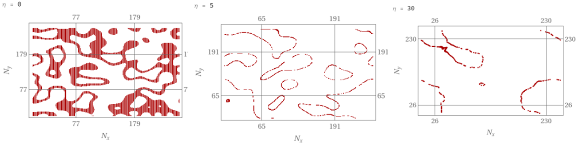


DISCRETE 2024

# DW-genesis: inducing the baryon number with domain walls


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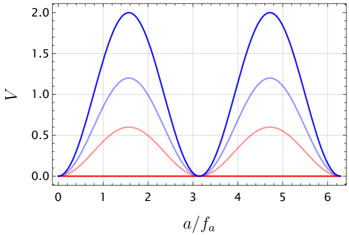
VUB, IIHE and COST Action


December 3, 2024

# Production of DWs from an axion

Universe high-T after inflation:cooling of primordial soup

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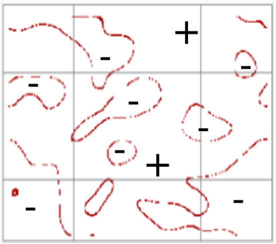

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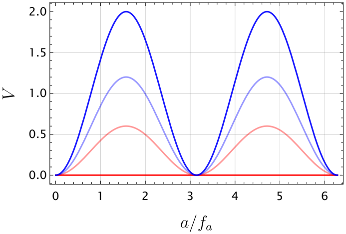


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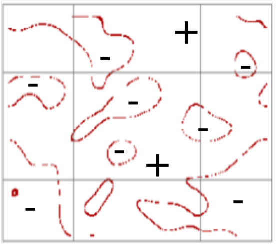

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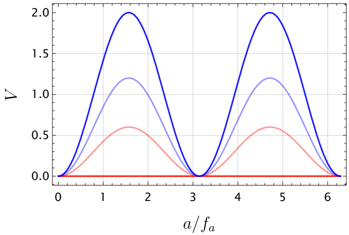


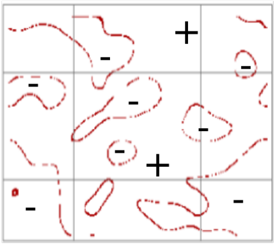


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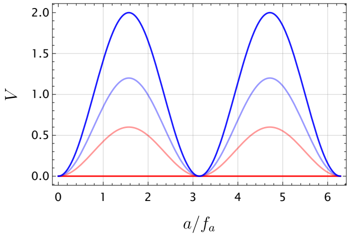


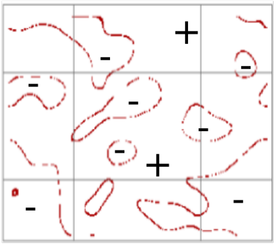

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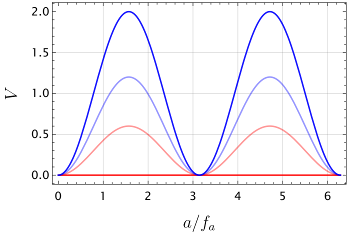


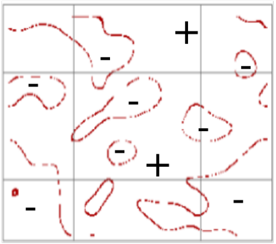

Blasi, Mariotti, Rase, MV

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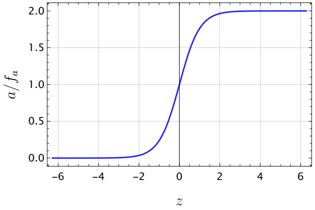
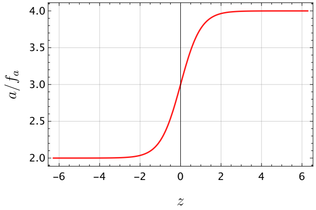
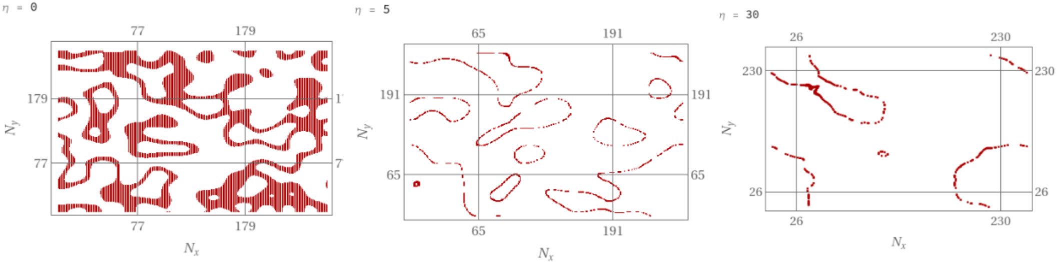


