ALP leptogenesis

CLUSTER OF EXCELLENCE QUANTUM UNIVERSE

M.Cataldi[1], A.Mariotti[2], S.Pascoli[3], F.Sala[3], M.Vanvlasselaer[2]

[1]*Deutsches Elektronen-Synchrotron DESY & II. Institute of Theoretical Physics, Universität Hamburg, Hamburg, Germany*
[2]*Theoretische Natuurkunde and IIHE/ELEM, Vrije Universiteit Brussel & The International Solvay Institutes, Brussels, Belgium*
[3]*Dipartimento di Fisica e Astronomia, Università di Bologna & INFN, Sezione di Bologna, Bologna, Italy*

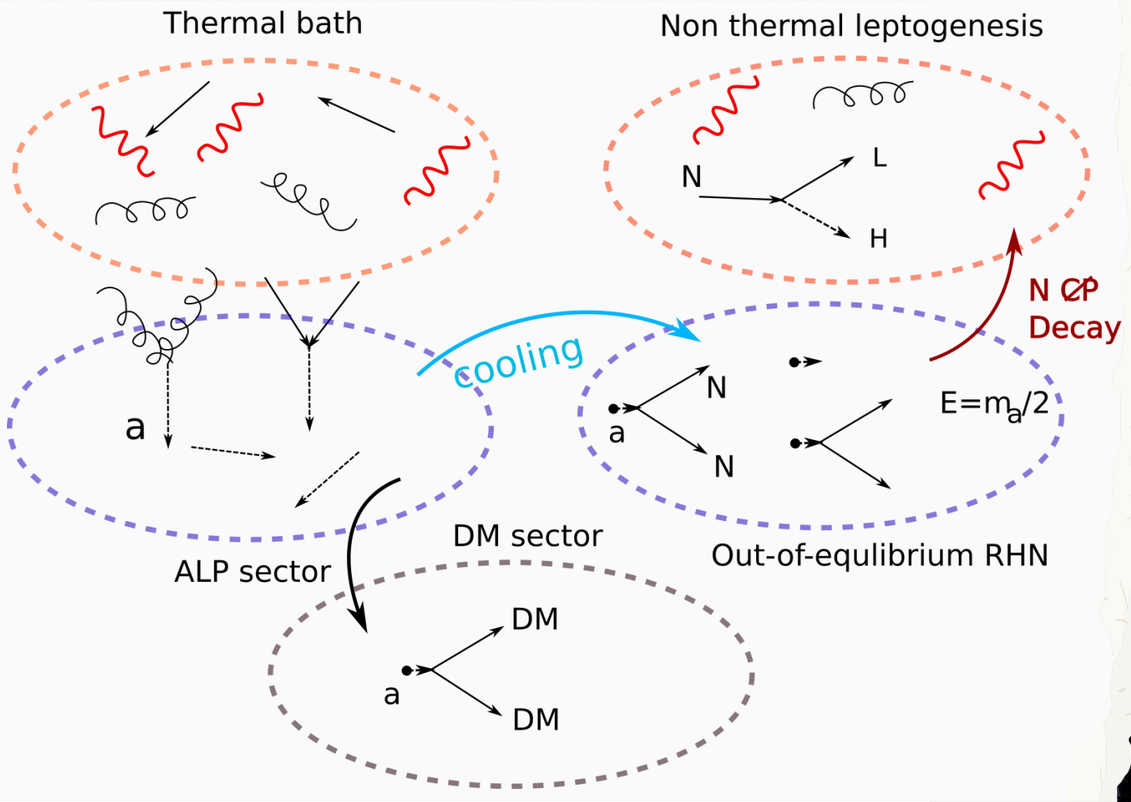
martina.cataldi@desy.de

Based on work under completion

Summary

↪ Novel realization of non-thermal leptogenesis from decays of sterile (right-handed) neutrinos (RHNs) sourced via axion-like particles (ALPs) decays in the early Universe

↪ Supersymmetric realization where the ALP is the R-axion



Motivation

ALPs → pseudo Nambu-Goldstone bosons of spontaneously broken global symmetries, present in many BSM scenarios

↓

But, how ALPs could affect baryogenesis?

