Consolidating secluded sectors with the Higgs Portals

Particle Physics in Poland

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Esau Cervantes

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Supervisor: Andrzej Hryczuk

Self Interacting Dark Matter

SELF-INTERACTING DARK MATTER

ERIC D. CARLSON
Lyman Laboratory of Physics, Harvard University, Cambridge, MA 02138

MARIE E. MACHACEK
Department of Physics, Northeastern University, Boston, MA 02115
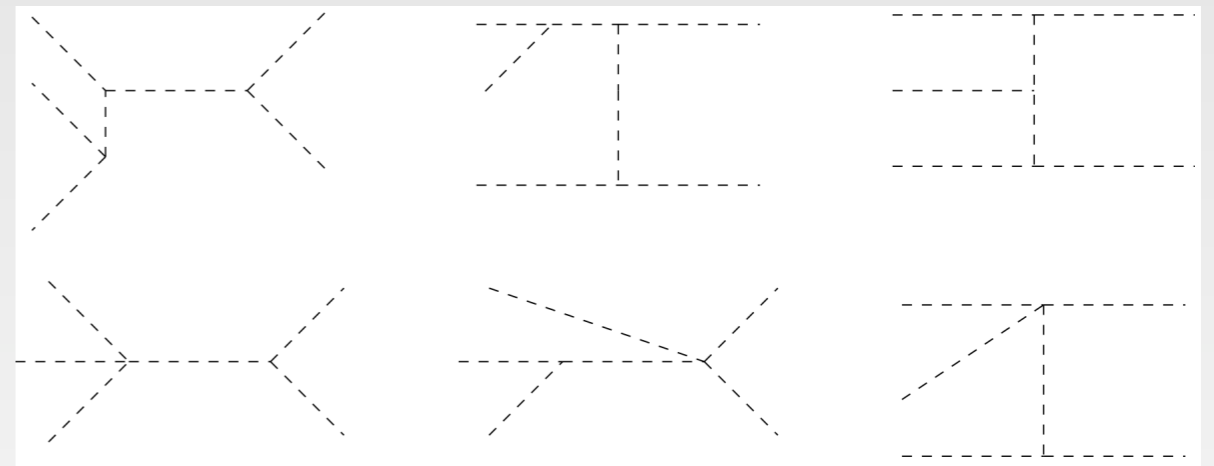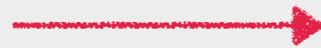
AND

LAWRENCE J. HALL
Department of Physics, University of California; and Theoretical Physics Group, Physics Division,
Lawrence Berkeley Laboratory, 1 Cyclotron Road, Berkeley, CA 94720

Simple realisation with a scalar field: $\dfrac{g}{3!}\phi^3 + \dfrac{\lambda}{4!}\phi^4$

If DM is non-relativstic, $\Gamma_{3\to2} > \Gamma_{2\to3}$. The DM fluid **exchanges** particle number for kinetic energy!
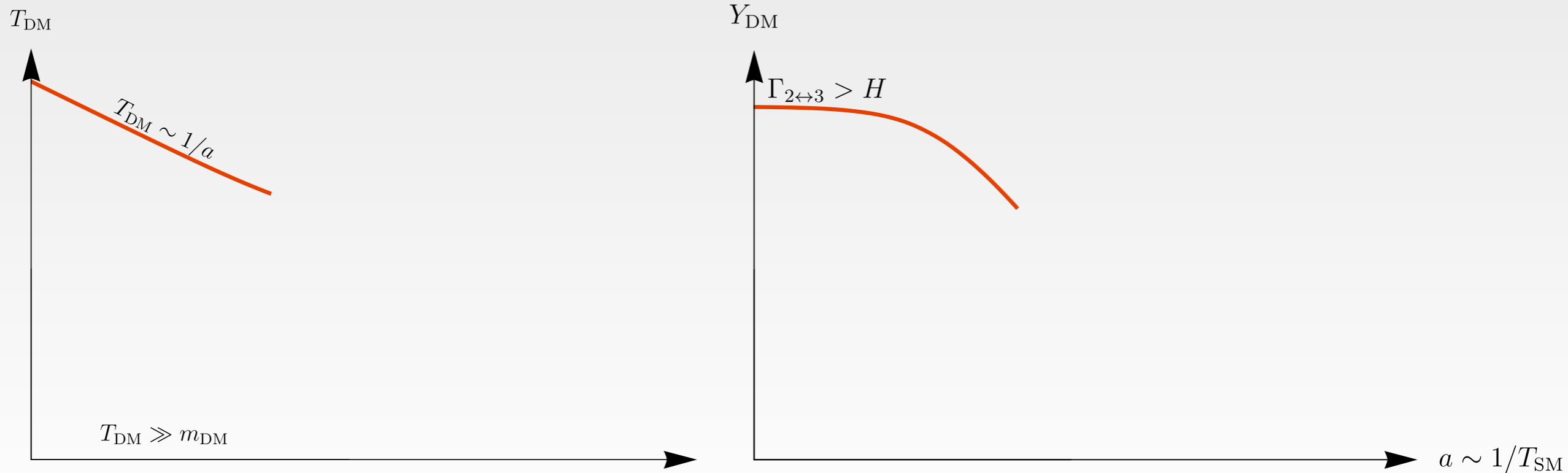
Self Interacting Dark Matter

