ALP leptogenesis

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Based on arXiv:**2407.01667**

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ALP leptogenesis

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Non-thermal leptogenesis from Majorana right-handed neutrinos produced out-of-equilibrium via **ALP decay**

$$\mathcal{L} \supset -y_\nu \overline{L} \cdot \phi N_R - \frac{1}{2} M_N \overline{N}^c_R N_R + \frac{\partial_\mu a}{f_a} \overline{N}_R \gamma^\mu N_R$$

Type I see-saw

$a \longrightarrow N\,N$

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In a nutshell

- **ALP production** via thermal scatterings

freeze-out

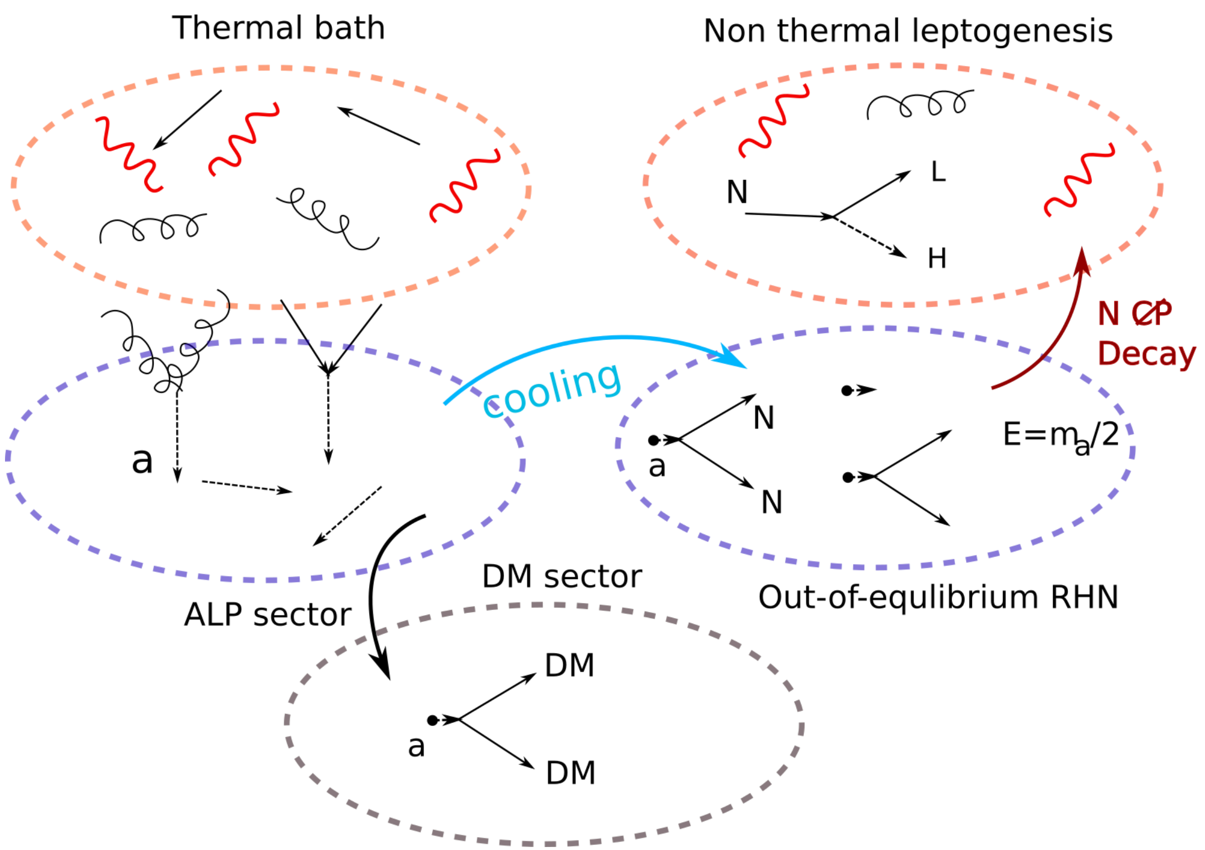
$$Y_a = Y_a^{\rm eq} \simeq 2.15 \cdot 10^{-3}$$

freeze-in

$$Y_a \ll Y_a^{\rm eq}$$

- **ALP decay** mostly to RHNs

- **Non–thermal leptogenesis**



ALP leptogenesis

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- Available parameter space for successful ALP leptogenesis