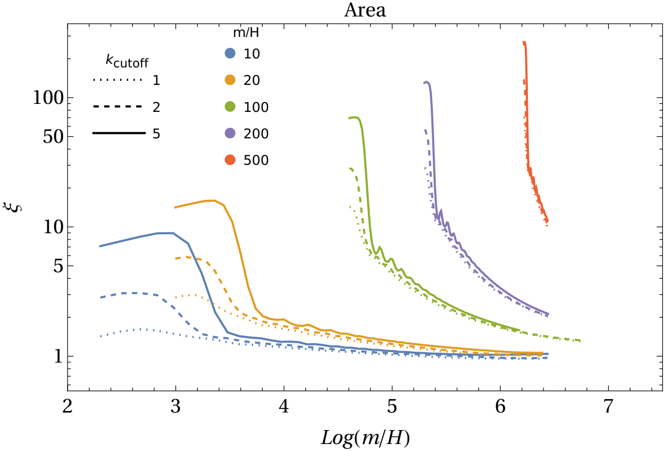



# Approach to scaling (using Cosmo-Lattice)

[25XX.]:Blasi, Mariotti, Rase, MV

$\xi \sim$ Number of DWs in a Hubble patch $\to \sim 1$



# DW domination and collapse

- DW domination

$$\Omega_{\rm DW} \sim \sigma H \sim m_a f_a^2 H \qquad \frac{\Omega_{\rm DW}}{\Omega_{\rm rad}} \propto \frac{m_a f_a^2}{T^2 M_{\rm pl}} \qquad \Rightarrow \text{DW domination at } T_{\rm dom} \approx \sqrt{\sigma / M_{\rm pl}}$$

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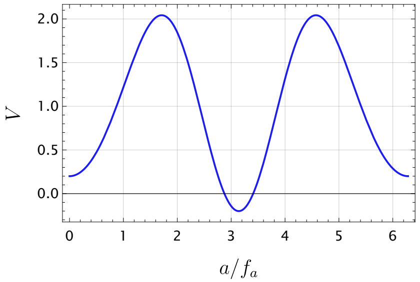
- Introduce a bias:

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$$T_{\rm ann}^2 \approx \frac{\Delta V M_{\rm pl}}{24\, m_a f_a^2}$$

- Amount of breaking:

$$\boxed{\Delta\theta \equiv \frac{\Delta V}{V_0}}$$

# Baryogenesis with Domain Walls: DW-genesis

# DW-genesis: idea

[2411.13494]: Mariotti, Nagels, Rase, MV

- See-saw model: breaks L number

$$\mathcal{L}_{\not{L}} = y_N (\tilde{H}\bar{L}) N_R + \frac{1}{2} M_N \bar{N}_R^c N_R + \text{h.c.}$$

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$$\mathcal{L}_{a-L} = \frac{c_L\partial_\mu a}{f_a} j_L^\mu \,, \qquad j_L^\mu \equiv \bar{L}\gamma^\mu L \qquad \mathcal{L} = \mathcal{L}_{a-j} + \mathcal{L}_{\not{L}}$$

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$$\mathcal{L}_{a-L} = \dot{\theta} j_L^0 \simeq \mu j_L^0\,, \qquad \dot{\theta} \equiv \frac{\dot{a}_{\rm DW}(t,z)}{f_a} = \frac{2m_a\gamma_w v_w}{\cosh\left[m_a\gamma_w v_w\left(t - t_{\text{passage}}\right)\right]}$$

