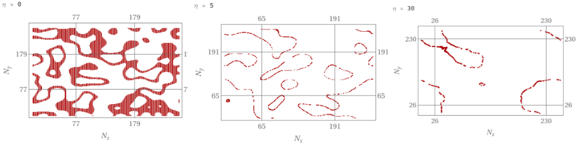


HiDDeN 2025

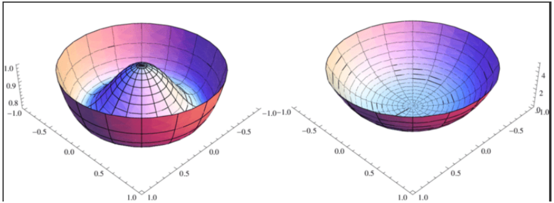
DW-genesis: inducing the baryon number with domain walls

Miguel Vanvlasselaer
miguel.vanvlasselaer@vub.be

VUB, IIHE and COST Action

February 26, 2025

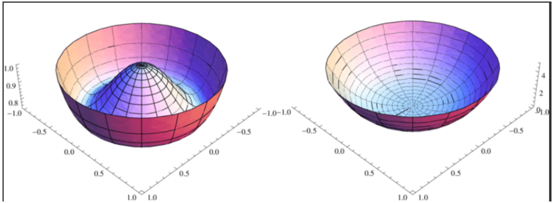
Mexican hat potential



- Mexican hat potential for a complex field ϕ with $U(1)$ global symmetry

$$\text{high T} \gg f_a : \quad V(\phi) \approx |\phi|^2 T^2 \qquad\qquad \text{low T} \ll f_a : \quad V(\phi) = \lambda\Big(|\phi|^2 - f_a^2/2\Big)^2$$

Mexican hat potential



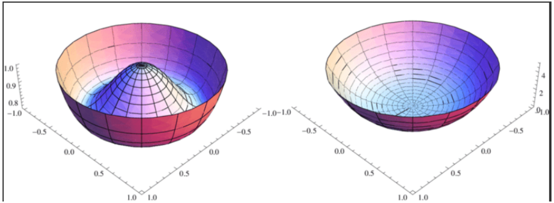
- Mexican hat potential for a complex field ϕ with $U(1)$ global symmetry

$$\text{high T} \gg f_a : \quad V(\phi) \approx |\phi|^2 T^2 \qquad\qquad \text{low T} \ll f_a : \quad V(\phi) = \lambda\Big(|\phi|^2 - f_a^2/2\Big)^2$$

- Axions are characterized by a spontaneously broken $U(1)$ symmetry with periodicity f_a

$$\phi = \rho e^{ia/f_a}$$

Mexican hat potential



- Mexican hat potential for a complex field ϕ with $U(1)$ global symmetry

$$\text{high T} \gg f_a : \quad V(\phi) \approx |\phi|^2 T^2 \qquad\qquad \text{low T} \ll f_a : \quad V(\phi) = \lambda\left(|\phi|^2 - f_a^2/2\right)^2$$

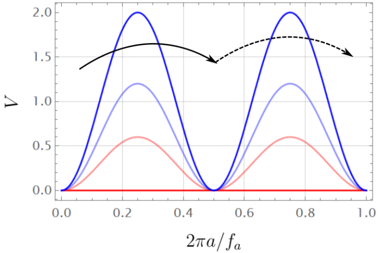
- Axions are characterized by a spontaneously broken $U(1)$ symmetry with periodicity f_a

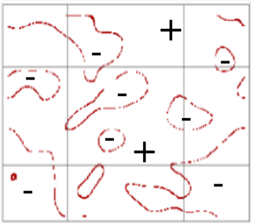
$$\phi = \rho e^{ia/f_a}$$

- Formation of cosmic strings at $T \sim f_a$ and spreads of value of a around strings

Production of DWs from an axion

Universe high-T after inflation:cooling of primordial soup



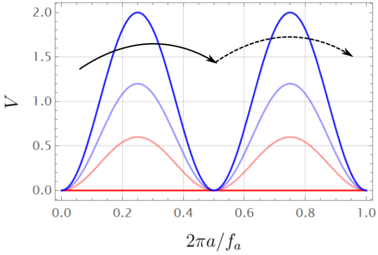


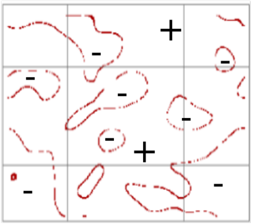
Production of DWs from an axion

Universe high-T after inflation:cooling of primordial soup

- $T \sim \Lambda \sim \sqrt{m_a f_a}$, dark sector confines:

$$\frac{a}{f_a} G_d \tilde{G}_d \quad \Rightarrow \quad V(a) = \Lambda^4 \left(1 - \cos\left(\frac{a N_{\rm DW}}{f_a}\right)\right)$$





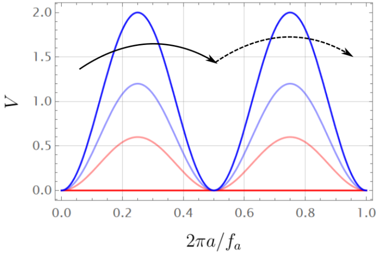
Production of DWs from an axion

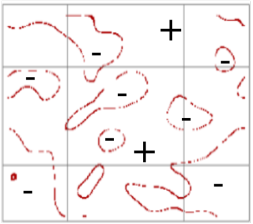
Universe high-T after inflation:cooling of primordial soup

- $T \sim \Lambda \sim \sqrt{m_a f_a}$, dark sector confines:

$$\frac{a}{f_a} G_d \tilde{G}_d \quad \Rightarrow \quad V(a) = \Lambda^4 \left(1 - \cos\left(\frac{a N_{\rm DW}}{f_a}\right)\right)$$