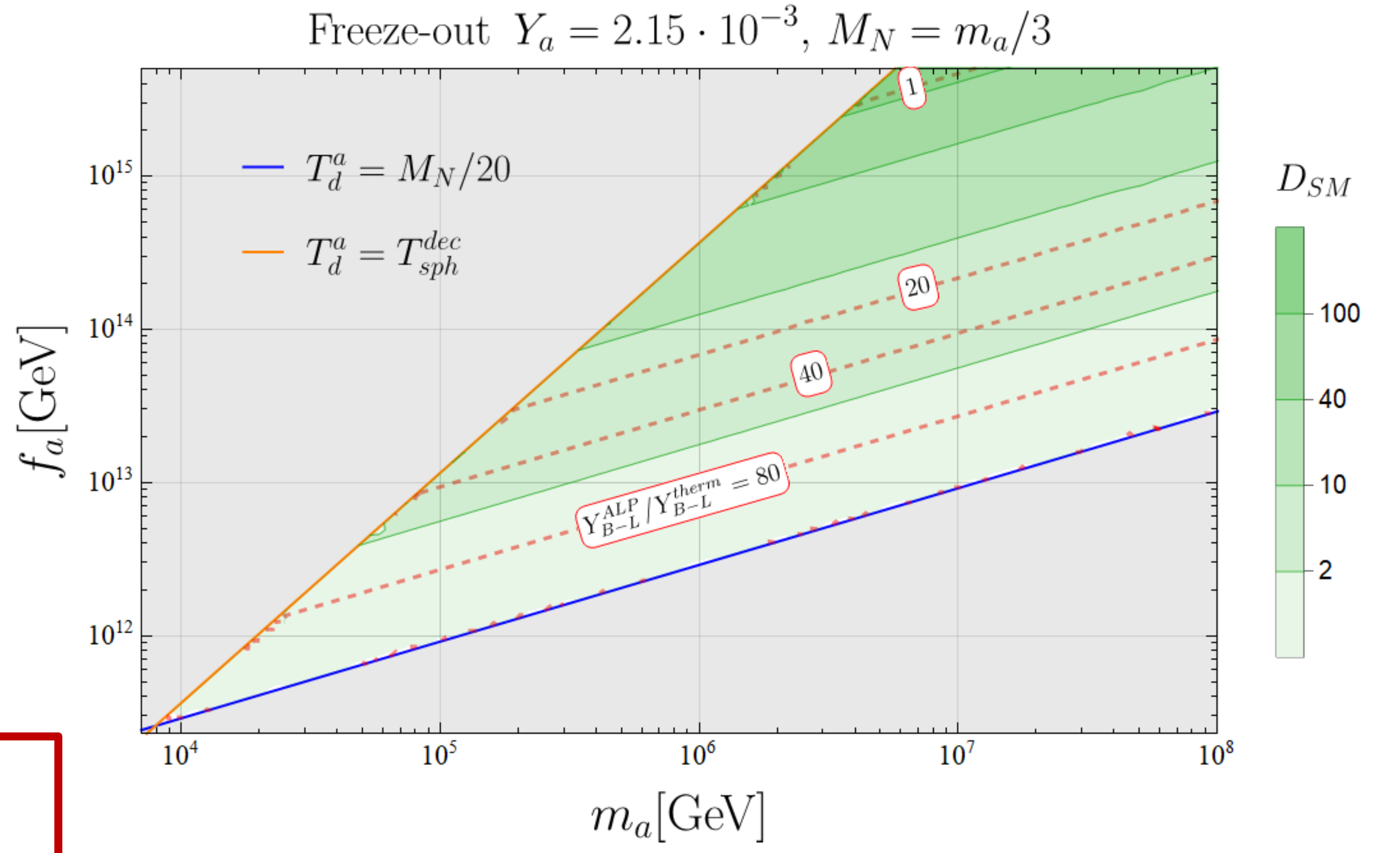
$$132\,\text{GeV} \lesssim T_D^a \lesssim \frac{M_N}{20}$$

active sphalerons — no strong washout

- Baryon asymmetry computed by either solving BEs or analytical parametrization

$$Y_{\Delta B}^{\text{ALP lepto}} \simeq \frac{2Y_a^{\text{initial}} \text{Br}_{a\to NN}\, c_{\text{sph}}\, \epsilon_{\text{CP}}}{D_{\text{SM}}}$$

- **gain factor** of **100** in baryon asymmetry produced



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Summary

- **Non-thermal leptogenesis** sourced via **ALP decay** into RHNs
- ALP leptogenesis requires $m_a > 10^4$ GeV and $f_a > 10^{11}$ GeV
- **More efficient** w.r.t. thermal leptogenesis by a factor **100**