Absence of portals to the SM implies $T_{DM} \neq T_{SM}$. Temperature evolution becomes relevant:

Self Interacting Dark Matter

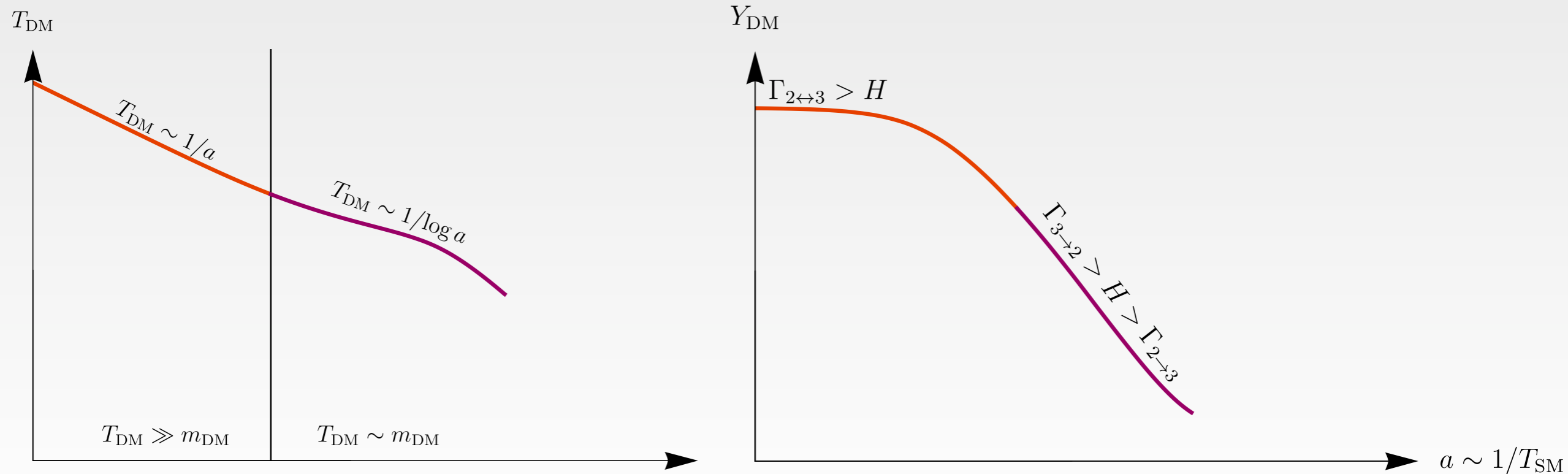Absence of portals to the SM implies $T_{DM} \neq T_{SM}$. Temperature evolution becomes relevant:

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Self Interacting Dark Matter

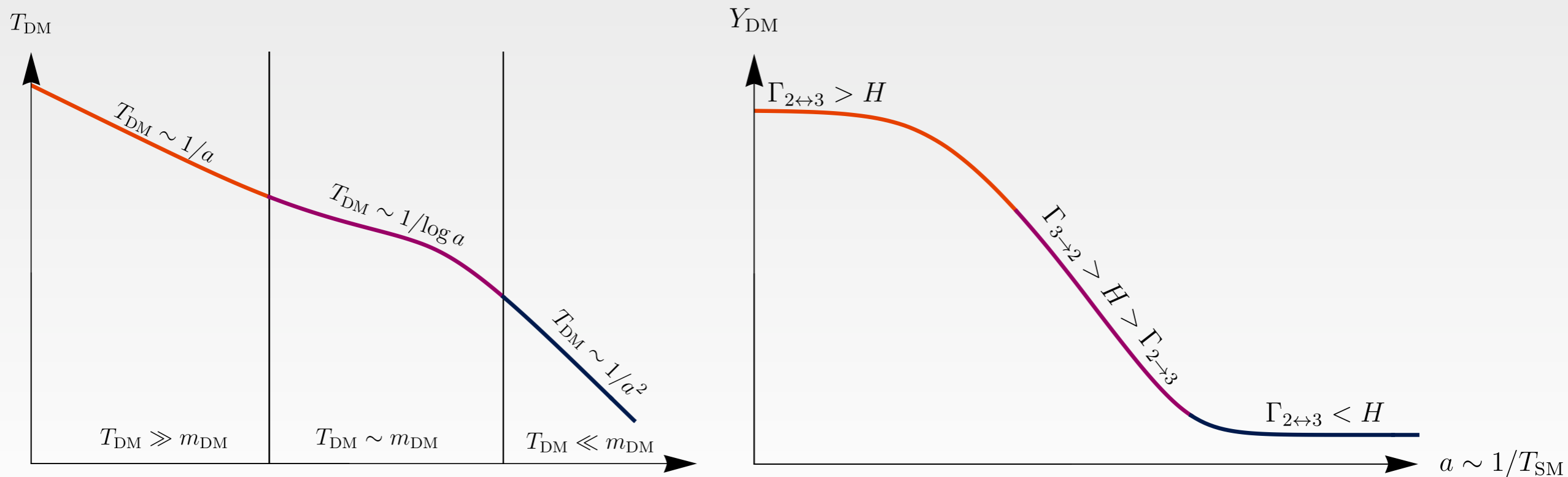Absence of portals to the SM implies $T_{DM} \neq T_{SM}$. Temperature evolution becomes relevant:

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See also Hufnagel, Tygat 22 and Arcadi, Lebedev 19
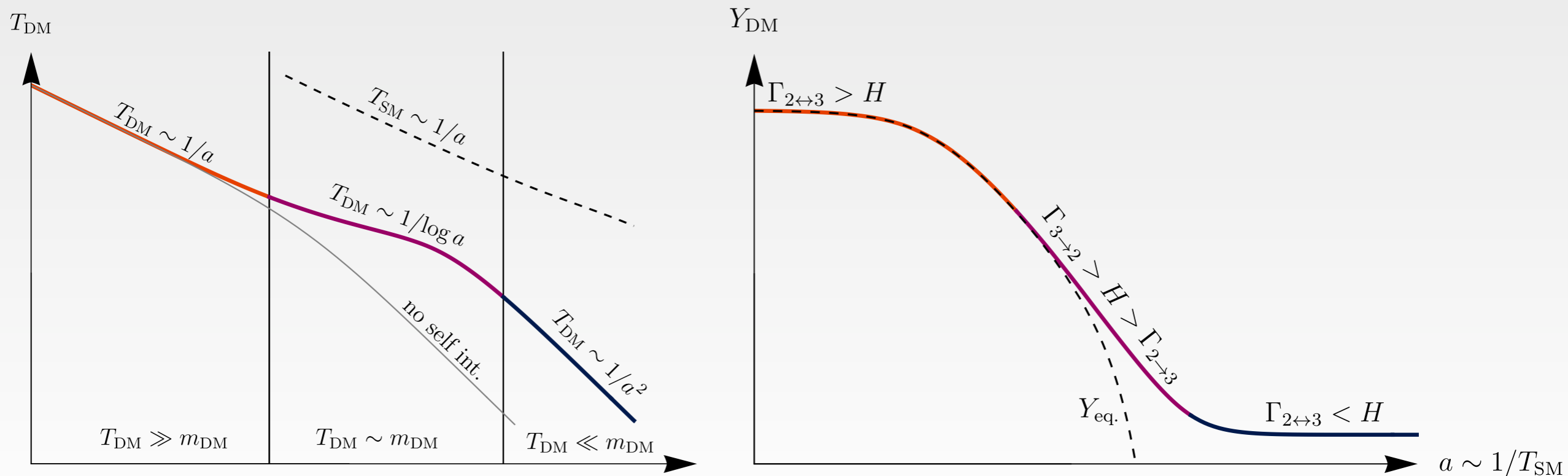
Stable DM with decaying mediator