- Breaking of the $U(1) \to Z_{N_{\rm DW}}$





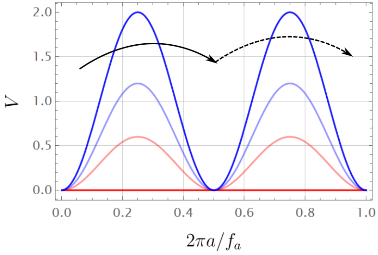
Production of DWs from an axion

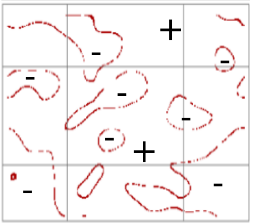
Universe high-T after inflation:cooling of primordial soup

- $T \sim \Lambda \sim \sqrt{m_a f_a}$, dark sector confines:

$$\frac{a}{f_a} G_d \tilde{G}_d \quad \Rightarrow \quad V(a) = \Lambda^4 \left(1 - \cos\left(\frac{a N_{\rm DW}}{f_a}\right)\right)$$

- Breaking of the $U(1) \to Z_{N_{\rm DW}}$
- Formation of DW for $T < \Lambda$

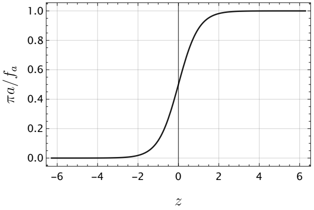


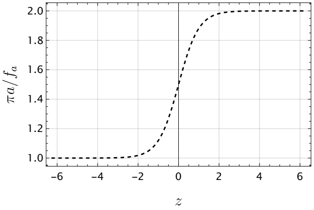


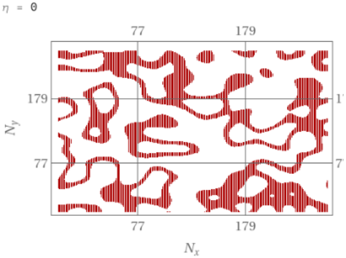
Formation of domain walls

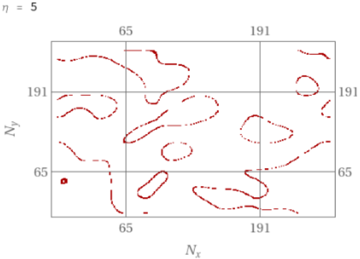
Blasi, Mariotti, Rase, MV

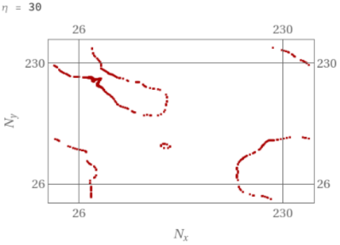
Two types of walls: $0 \to \pi$ $\pi \to 2\pi$







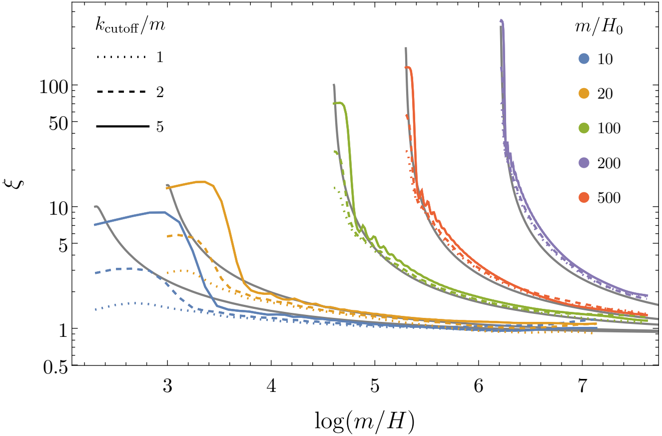




Approach to scaling (using Cosmo-Lattice)

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

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



DW domination and collapse

- Domain wall precludes discrete symmetries ? Zel'dovich, Kobzarev, Okun (1974)

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

DW domination and collapse

- Domain wall precludes discrete symmetries ? Zel'dovich, Kobzarev, Okun (1974)

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

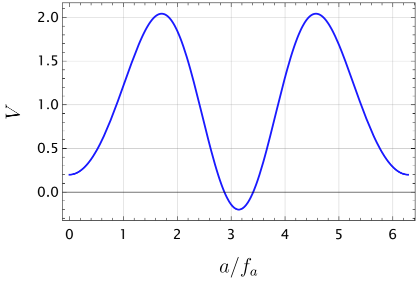
- Solution: DWs have to decay at $T_{\text{ann}} > T_{\text{dom}}$

DW domination and collapse

- Domain wall precludes discrete symmetries ? Zel'dovich, Kobzarev, Okun (1974)

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

- Solution: DWs have to decay at $T_{\rm ann} > T_{\rm dom}$
- Introduce a bias:



- Example: gravitational breaking

$$V_{\rm bias} \sim \frac{\phi^5}{M_{\rm pl}}$$

-

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

- Amount of breaking:

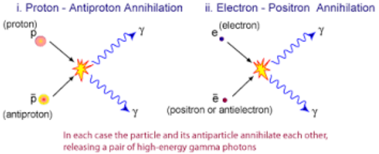
$$\boxed{\Delta\theta \equiv \frac{\Delta V}{V_0}}$$

Baryogenesis with Domain Walls: DW-genesis

[2411.13494]: Alberto Mariotti, Xander Nagels, Aaron Rase, MV

Problem of baryogenesis and Sakharov conditions

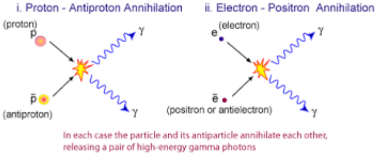
- Inflation: erase the initial conditions and produce $n_B = n_{\bar{B}}$ (likely...)