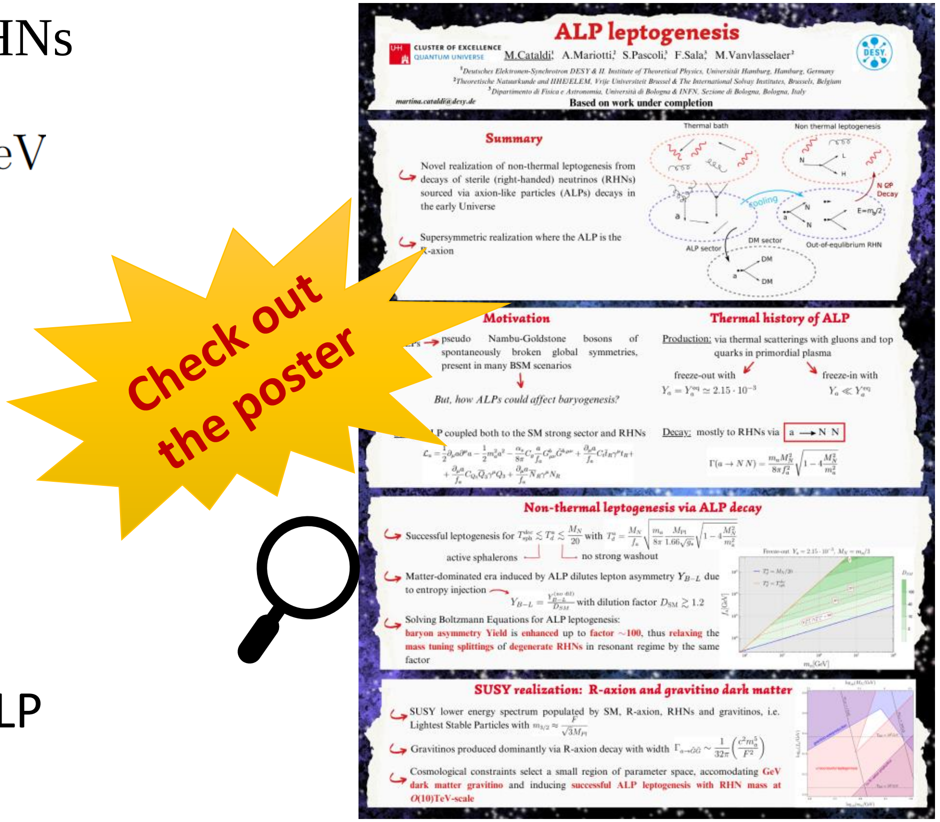
And much more in arXiv:**2407.01667**

★ gain in tuning of mass splittings in resonant regime

★ BEs for ALP leptogenesis

★ Matter-domination by ALP

★ SUSY realization: R-axion and gravitino dark matter



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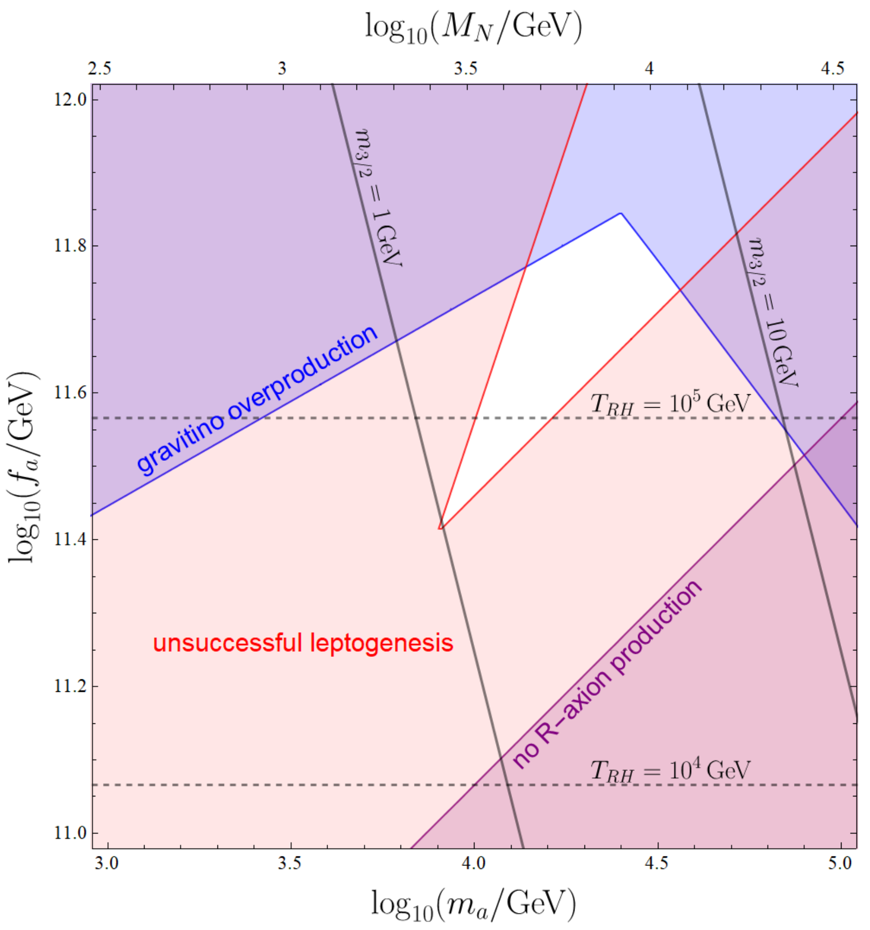
SUSY realization