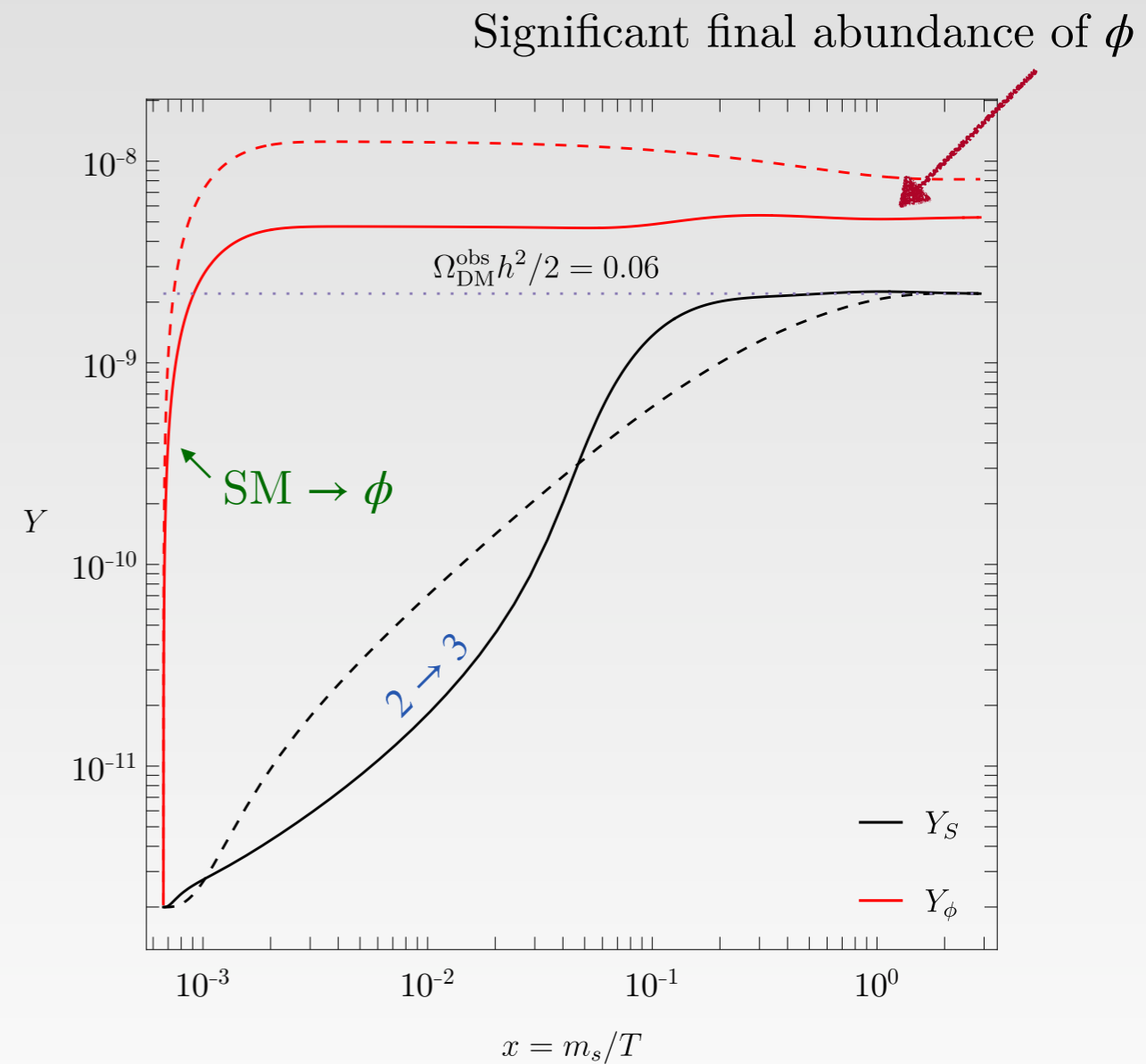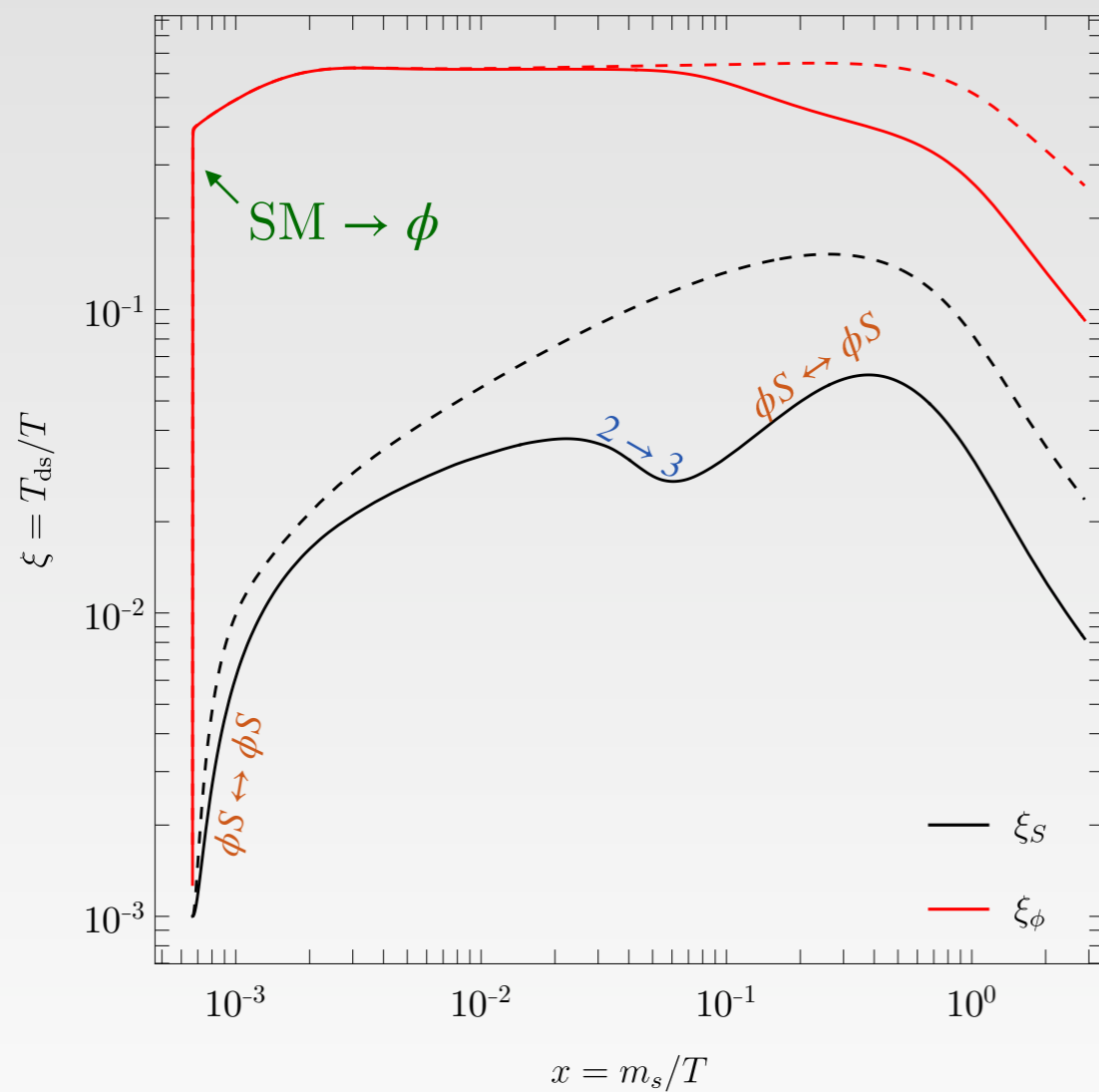Simple framework: A complex ($\mathbb{Z}_3$ stabilised) DM candidate S and a real singlet mediator ϕ:

$$\mathcal{L} \supset -\frac{1}{3!}g_s(S^3 + (S*)^3) - \frac{\lambda_s}{4}|S|^4 - A_{\phi s}\phi|S|^2 - \frac{\lambda_{\phi s}}{2}\phi^2|S|^2 - B_{\phi h}\phi|H|^2$$

DM self interactions   DM-mediator int.   Portal

Portal term **induces mixing** between ϕ and the Higgs. ϕ couples to matter as a *second* Higgs.

Dark Matter-mediator evolution
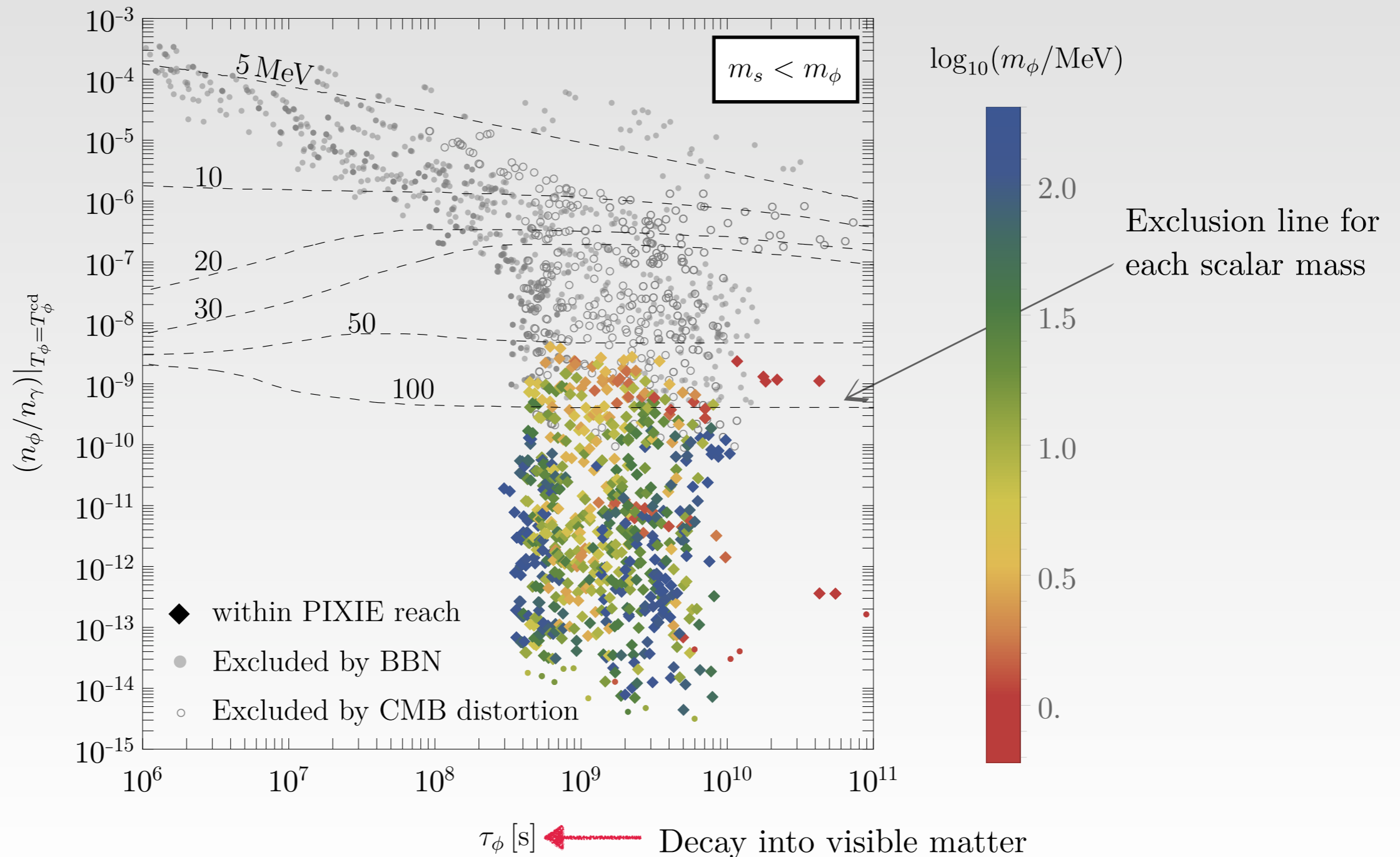
Benchmark point with $m_\phi < m_s$.

Significant final abundance of ϕ

Constraints on mediator