- $\frac{n_B - n_{\bar{B}}}{n_\gamma} \to 0(10^{-20}...)$ (naive expectation): empty universe

Problem of baryogenesis and Sakharov conditions

- Inflation: erase the initial conditions and produce $n_B = n_{\bar{B}}$ (likely...)



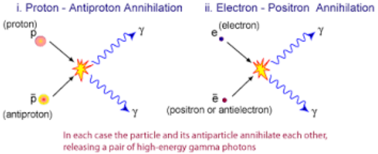
- $\frac{n_B - n_{\bar{B}}}{n_\gamma} \to 0(10^{-20}...)$ (naive expectation): empty universe
- $\frac{n_B - n_{\bar{B}}}{n_\gamma} \to 10^{-10}$ (observation): need a process that turns one out of 10^{10} anti-baryon $\to$ baryon

Sakharov conditions

- **Out-of-equilibrium situation**; if CPT theorem
- **CP-violation**: $\Gamma \neq \bar{\Gamma}$
- **B-number violation**

Problem of baryogenesis and Sakharov conditions

- Inflation: erase the initial conditions and produce $n_B = n_{\bar{B}}$ (likely...)



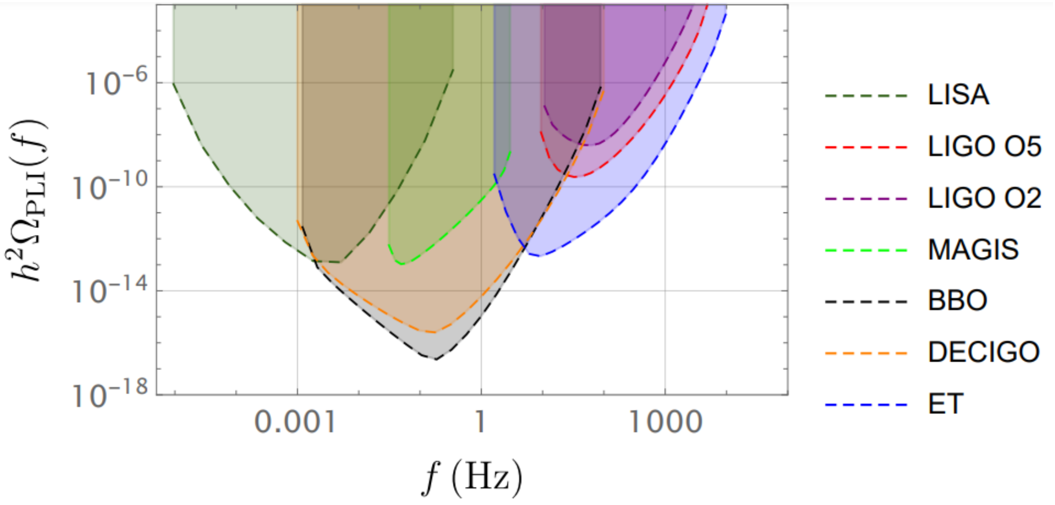
- $\frac{n_B - n_{\bar{B}}}{n_\gamma} \to 0(10^{-20}...)$ (naive expectation): empty universe
- $\frac{n_B - n_{\bar{B}}}{n_\gamma} \to 10^{-10}$ (observation): need a process that turns one out of 10^{10} anti-baryon $\to$ baryon

Sakharov conditions

- **Out-of-equilibrium situation**; if CPT theorem
- **CP-violation**: $\Gamma \neq \bar{\Gamma}$
- **B-number violation**

- Example: electroweak baryogenesis, leptogenesis, GUT baryogenesis, Affleck-Dine baryogenesis

Observation prospects of GW

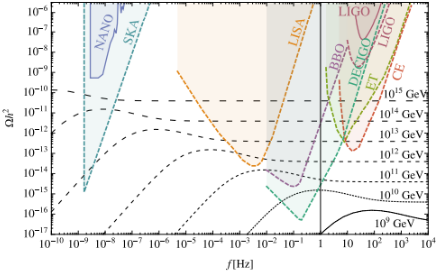


GW from baryogenesis

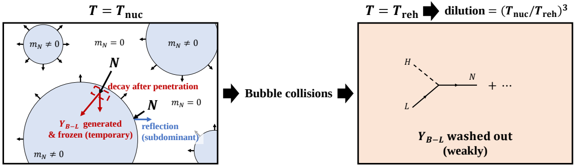
1. Baryogenesis with gravitational waves signal

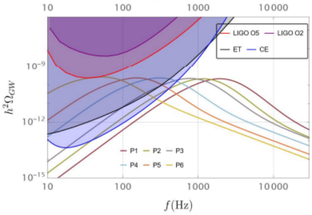
GW from baryogenesis

1. Baryogenesis with gravitational waves signal



Dror, Hiramatsu, Khori, Murayama, White 19'





Eung,Dutka,Jung, Nagels, MV, 23':

DW-genesis: idea

[2411.13494]: Mariotti, Nagels, Rase, MV

- See-saw model: breaks L number

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

DW-genesis: idea

[2411.13494]: Mariotti, Nagels, Rase, MV

- See-saw model: breaks L number

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

- Coupling between an axion and the lepton number

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

DW-genesis: idea

[2411.13494]: Mariotti, Nagels, Rase, MV

- See-saw model: breaks L number

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

- Coupling between an axion and the lepton number

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

- Moving non-trivial profile for the axion breaks both CP and CPT

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

DW-genesis: idea

[2411.13494]: Mariotti, Nagels, Rase, MV

- See-saw model: breaks L number

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

- Coupling between an axion and the lepton number

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

- Moving non-trivial profile for the axion breaks both CP and CPT

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

- Boltzmann equations deduced

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

Intuition and computation

[2411.13494]: Mariotti, Nagels, Rase, MV

- Rotate away to the coupling to the DW

$$L \to e^{ic_L a/f_a} L \qquad \Rightarrow \qquad i\bar{L}\partial\!\!\!/ L \to i\bar{L}\partial\!\!\!/ L - c_L \frac{\partial_\mu a}{f_a} j_L^\mu \,, \qquad y_N(\tilde{H}\bar{L})N_R \to e^{-ic_L a/f_a} y_N(\tilde{H}\bar{L})N_R \,.$$

$$\Rightarrow \qquad \mathcal{L}_{\not{L}} = e^{-ic_L a/f_a} y_N(\tilde{H}\bar{L})N_R + \frac{1}{2} M_N \bar{N}_R^c N_R + \text{h.c.}\,.$$