- SUSY lower spectrum populated by SM, RHNs, R-axion and gravitinos

- Gravitino production via R-axion decay

$$\Gamma_{a\to\tilde{G}\tilde{G}} \sim \frac{1}{32\pi}\left(\frac{c^2 m_a^5}{F^2}\right)$$

- GeV dark matter gravitino and successful ALP leptogenesis with $O(10)$ TeV RHNs



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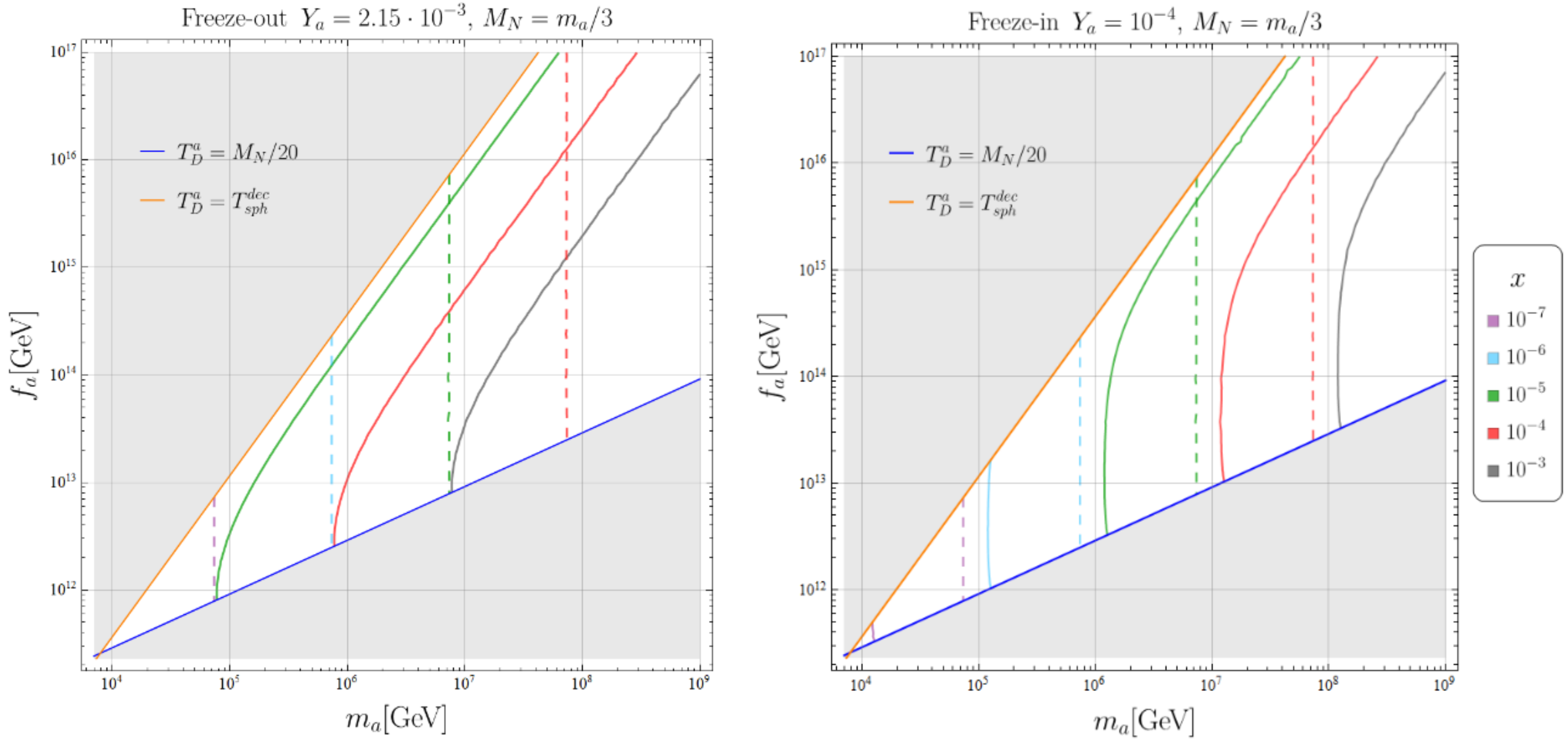
Mass tuning relaxation

