Baryogenesis via Cosmic Quantum Fluctuation

Adrian Manning

School of Physics, University of Sydney

ARC Centre of Excellence for Particle Physics at the Terascale

---

Based on arXiv:1506.01511

Outline

- The Observable Universe is predominantly made of matter
- Big Bang Nucleosynthesis (BBN) - Requires a baryon asymmetry:

$$\eta_B = \frac{(n_B - n_{\bar{B}})}{s} \approx 8.6 \times 10^{-11}$$

- The Standard Model has no mechanism in which to generate this amount of asymmetry with standard cosmology
- There are potential solutions:
  - Leptogenesis
  - GUT Theories
  - Extra Particles, Forces, Interactions

Matter/Anti-Matter Asymmetry

- The Observable Universe is predominantly made of matter
- Big Bang Nucleosynthesis (BBN) - Requires a baryon asymmetry:

$$\eta_B = \frac{(n_B - n_{\bar{B}})}{s} \approx 8.6 \times 10^{-11}$$

- The Standard Model has no mechanism in which to generate this amount of asymmetry with standard cosmology
- There are potential solutions:
  - Leptogenesis
  - GUT Theories
  - Extra Particles, Forces, Interactions

Matter/Anti-Matter Asymmetry

- The Observable Universe is predominantly made of matter
- Big Bang Nucleosynthesis (BBN) - Requires a baryon asymmetry:

$$\eta_B = \frac{(n_B - n_{\bar{B}})}{s} \approx 8.6 \times 10^{-11}$$

- The Standard Model has no mechanism in which to generate this amount of asymmetry with standard cosmology
- There are potential solutions:
    - Leptogenesis
    - GUT Theories
    - Extra Particles, Forces, Interactions

Matter/Anti-Matter Asymmetry

- The Observable Universe is predominantly made of matter
- Big Bang Nucleosynthesis (BBN) - Requires a baryon asymmetry:

$$\eta_B = \frac{(n_B - n_{\bar{B}})}{s} \approx 8.6 \times 10^{-11}$$

- The Standard Model has no mechanism in which to generate this amount of asymmetry with standard cosmology
- There are potential solutions:
  - Leptogenesis
  - GUT Theories
  - Extra Particles, Forces, Interactions

Typical extensions to the SM involve mechanisms which provide the following:

- B violation
- C and CP violation
- Departure from thermal equilibrium

Can we achieve the asymmetry without these conditions?

Proposed Solution

- Assume an inflationary epoch, with no initial baryon asymmetry
- Propose that $\langle B \rangle = 0$
- In general we expect $\langle B^2 \rangle \neq 0$
- Expect $\langle B^2 \rangle$ to grow during the inflationary epoch
- Propose that this quantum fluctuation is large enough at the end of inflation to give rise to the observed baryon asymmetry

Proposed Solution

- Assume an inflationary epoch, with no initial baryon asymmetry
- Propose that $\langle B \rangle = 0$
- In general we expect $\langle B^2 \rangle \neq 0$
- Expect $\langle B^2 \rangle$ to grow during the inflationary epoch
- Propose that this quantum fluctuation is large enough at the end of inflation to give rise to the observed baryon asymmetry

Proposed Solution

- Assume an inflationary epoch, with no initial baryon asymmetry
- Propose that $\langle B \rangle = 0$
- In general we expect $\langle B^2 \rangle \neq 0$
- Expect $\langle B^2 \rangle$ to grow during the inflationary epoch
- Propose that this quantum fluctuation is large enough at the end of inflation to give rise to the observed baryon asymmetry

Proposed Solution

- Assume an inflationary epoch, with no initial baryon asymmetry
- Propose that $\langle B \rangle = 0$
- In general we expect $\langle B^2 \rangle \neq 0$
- Expect $\langle B^2 \rangle$ to grow during the inflationary epoch
- Propose that this quantum fluctuation is large enough at the end of inflation to give rise to the observed baryon asymmetry

PROPOSED SOLUTION

- Assume an inflationary epoch, with no initial baryon asymmetry
- Propose that $\langle B \rangle = 0$
- In general we expect $\langle B^2 \rangle \neq 0$
- Expect $\langle B^2 \rangle$ to grow during the inflationary epoch
- Propose that this quantum fluctuation is large enough at the end of inflation to give rise to the observed baryon asymmetry

Model - Overview

- Use an inflationary epoch approximated by de-Sitter space
- Introduce a new complex scalar field, $\hat{\phi}(x)$ which caries unit baryon charge
- Impose $U(1)_B$ global symmetry representing baryon number which is strictly conserved
- Calculate the baryonic charge uncertainty in $\hat{\phi}(x)$ at the end of inflation
- Estimate the size of the baryonic fluctuations over the size of the observable universe after inflation
- Can the baryon asymmetry be the result of a large scale quantum fluctuation?