During Big Bang Nucleosynthesis ($T_{SM} \sim 1$ MeV) nucleons combined. Presence of mediators may **violate** BBN constraints:

Conclusions

- *Frozen-in* Cannibal DM is a viable scenario that explains the origin of a cannibalising dark sector (often not addressed);

- It has unique evolution in the Early Universe & potentially **detectable signals in direct and indirect searches**;

- Temperature (and momentum distribution) can have a **non-trivial** impact in such scenarios and **need to be studied** carefully.
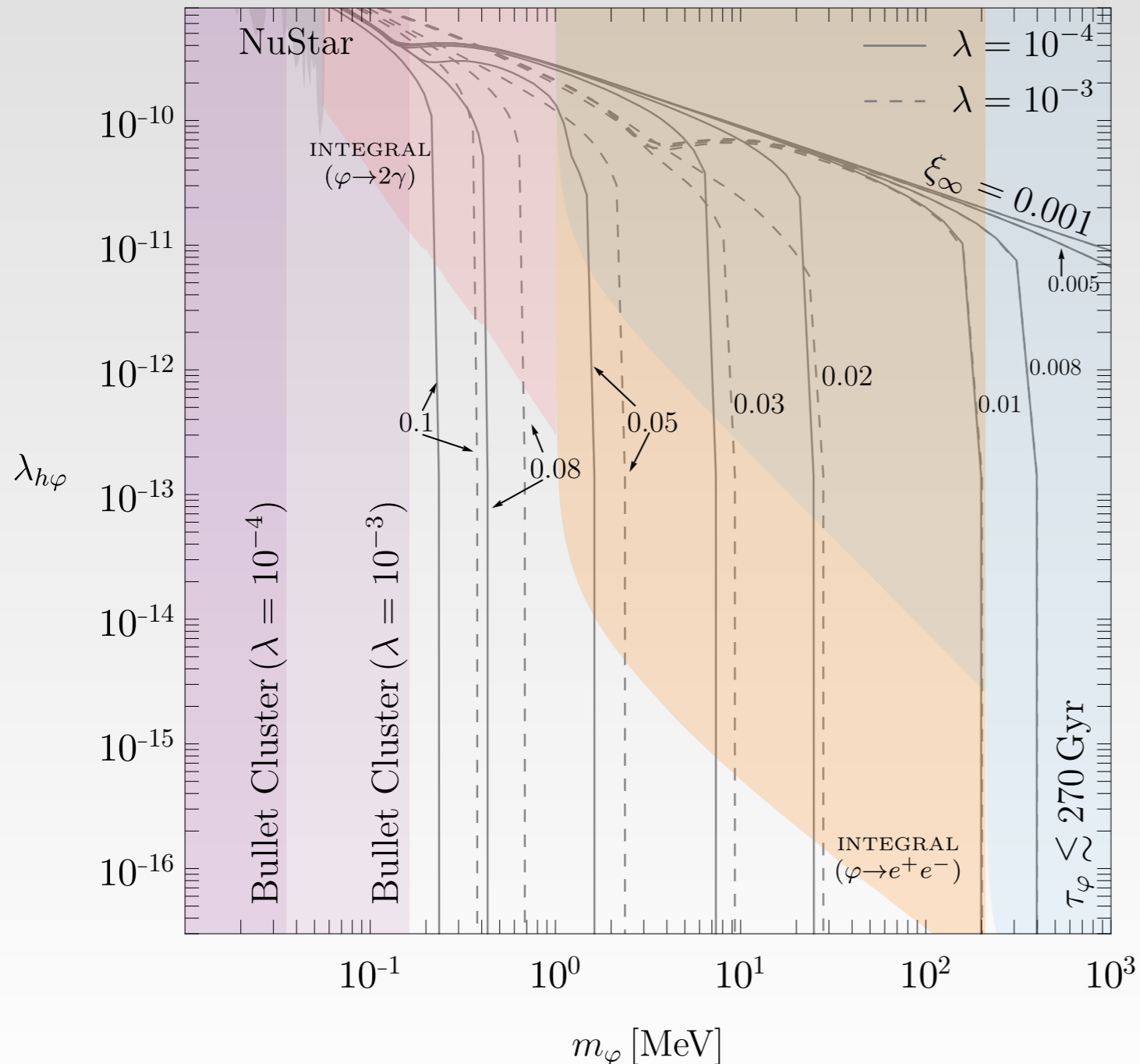
Consolidating interactions with matter