Intuition and computation

[2411.13494]: Mariotti, Nagels, Rase, MV

- Rotate away to the coupling to the DW

$$L \to e^{ic_L a/f_a} L \qquad \Rightarrow \qquad i\bar{L}\partial\!\!\!/ L \to i\bar{L}\partial\!\!\!/ L - c_L \frac{\partial_\mu a}{f_a} j_L^\mu \, , \qquad y_N(\tilde{H}\bar{L})N_R \to e^{-ic_L a/f_a} y_N(\tilde{H}\bar{L})N_R \, .$$

$$\Rightarrow \qquad \mathcal{L}_{\not{L}} = e^{-ic_L a/f_a} y_N(\tilde{H}\bar{L})N_R + \frac{1}{2} M_N \bar{N}_R^c N_R + \text{h.c.} \, .$$

- New Feynman rules from the vertex : $\delta(\sum_i E_i) \to \delta(\sum_i E_i + c_L \dot{a}/f_a)$

$$\dot{n}_L + 3Hn_L = \int \frac{d^3 p_L}{(2\pi)^3} \left(\mathcal{C}^{\rm decay}[f_L] + \mathcal{C}^{\rm scatt}[f_L] \right) \equiv I^{\rm decay} + I^{\rm scatt} \, ,$$

$$I^{\rm decay} = \int d\Pi_L d\Pi_N d\Pi_H (2\pi)^4 \delta^3(p_N - p_L - p_H) \delta(E_N - E_L - E_H - c_L \dot{a}/f_a)$$
$$\times \left[|\mathcal{M}_{N\to LH}|^2 f_N - |\mathcal{M}_{LH\to N}|^2 f_L f_H \right]$$

Intuition and computation

[2411.13494]: Mariotti, Nagels, Rase, MV

- Rotate away to the coupling to the DW

$$L \to e^{ic_L a/f_a} L \qquad \Rightarrow \qquad i\bar{L}\partial\!\!\!/ L \to i\bar{L}\partial\!\!\!/ L - c_L \frac{\partial_\mu a}{f_a} j_L^\mu , \qquad y_N(\tilde{H}\bar{L})N_R \to e^{-ic_L a/f_a} y_N(\tilde{H}\bar{L})N_R .$$

$$\Rightarrow \qquad \mathcal{L}_{L\!\!\!/} = e^{-ic_L a/f_a} y_N(\tilde{H}\bar{L})N_R + \frac{1}{2} M_N \bar{N}_R^c N_R + \text{h.c.} .$$

- New Feynman rules from the vertex : $\delta(\sum_i E_i) \to \delta(\sum_i E_i + c_L \dot{a}/f_a)$

$$\dot{n}_L + 3Hn_L = \int \frac{d^3p_L}{(2\pi)^3} \left(\mathcal{C}^{\text{decay}}[f_L] + \mathcal{C}^{\text{scatt}}[f_L] \right) \equiv I^{\text{decay}} + I^{\text{scatt}} ,$$

$$I^{\text{decay}} = \int d\Pi_L d\Pi_N d\Pi_H (2\pi)^4 \delta^3(p_N - p_L - p_H) \delta(E_N - E_L - E_H - c_L \dot{a}/f_a)$$

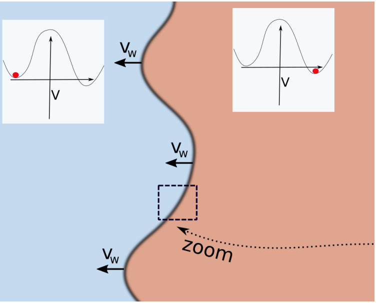
$$\times \left[|\mathcal{M}_{N\to LH}|^2 f_N - |\mathcal{M}_{LH\to N}|^2 f_L f_H \right]$$

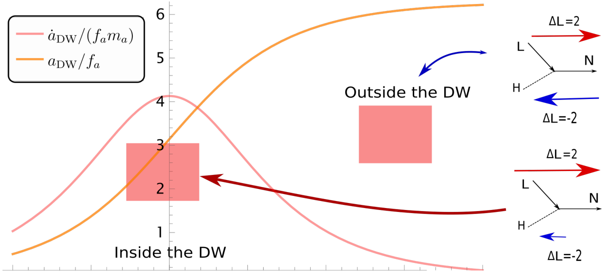
- Shift in the distributions: like a chemical potential $= c_L \dot{a}/f_a$:

$$f_L f_H \approx e^{-\frac{E_H + E_L}{T}} = e^{-\frac{E_N - c_L \dot{a}/f_a}{T}}$$