Model - Overview

- Use an inflationary epoch approximated by de-Sitter space
- Introduce a new complex scalar field, $\hat{\phi}(x)$ which caries unit baryon charge
- Impose $U(1)_B$ global symmetry representing baryon number which is strictly conserved
- Calculate the baryonic charge uncertainty in $\hat{\phi}(x)$ at the end of inflation
- Estimate the size of the baryonic fluctuations over the size of the observable universe after inflation
- Can the baryon asymmetry be the result of a large scale quantum fluctuation?

Model - Overview

- Use an inflationary epoch approximated by de-Sitter space
- Introduce a new complex scalar field, $\hat{\phi}(x)$ which caries unit baryon charge
- Impose $U(1)_B$ global symmetry representing baryon number which is strictly conserved
- Calculate the baryonic charge uncertainty in $\hat{\phi}(x)$ at the end of inflation
- Estimate the size of the baryonic fluctuations over the size of the observable universe after inflation
- Can the baryon asymmetry be the result of a large scale quantum fluctuation?

- Use an inflationary epoch approximated by de-Sitter space
- Introduce a new complex scalar field, $\hat{\phi}(x)$ which caries unit baryon charge
- Impose $U(1)_B$ global symmetry representing baryon number which is strictly conserved
- Calculate the baryonic charge uncertainty in $\hat{\phi}(x)$ at the end of inflation
- Estimate the size of the baryonic fluctuations over the size of the observable universe after inflation
- Can the baryon asymmetry be the result of a large scale quantum fluctuation?

Model - Overview

- Use an inflationary epoch approximated by de-Sitter space
- Introduce a new complex scalar field, $\hat{\phi}(x)$ which caries unit baryon charge
- Impose $U(1)_B$ global symmetry representing baryon number which is strictly conserved
- Calculate the baryonic charge uncertainty in $\hat{\phi}(x)$ at the end of inflation
- Estimate the size of the baryonic fluctuations over the size of the observable universe after inflation
- Can the baryon asymmetry be the result of a large scale quantum fluctuation?

- Use an inflationary epoch approximated by de-Sitter space
- Introduce a new complex scalar field, $\hat{\phi}(x)$ which caries unit baryon charge
- Impose $U(1)_B$ global symmetry representing baryon number which is strictly conserved
- Calculate the baryonic charge uncertainty in $\hat{\phi}(x)$ at the end of inflation
- Estimate the size of the baryonic fluctuations over the size of the observable universe after inflation
- Can the baryon asymmetry be the result of a large scale quantum fluctuation?

Model - Details

- Inflationary action in conformal time:

$$S = \int d^3x \, d\eta \left[\eta^{\mu\nu} \partial_\mu \Phi^* \partial_\nu \Phi + \left(\frac{a''}{a} - (ma)^2 \right) \Phi^* \Phi \right] \quad a = -\frac{1}{\eta H}$$

- With comoving field operator

$$\hat{\Phi} = \frac{1}{\sqrt{2}} \left(\hat{\Phi}_1 + i \hat{\Phi}_2 \right) = a(\eta) \hat{\phi}$$

- Comoving charge operator

$$\hat{Q}(\eta, \vec{x}) = \left(\hat{\Phi}_2 \partial_\eta \hat{\Phi}_1 - \hat{\Phi}_1 \partial_\eta \hat{\Phi}_2 \right)$$

MODEL - DETAILS

- Inflationary action in conformal time:

$$S = \int d^3x \, d\eta \left[\eta^{\mu\nu} \partial_\mu \Phi^* \partial_\nu \Phi + \left(\frac{a''}{a} - (ma)^2 \right) \Phi^* \Phi \right] \quad a = -\frac{1}{\eta H}$$

- With comoving field operator

$$\hat{\Phi} = \frac{1}{\sqrt{2}} \left(\hat{\Phi}_1 + i \hat{\Phi}_2 \right) = a(\eta) \hat{\phi}$$

- Comoving charge operator

$$\hat{Q}(\eta, \vec{x}) = \left(\hat{\Phi}_2 \partial_\eta \hat{\Phi}_1 - \hat{\Phi}_1 \partial_\eta \hat{\Phi}_2 \right)$$

- Inflationary action in conformal time:

$$S = \int d^3x\, d\eta \left[\eta^{\mu\nu} \partial_\mu \Phi^* \partial_\nu \Phi + \left(\frac{a''}{a} - (ma)^2 \right) \Phi^* \Phi \right] \quad a = -\frac{1}{\eta H}$$

- With comoving field operator

$$\hat{\Phi} = \frac{1}{\sqrt{2}} \left(\hat{\Phi}_1 + i\hat{\Phi}_2 \right) = a(\eta)\hat{\phi}$$