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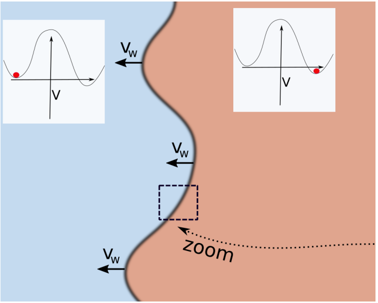
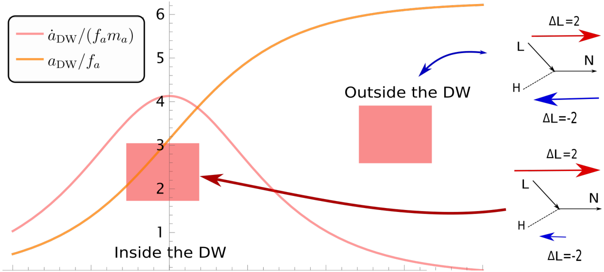
- Boltzmann equations deduced

$$\frac{dY_{\Delta L}}{dt} = -\left(\frac{\gamma_D}{n_L^{\rm eq}}(Y_{\Delta L} + Y_{\Delta L}^{\rm eq}(t)) + 2\frac{\gamma_{2\to 2}}{n_L^{\rm eq}}\left(Y_{\Delta L} + Y_{\Delta L}^{\rm eq}(t)\right)\right), \quad Y_{\Delta L}^{\rm eq}(t) \equiv \frac{n_L^{\rm eq}}{s}\frac{2c_L\dot{a}}{f_a T}$$

# DW-genesis: Idea

[1504.07917]:Daido, Kitajima, Takahashi, [2411.13494]: Mariotti, Nagels, Rase, MV

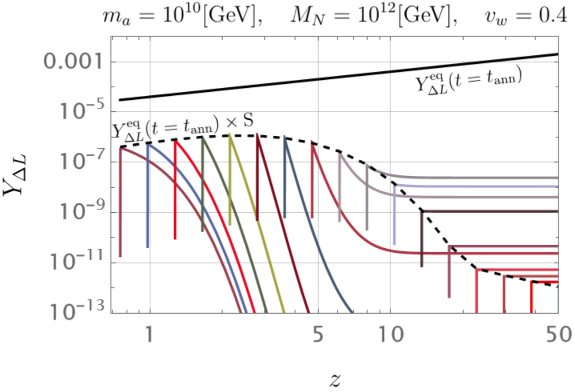


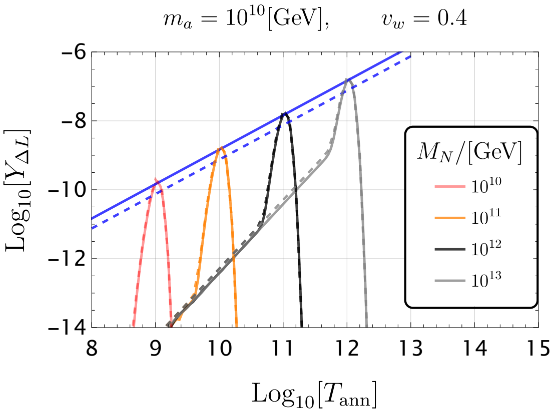




Production and wash-outs coming from $HL \to N$, $LH \to H\bar{L}$ (usually called wash-outs)!