DW-genesis: Idea

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

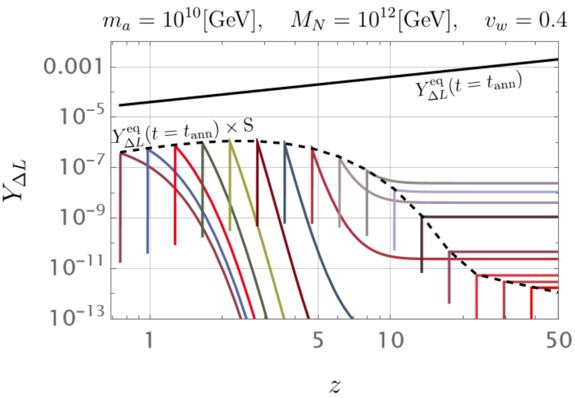


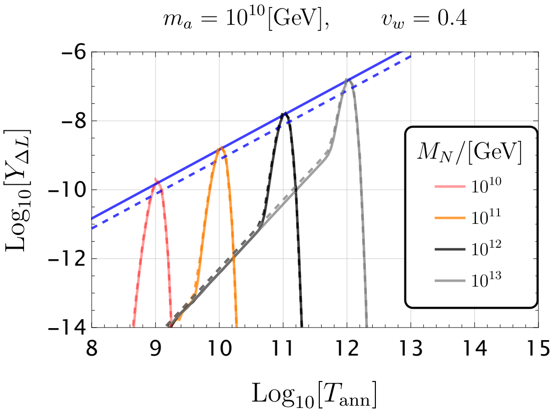


Production and wash-outs coming from $HL \to N$, $LH \to H\bar{L}$ (usually called wash-outs)!

Domain wall leptogenesis

[2411.13494]: Mariotti, Nagels, Rase, MV

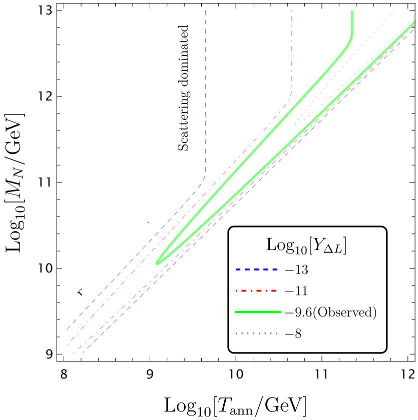


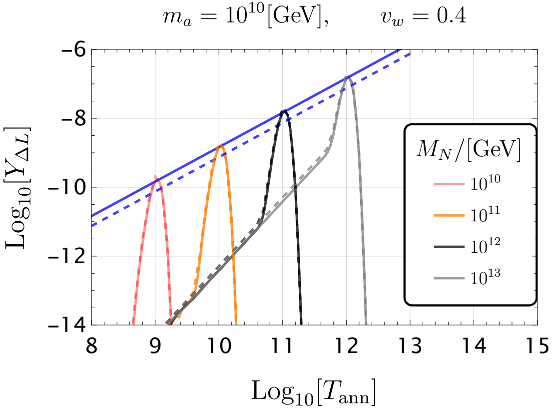


Production maximal when $T_{ann} \sim T^{\not L}_{dec} \sim M_N/10$

Domain wall leptogenesis

[2411.13494]: Mariotti, Nagels, Rase, MV

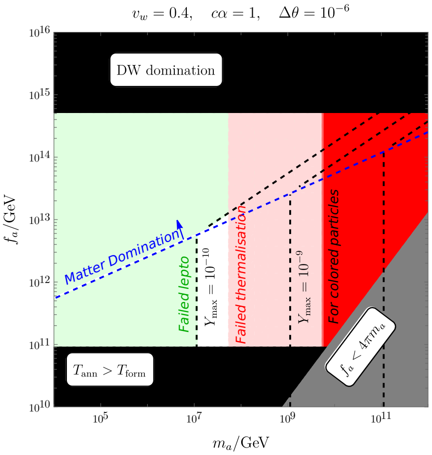




Observed abundance $Y_{\Delta L} \sim 10^{-10}$ requires $T_{\mathrm{ann}} \gtrsim 10^9$ GeV.

Parameter space for DW-genesis I

[2411.13494]: Mariotti, Nagels, Rase, MV



- Thermalisation condition inside the DW:

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

$$\mathcal{O}(10)\alpha_w^2 \gtrsim \frac{\gamma_w v_w m_a}{T_{\rm ann}} \qquad T_{\rm ann} \gg 10^2 m_a \gamma_w v_w$$

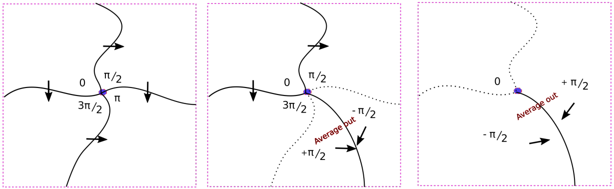
$$\mathcal{O}(10)\alpha_s^2 \gtrsim \frac{\gamma_w v_w m_a}{T_{\rm ann}} \qquad T_{\rm ann} \gg 10 m_a \gamma_w v_w$$

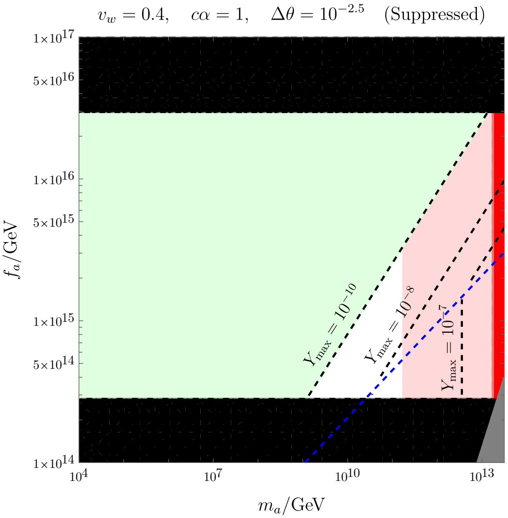
- Dilution from the axion decay: $\rho_a = H(T_{\rm ann})\sigma$:

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

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

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

- Gravitational waves from a mass distribution

$$h_{ij}(r,t) = \frac{2G}{r}\ddot{I}_{ij}(t-r), \qquad I_{ij} \equiv \int d^3r \rho_{dw}\left(r_i r_j - \frac{r^2\delta_{ij}}{3}\right)$$