Toy model with Higgs Portal: $\mathcal{L} \supset -\lambda_{h\varphi}\varphi^2 H^\dagger H$, $\lambda_{h\varphi} \ll 1$, and initially cold DM; $T_{DM}/T_{SM} = 10^{-2}$:
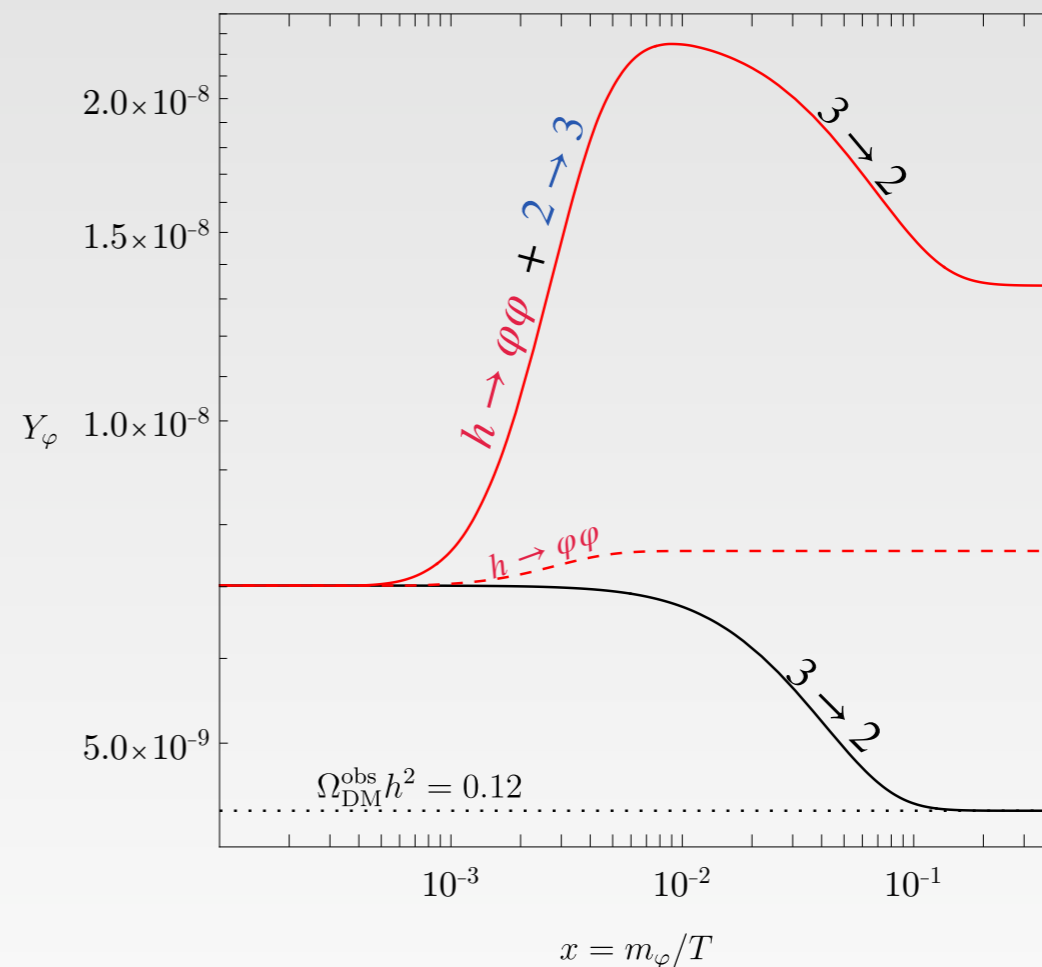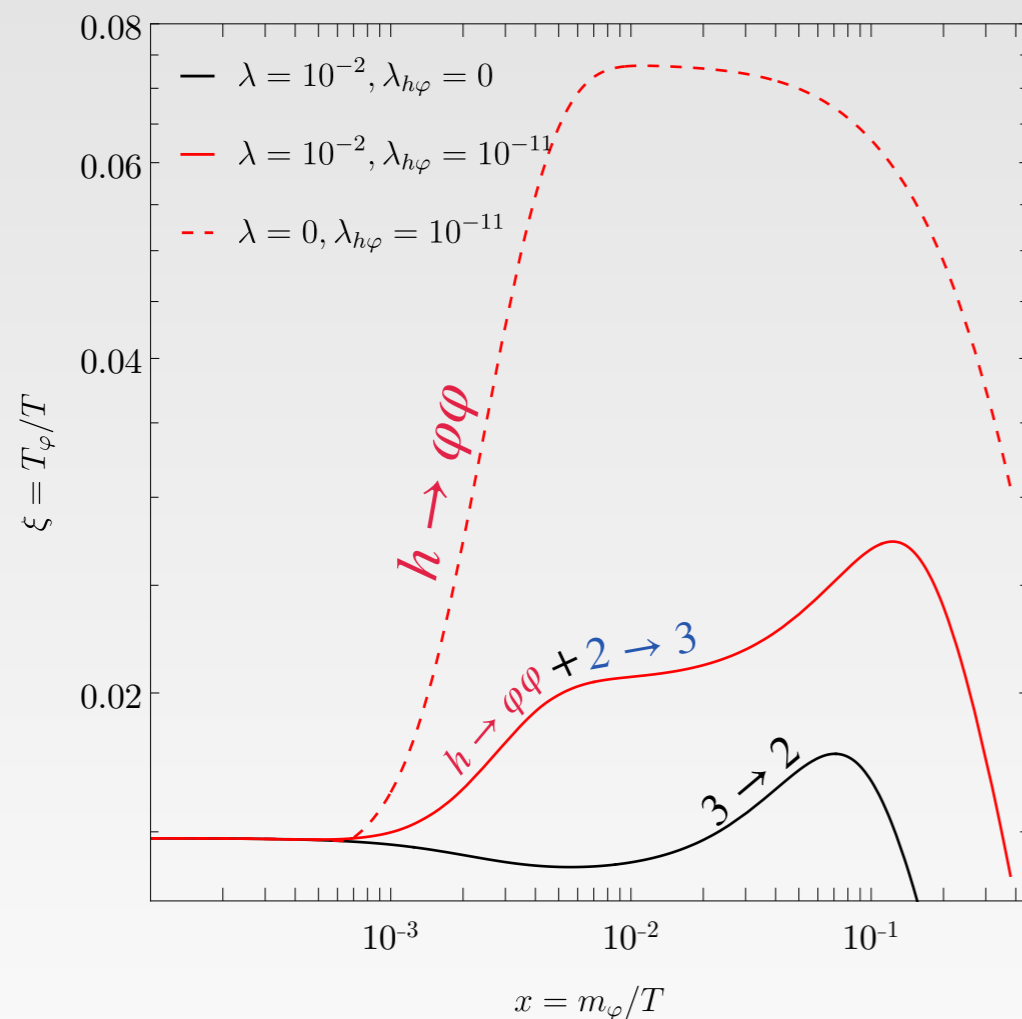
Decaying Dark Matter

If the symmetry stabilizing DM is broken, it will decay with
$\tau_\varphi \propto 1/\lambda_{h\varphi}^2$:

- $\xi_\infty = T_{DM}^i/T_{SM}^i < 1$;

- NuStar and INTEGRAL are telescopes constraints;

- 270 Gyr is the constraint by CMB;

- Bullet Cluster constraints DM self interactions $\sigma_{2\to2}$;

- The case $\lambda_{h\varphi} = 0$ is studied in Hufnagel, Tygat 22.