# Domain wall leptogenesis

[2411.13494]: Mariotti, Nagels, Rase, MV




Production maximal when $T_{\rm ann} \sim T^{\not L}_{\rm dec} \sim M_N/10$

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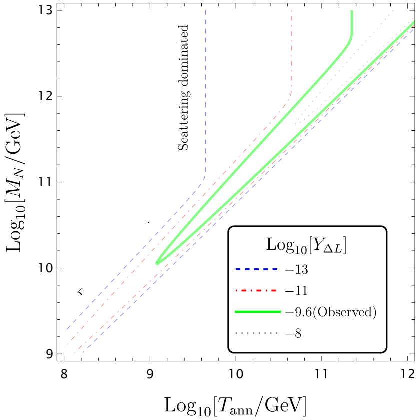
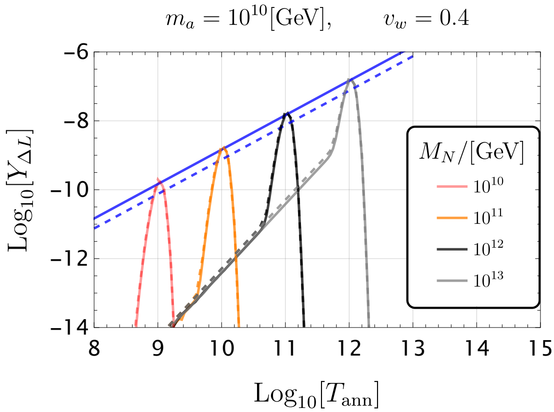
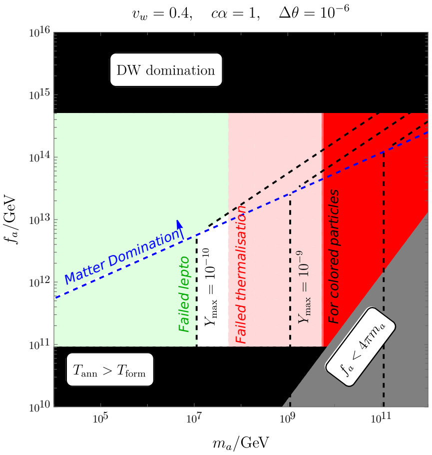



Observed abundance $Y_{\Delta L} \sim 10^{-10}$ requires $T_{\rm ann} \gtrsim 10^9$ GeV.

# Parameter space for DW-genesis I

[2411.13494]: Mariotti, Nagels, Rase, MV




- Thermalisation condition inside the DW:

$$L_{\text{thermalisation}} \ll L_{\text{DW}}$$

- Dilution from the axion decay: $\rho_a = H(T_{\text{ann}})\sigma$:

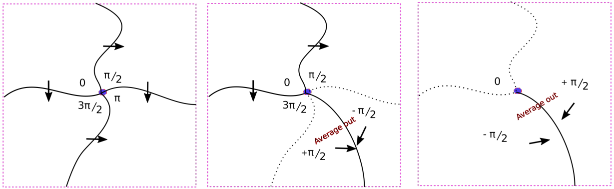
$$Y_{\Delta L} = Y^0_{\Delta L} \times D\,, \quad \text{with}$$

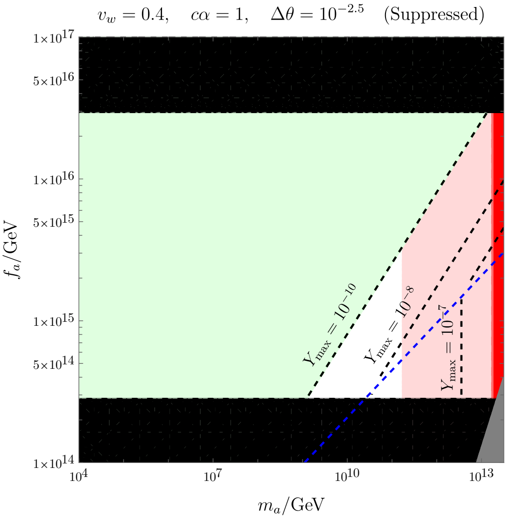
$$D = \text{Min}\left[1, 0.57\frac{g_*(T_{\text{ann}})}{g_*(T_{\text{alp dec}})^{1/4}}\frac{\sqrt{M_{\text{Pl}}\Gamma}\;T^3_{\text{ann}}}{\Delta V}\right]$$

# Parameter space for DW-genesis II

[2411.13494]: Mariotti, Nagels, Rase, MV

Two types of walls: $0 \to \pi, \qquad \pi \to 2\pi$




- Cancellation is not exact:

$$\sigma_1 \neq \sigma_2 \qquad \Rightarrow T_{\text{ann},1} \neq T_{\text{ann},2} \quad v_1 \neq v_2$$

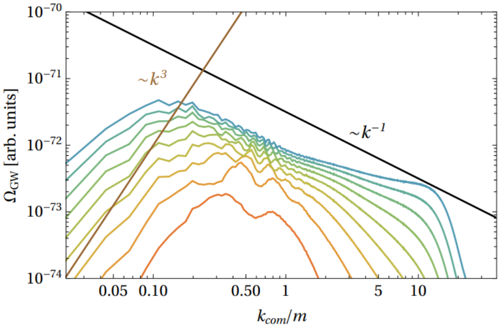
- 

$$\text{Suppression} \approx \mathcal{O}(1-10) \times \Delta\theta$$

# Gravitational wave spectrum

[1002.1555]:Hiramatsu, Kawasaki,Saikawa, [25XX.]:Blasi, Mariotti, Rase, MV

$$\Omega_{\rm GW}(f) = \Omega_{\rm GW}^{\rm peak}\begin{cases}(f/f_{\rm peak})^3 & f < f_{\rm peak}\\ (f/f_{\rm peak})^{-1} & f > f_{\rm peak}\end{cases}$$