Gravitational wave spectrum

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

- Gravitational waves from a mass distribution

$$h_{ij}(r,t) = \frac{2G}{r}\ddot{I}_{ij}(t-r), \qquad I_{ij} \equiv \int d^3r\,\rho_{dw}\left(r_i r_j - \frac{r^2\delta_{ij}}{3}\right)$$

- In the case of DW network in scaling

$$R \sim D \sim H^{-1} \sim k^{-1}\,, \qquad v_{dw} \sim 1$$

Gravitational wave spectrum

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

- Gravitational waves from a mass distribution

$$h_{ij}(r,t) = \frac{2G}{r}\ddot{I}_{ij}(t-r), \qquad I_{ij} \equiv \int d^3r\,\rho_{dw}\left(r_i r_j - \frac{r^2\delta_{ij}}{3}\right)$$

- In the case of DW network in scaling

$$R \sim D \sim H^{-1} \sim k^{-1}\,, \qquad v_{dw} \sim 1$$

-

$$I_{ij} \sim \rho_{dw} R^5 \qquad \Rightarrow \qquad h_{ij}(r,t) \sim \frac{G}{R}\frac{\rho_{dw}R^5}{R^2} \sim G\sigma H^{-1}$$

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

- Gravitational waves from a mass distribution

$$h_{ij}(r,t) = \frac{2G}{r}\ddot{I}_{ij}(t-r), \qquad I_{ij} \equiv \int d^3r\,\rho_{dw}\left(r_i r_j - \frac{r^2\delta_{ij}}{3}\right)$$

- In the case of DW network in scaling

$$R \sim D \sim H^{-1} \sim k^{-1}\,, \qquad v_{dw} \sim 1$$

-

$$I_{ij} \sim \rho_{dw}R^5 \qquad \Rightarrow \qquad h_{ij}(r,t) \sim \frac{G}{R}\frac{\rho_{dw}R^5}{R^2} \sim G\sigma H^{-1}$$

-

$$\frac{d\rho_{\rm gw}}{d\log k} = \frac{k^3|\dot{h}|^2}{2(2\pi)^3 G a^2} \sim G\sigma^2 H a^{-2}$$

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

- Gravitational waves from a mass distribution

$$h_{ij}(r,t) = \frac{2G}{r}\ddot{I}_{ij}(t-r), \qquad I_{ij} \equiv \int d^3r \rho_{dw}\left(r_i r_j - \frac{r^2\delta_{ij}}{3}\right)$$

- In the case of DW network in scaling

$$R \sim D \sim H^{-1} \sim k^{-1}\,, \qquad v_{dw} \sim 1$$

- $$I_{ij} \sim \rho_{dw} R^5 \qquad \Rightarrow \qquad h_{ij}(r,t) \sim \frac{G}{R}\frac{\rho_{dw}R^5}{R^2} \sim G\sigma H^{-1}$$

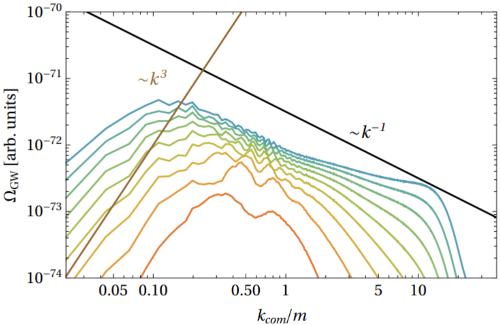
- $$\frac{d\rho_{\rm gw}}{d\log k} = \frac{k^3|\dot{h}|^2}{2(2\pi)^3 G a^2} \sim G\sigma^2 H a^{-2}$$

- $$\rho_{\rm gw} = \epsilon_{\rm gw} G\mathcal{A}^2\sigma^2 \sim \text{CONST} \qquad \boxed{\Rightarrow \Omega_{\rm GW} = \frac{G\mathcal{A}^2\sigma^2}{3H^2M_{\rm pl}^2}},$$

Gravitational wave spectrum

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

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



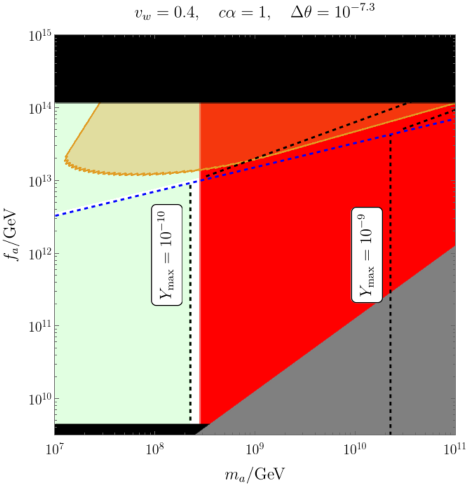
$$\Omega_{\rm GW}(T) \approx 2.34\times 10^{-6}\tilde{\epsilon}_{\rm GW}\mathcal{A}^2 \left(\frac{g_\star(T)}{10}\right)\left(\frac{g_{s\star}(T)}{10}\right)^{-4/3}\left(\frac{T_{\rm dom}}{T}\right)^4 \text{Min}\left[1, \left(\frac{T_{\text{alp dec}}}{T_{\text{mat dom}}}\right)^{4/3}\right]$$

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

GW signal and leptogenesis

[2411.13494]: Mariotti, Nagels, Rase, MV

Incompatibility of leptogenesis and detectable GWs



- amplitude GW signal maximal if $T_{\rm ann} \sim T_{\rm dom}$.
- Suppressions scales like $T_{\rm ann}$:

$$\Delta\theta \equiv \frac{\Delta V}{V_0} \sim \frac{T_{\rm ann}^2}{m_a M_{\rm pl}} \xrightarrow{T=T_{\rm dom}} \frac{v^2}{M_{\rm pl}^2} \ll 1$$