$$x \equiv \frac{M_1^2 - M_2^2}{M_1 M_2}$$



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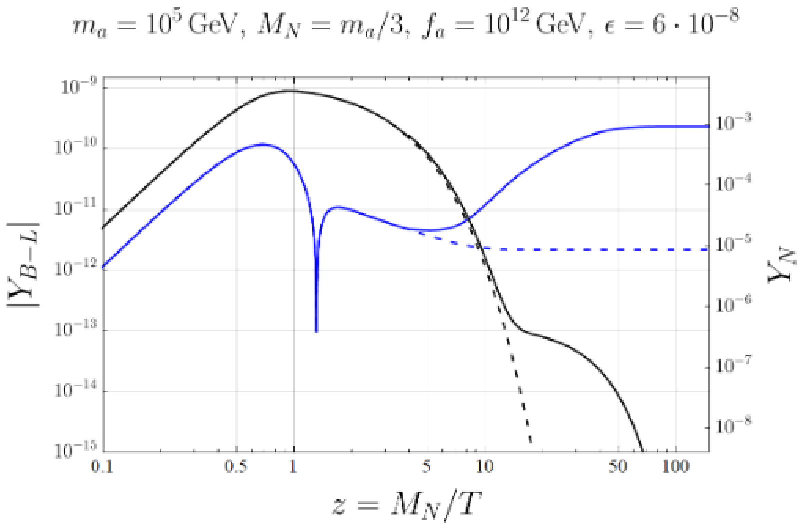
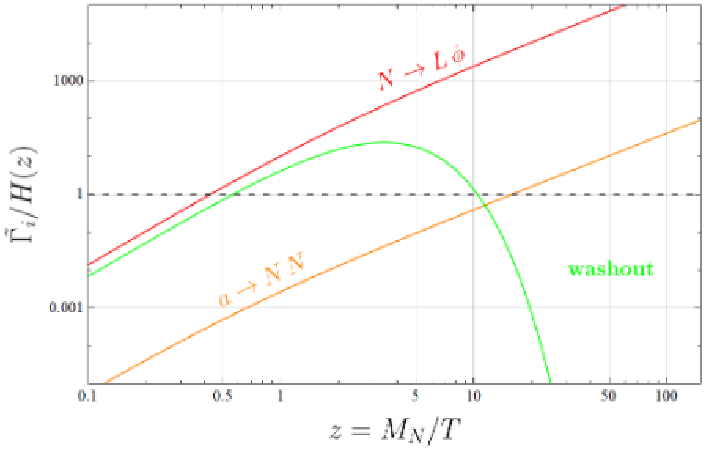
BEs for ALP leptogenesis

$$\begin{cases} \frac{dY_a}{dz} = -\mathrm{Br}_N \frac{\gamma_a}{Hsz} \frac{Y_a}{Y_a^{eq}} - \mathrm{Br}_g \frac{\gamma_a}{Hsz} \left(\frac{Y_a}{Y_a^{\mathrm{eq}}} - 1 \right) - \mathrm{Br}_t \frac{\gamma_a}{Hsz} \left(\frac{Y_a}{Y_a^{\mathrm{eq}}} - 1 \right) \\ \frac{dY_N}{dz} = -\frac{\gamma_D}{Hsz} \left(\frac{2M_N}{m_a} \frac{Y_N}{Y_N^{\mathrm{eq}}} - 1 \right) + 2 \frac{\mathrm{Br}_N \gamma_a}{Hsz} \frac{Y_a}{Y_a^{\mathrm{eq}}} \\ \frac{dY_{B-L}}{dz} = \frac{\gamma_D \epsilon}{Hsz} \left(\frac{2M_N}{m_a} \frac{Y_N}{Y_N^{\mathrm{eq}}} - 1 \right) - \frac{\gamma_D}{Hsz} \frac{Y_{B-L}}{2Y_l^{\mathrm{eq}}} \end{cases}$$





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