Thermal history of ALP

Production: via thermal scatterings with gluons and top quarks in primordial plasma

↙ freeze-out with $Y_a = Y_a^{\rm eq} \simeq 2.15 \cdot 10^{-3}$

↘ freeze-in with $Y_a \ll Y_a^{\rm eq}$

Setup: ALP coupled both to the SM strong sector and RHNs

$$\mathcal{L}_a = \frac{1}{2}\partial_\mu a \partial^\mu a - \frac{1}{2}m_a^2 a^2 - \frac{\alpha_s}{8\pi} C_g \frac{a}{f_a} G^b_{\mu\nu}\tilde{G}^{b,\mu\nu} + \frac{\partial_\mu a}{f_a} C_t \bar{t}_R \gamma^\mu t_R + \\ + \frac{\partial_\mu a}{f_a} C_{Q_3} \overline{Q}_3 \gamma^\mu Q_3 + \frac{\partial_\mu a}{f_a} \overline{N}_R \gamma^\mu N_R$$

Decay: mostly to RHNs via $a \longrightarrow N\ N$

$$\Gamma(a \to N\,N) = \frac{m_a M_N^2}{8\pi f_a^2}\sqrt{1 - 4\frac{M_N^2}{m_a^2}}$$

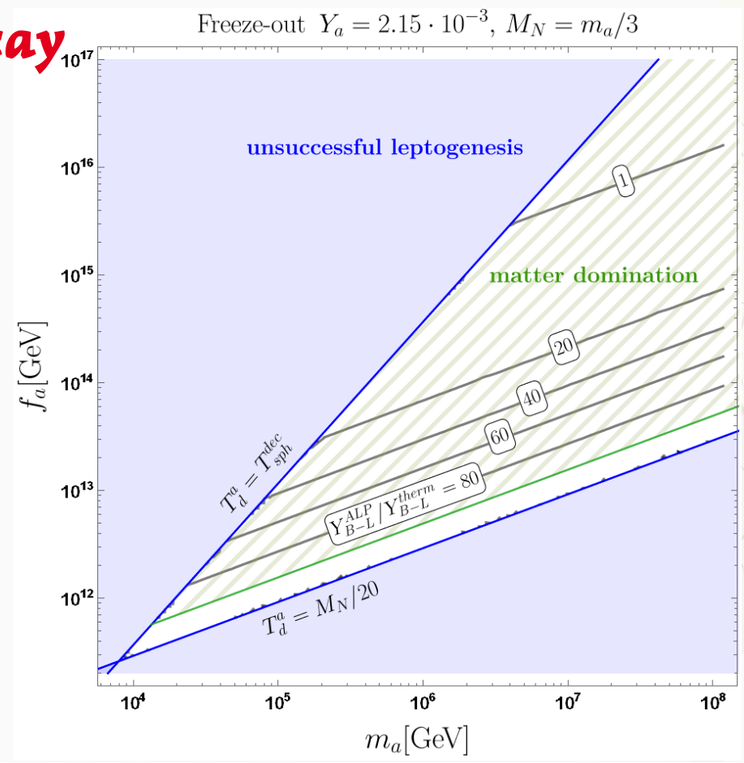
Non-thermal leptogenesis via ALP decay

↪ Successful leptogenesis for $T^{dec}_{\rm sph} \lesssim T^a_d \lesssim \frac{M_N}{20}$ with $T^a_d = \frac{M_N}{f_a}\sqrt{\frac{m_a}{8\pi}\frac{M_{\rm Pl}}{1.66\sqrt{g_*}}\sqrt{1-4\frac{M_N^2}{m_a^2}}}$

↳ active sphalerons ↳ no strong washout

↪ Matter-dominated era induced by ALP dilutes lepton asymmetry Y_{B-L} due to entropy injection ⤳ $Y_{B-L} = \frac{Y^{(\rm no\ dil)}_{B-L}}{D_{SM}}$ with dilution factor $D_{\rm SM} \gtrsim 1.2$

↪ Solving Boltzmann Equations for ALP leptogenesis:
baryon asymmetry Yield is **enhanced** up to **factor** $\sim$**100**, thus **relaxing** the **mass tuning splittings** of **degenerate RHNs** in resonant regime by the same factor



SUSY realization: R-axion and gravitino dark matter

↪ SUSY lower energy spectrum populated by SM, R-axion, RHNs and gravitinos, i.e. Lightest Stable Particles with $m_{3/2} \approx \frac{F}{\sqrt{3}M_{Pl}}$

↪ Gravitinos produced dominantly via R-axion decay with width $\Gamma_{a\to\tilde{G}\tilde{G}} \sim \frac{1}{32\pi}\left(\frac{c^2 m_a^5}{F^2}\right)$

↪ Cosmological constraints select a small region of parameter space, accomodating **GeV dark matter gravitino** and inducing **successful ALP leptogenesis with RHN mass at** ***O*****(10)TeV-scale**