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

- Competition between GW suppression and lepto suppression

DW-Cogenesis

[2411.13494]: Mariotti, Nagels, Rase, MV

- Baryon-DM coincidence

$$\Omega_{\rm DM} \sim 5\Omega_b$$

DW-Cogenesis

[2411.13494]: Mariotti, Nagels, Rase, MV

- Baryon-DM coincidence

$$\Omega_{\rm DM} \sim 5\Omega_b$$

- Typical solution *Cogenesis*: relate the mechanism of baryogenesis and DM production

$$n_b \sim n_{\rm DM} \qquad \Rightarrow \Omega_{\rm DM} \sim 5\Omega_b \qquad \Rightarrow \frac{m_{\rm DM}}{m_b} \sim 5$$

DW-Cogenesis

[2411.13494]: Mariotti, Nagels, Rase, MV

- Baryon-DM coincidence

$$\Omega_{\rm DM} \sim 5\Omega_b$$

- Typical solution *Cogenesis*: relate the mechanism of baryogenesis and DM production

$$n_b \sim n_{\rm DM} \qquad \Rightarrow \Omega_{\rm DM} \sim 5\Omega_b \qquad \Rightarrow \frac{m_{\rm DM}}{m_b} \sim 5$$

- Domain wall co-genesis

$$\mathcal{L} \supset \underbrace{y(\tilde{H}\bar{L})N_R + \frac{1}{2}M_N \bar{N}_R^c N_R}_{\text{see-saw sector}} + \underbrace{y_D(\phi^\dagger \bar{\chi})N_R + m_\chi \bar{\chi}\chi}_{\text{DM sector}} + h.c.\,,$$

$$\mathcal{L}_{a-j} = c_L \frac{\partial_\mu a}{f_a} j_L^\mu + c_\chi \frac{\partial_\mu a}{f_a} j_\chi^\mu$$

DW-Cogenesis

[2411.13494]: Mariotti, Nagels, Rase, MV

- Baryon-DM coincidence

$$\Omega_{\rm DM} \sim 5\Omega_b$$

- Typical solution *Cogenesis*: relate the mechanism of baryogenesis and DM production

$$n_b \sim n_{\rm DM} \qquad \Rightarrow \Omega_{\rm DM} \sim 5\Omega_b \qquad \Rightarrow \frac{m_{\rm DM}}{m_b} \sim 5$$

- Domain wall co-genesis

$$\mathcal{L} \supset \underbrace{y(\tilde{H}\bar{L})N_R + \frac{1}{2}M_N \bar{N}_R^c N_R}_{\text{see-saw sector}} + \underbrace{y_D(\phi^\dagger \bar{\chi})N_R + m_\chi \bar{\chi}\chi}_{\text{DM sector}} + h.c.\,,$$

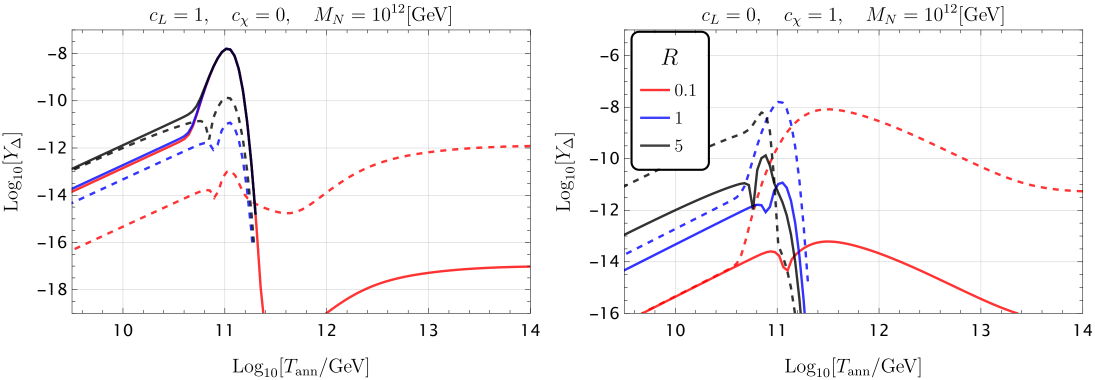
$$\mathcal{L}_{a-j} = c_L \frac{\partial_\mu a}{f_a} j_L^\mu + c_\chi \frac{\partial_\mu a}{f_a} j_\chi^\mu$$

- Different hierarchies: $y_D/y \equiv R > 1, < 1, = 1$.

$$\text{Br}_{N\to\phi\chi} = \frac{R^2}{1+R^2}, \qquad \text{Br}_{N\to HL} = \frac{1}{1+R^2} \qquad \Gamma^D_{\rm tot} = \frac{y^2(1+R^2)M_N}{16\pi}.$$

