306.13061

BACK-UP

Relativistic effect



Non-instantaneous reheating

$$m_\psi Y = 4 \times m_\psi Y_{inst}$$

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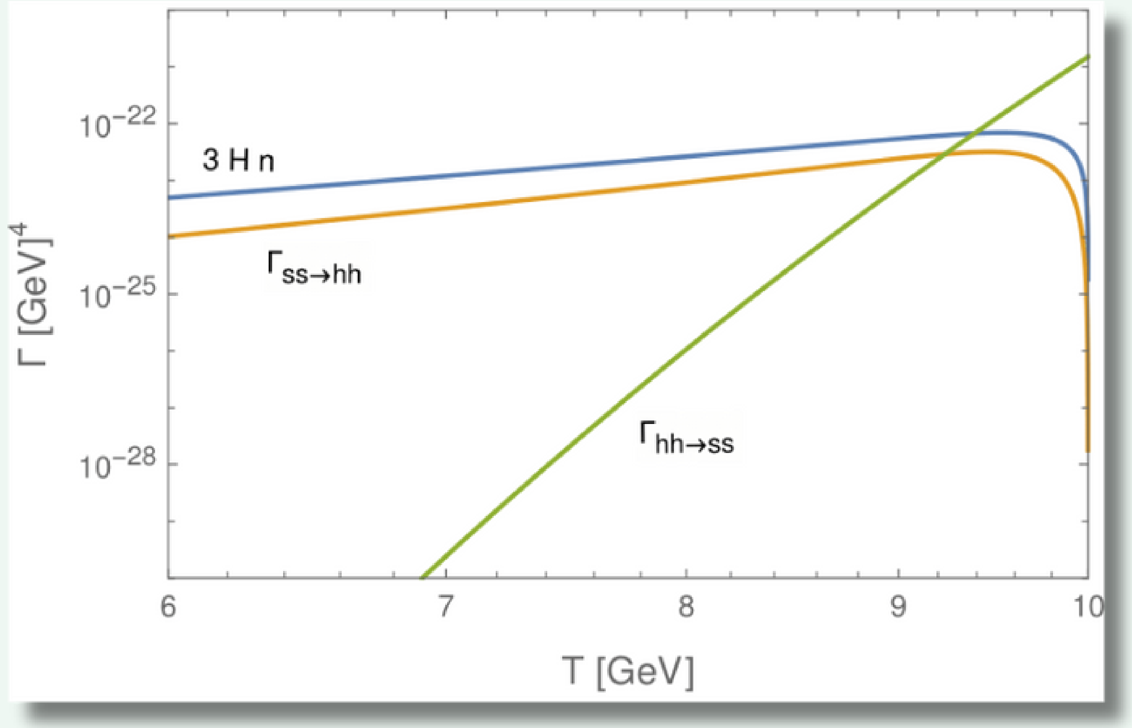
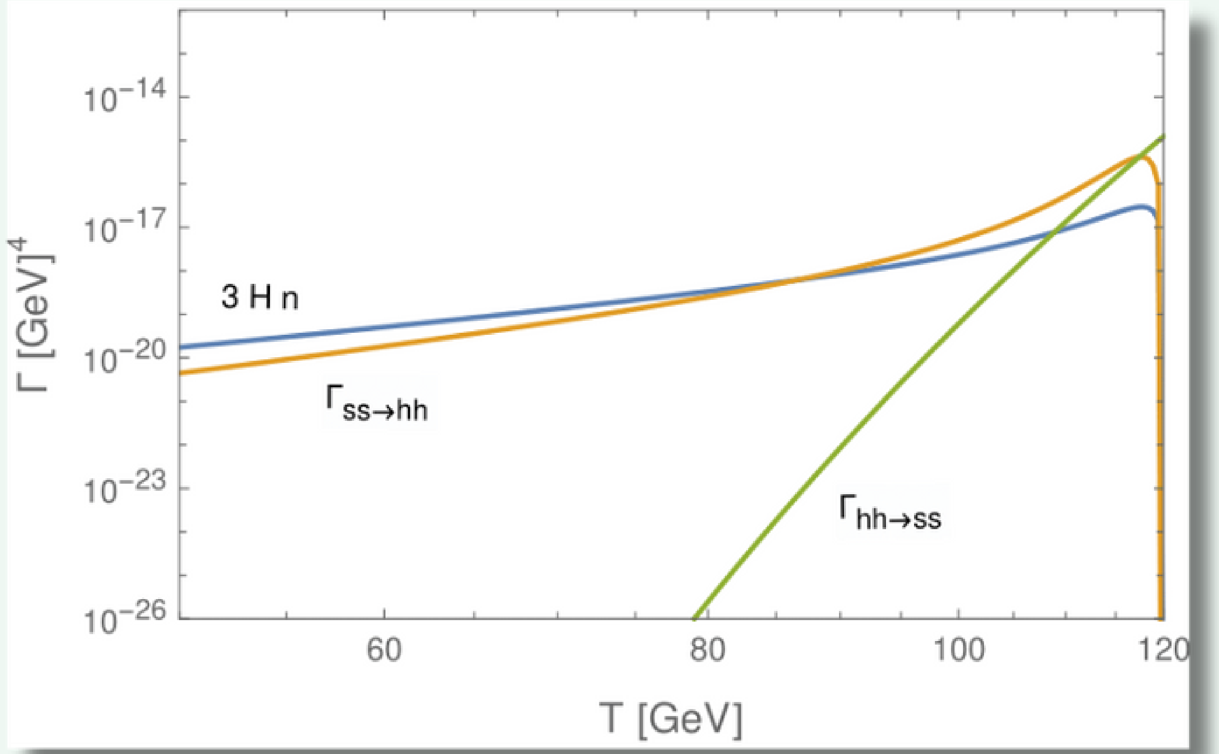
THREE REGIMES

Boltzmann suppressed freeze-in



Annihilation becomes relevant



Dark Matter thermalises