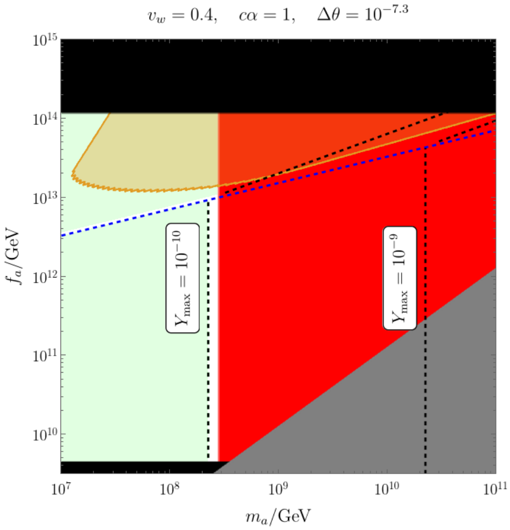



$$\Omega_{\rm GW}(T) \approx 2.34\times 10^{-6}\tilde{\epsilon}_{\rm GW}\mathcal{A}^2\left(\frac{g_\star(T)}{10}\right)\left(\frac{g_{s\star}(T)}{10}\right)^{-4/3}\left(\frac{T_{\rm dom}}{T}\right)^4 \text{Min}\left[1,\left(\frac{T_{\text{alp dec}}}{T_{\text{mat dom}}}\right)^{4/3}\right]$$

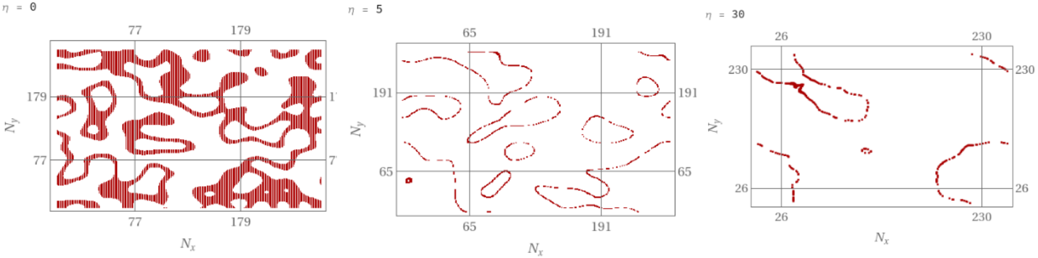
$$f_{\rm peak}(T) \approx 1.15\times 10^{-7}\text{Hz}\times\left(\frac{g_\star(T)}{10}\right)^{1/2}\left(\frac{g_{s\star}(T)}{10}\right)^{-1/3}\left(\frac{T}{\text{GeV}}\right)\text{Min}\left[1,\left(\frac{T_{\text{alp dec}}}{T_{\text{mat dom}}}\right)^{1/3}\right]$$

# GW signal and leptogenesis

[2411.13494]: Mariotti, Nagels, Rase, MV



# Conclusion




- DW-genesis: generation of baryon number independent on CP-violation in the couplings

Thank you ;)

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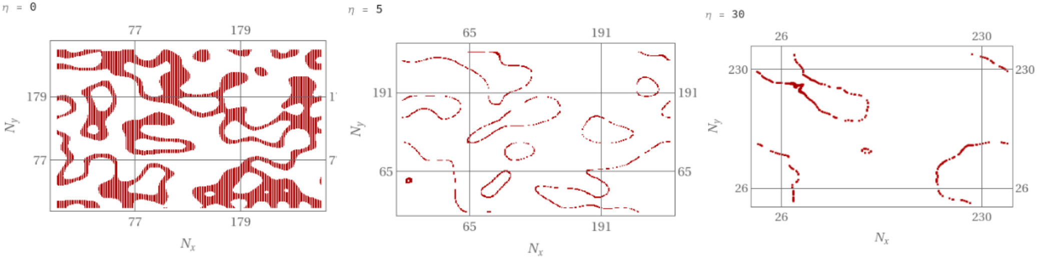