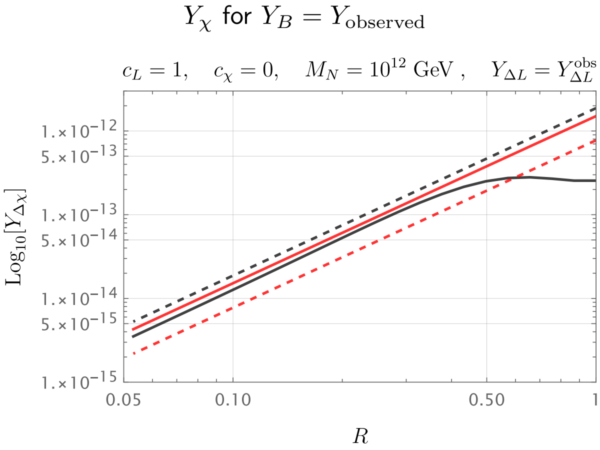
DW-Cogenesis

[2411.13494]: Mariotti, Nagels, Rase, MV



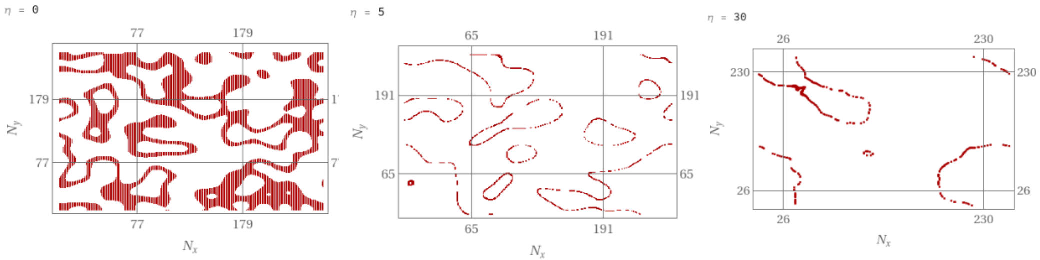
DW-Cogenesis

[2411.13494]: Mariotti, Nagels, Rase, MV



- For $c_L = 1, c_\chi = 0$, sharing induces $Y_\chi \ll Y_B$
- $m_{\rm DM} \gg m_b$

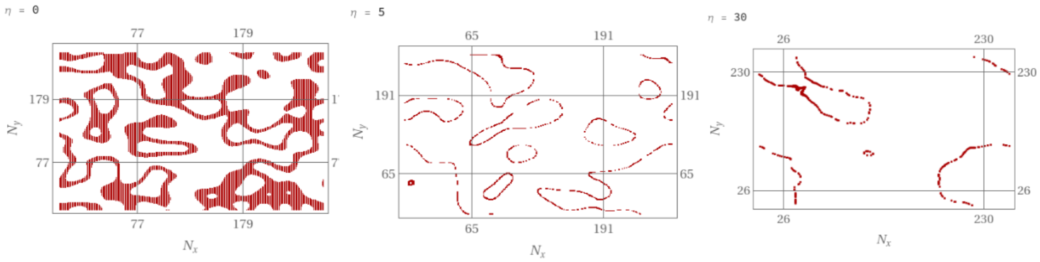
Conclusion



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

Thank you ;)

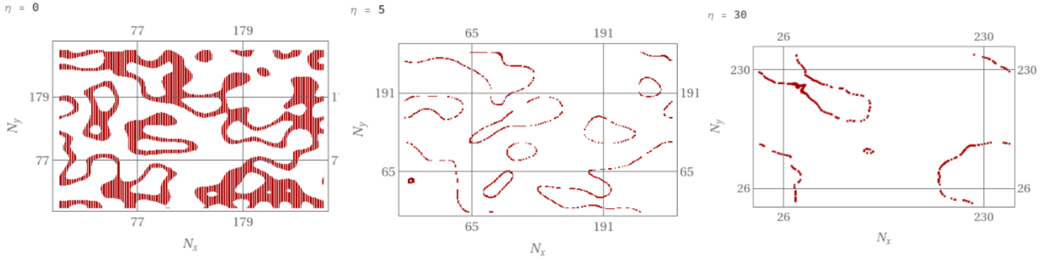
Conclusion



- DW-genesis: generation of baryon number independent on CP-violation in the couplings
- Suppressions from matter domination and opposite DWs

Thank you ;)

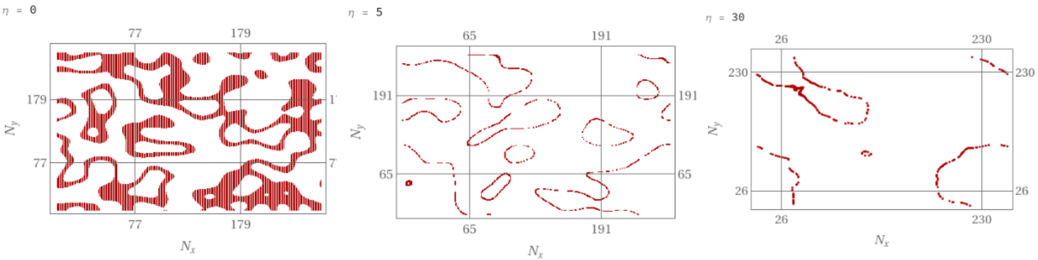
Conclusion



- DW-genesis: generation of baryon number independent on CP-violation in the couplings
- Suppressions from matter domination and opposite DWs
- DWs are copious source of GWs

Thank you ;)

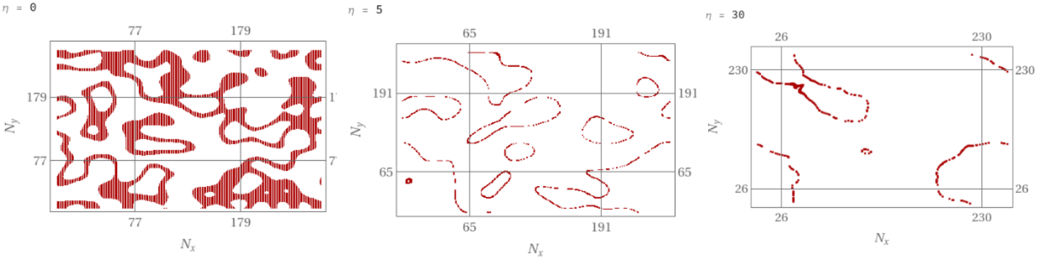
Conclusion



- DW-genesis: generation of baryon number independent on CP-violation in the couplings
- Suppressions from matter domination and opposite DWs
- DWs are copious source of GWs
- observable GW signal and successful DW-genesis seem mutually *exclusive*

Thank you ;)

Conclusion



- DW-genesis: generation of baryon number independent on CP-violation in the couplings
- Suppressions from matter domination and opposite DWs
- DWs are copious source of GWs
- observable GW signal and successful DW-genesis seem mutually *exclusive*
- Model of cogenesis with $Y_B \neq Y_\chi$!

Thank you ;)