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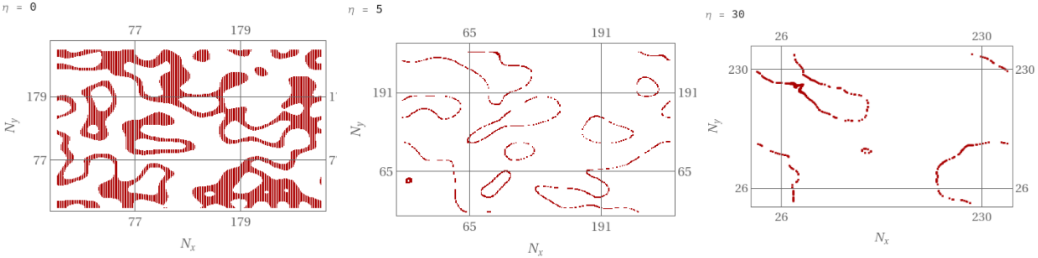


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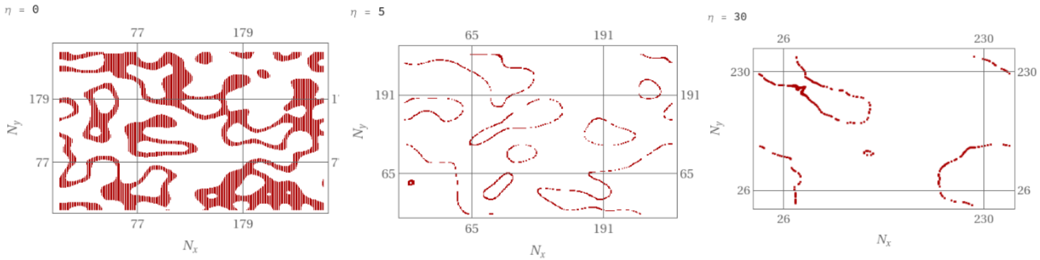


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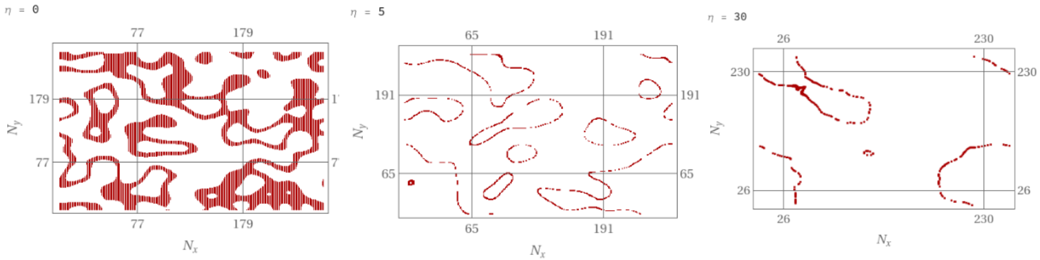


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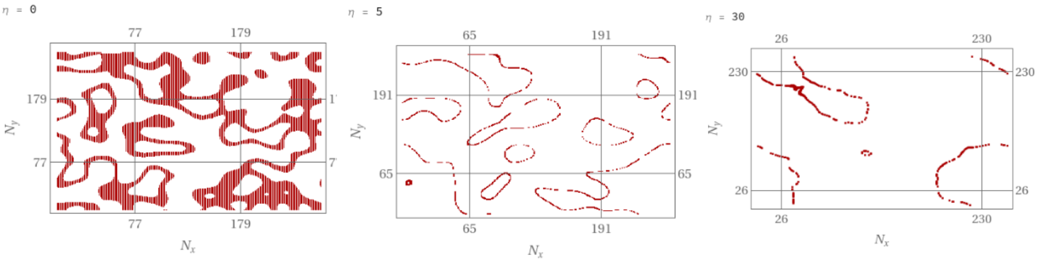


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- Model of leptogenesis
- We have explored several other realisations

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