- Comoving charge operator

$$\hat{Q}(\eta, \vec{x}) = \left(\hat{\Phi}_2 \partial_\eta \hat{\Phi}_1 - \hat{\Phi}_1 \partial_\eta \hat{\Phi}_2 \right)$$

Model - Details

- Evaluate Charge-Charge correlator at the end of inflation over a comoving scale, $\ell = |\vec{x} - \vec{y}|$

$$\bar{Q}_\ell^2 = \int d^3x\, d^3y\, W_\ell(\vec{x}) W_\ell(\vec{y}) \langle \hat{Q}(\eta_{\mathrm{inf}}, \vec{x}) \hat{Q}(\eta_{\mathrm{inf}}, \vec{y}) \rangle$$

- Gaussian window function

$$W_\ell(\vec{x}) = \frac{1}{(2\pi)^{\frac{3}{2}} \ell^3} e^{-|\vec{x}|^2/2\ell^2}$$

- Charge-Charge correlator

$$\langle \hat{Q}(x) \hat{Q}(x') \rangle = 2 \left[G(x,x') \frac{\partial^2}{\partial\eta\partial\eta'} G(x,x') - \frac{\partial}{\partial\eta'} G(x,x') \frac{\partial}{\partial\eta} G(x,x') \right]$$

- Evaluate Charge-Charge correlator at the end of inflation over a comoving scale, $\ell = |\vec{x} - \vec{y}|$

$$\bar{Q}_\ell^2 = \int d^3x \, d^3y \, W_\ell(\vec{x}) W_\ell(\vec{y}) \langle \hat{Q}(\eta_{\rm inf}, \vec{x}) \hat{Q}(\eta_{\rm inf}, \vec{y}) \rangle$$

- Gaussian window function

$$W_\ell(\vec{x}) = \frac{1}{(2\pi)^{\frac{3}{2}} \ell^3} e^{-|\vec{x}|^2/2\ell^2}$$

- Charge-Charge correlator

$$\langle \hat{Q}(x) \hat{Q}(x') \rangle = 2 \left[G(x,x') \frac{\partial^2}{\partial\eta \partial\eta'} G(x,x') - \frac{\partial}{\partial\eta'} G(x,x') \frac{\partial}{\partial\eta} G(x,x') \right]$$

- Evaluate Charge-Charge correlator at the end of inflation over a comoving scale, $\ell = |\vec{x} - \vec{y}|$

$$\bar{Q}_\ell^2 = \int d^3x \, d^3y \; W_\ell(\vec{x}) W_\ell(\vec{y}) \langle \hat{Q}(\eta_{\rm inf}, \vec{x}) \hat{Q}(\eta_{\rm inf}, \vec{y}) \rangle$$

- Gaussian window function

$$W_\ell(\vec{x}) = \frac{1}{(2\pi)^{\frac{3}{2}} \ell^3} e^{-|\vec{x}|^2/2\ell^2}$$

- Charge-Charge correlator

$$\langle \hat{Q}(x) \hat{Q}(x') \rangle = 2 \left[G(x, x') \frac{\partial^2}{\partial \eta \partial \eta'} G(x, x') - \frac{\partial}{\partial \eta'} G(x, x') \frac{\partial}{\partial \eta} G(x, x') \right]$$

- Two-point Function:

$$G(x,x') = \langle \hat{\Phi}_1(x)\hat{\Phi}_1(x')\rangle = \langle \hat{\Phi}_2(x)\hat{\Phi}_2(x')\rangle$$
$$= \int \frac{d^3\vec{k}}{(2\pi)^3}\Phi_k(\eta)\Phi_k^*(\eta')e^{i\vec{k}\cdot(\vec{x}-\vec{x}')}$$

- de-Sitter mode functions defined with Bunch-Davis vacuum

$$\Phi_k(\eta) = \sqrt{-\frac{\pi\eta}{4}}\, e^{i(\pi/2)(\nu-1/2)}H_\nu^{(1)}(-k\eta)$$
$$\nu^2 = \frac{9}{4} - \frac{M^2}{H^2}$$

$M \ll H$ | $k|\eta| \to 0$ | $\mathcal{O}(k|\eta|)$

Model - Details

- Two-point Function:

$$G(x,x') = \langle \hat{\Phi}_1(x)\hat{\Phi}_1(x')\rangle = \langle \hat{\Phi}_2(x)\hat{\Phi}_2(x')\rangle$$
$$= \int \frac{d^3\vec{k}}{(2\pi)^3}\Phi_k(\eta)\Phi_k^*(\eta')e^{i\vec{k}\cdot(\vec{x}-\vec{x}')}$$

- de-Sitter mode functions defined with Bunch-Davis vacuum

$$\Phi_k(\eta) = \sqrt{-\frac{\pi\eta}{4}}\, e^{i(\pi/2)(\nu-1/2)}H_\nu^{(1)}(-k\eta)$$
$$\nu^2 = \frac{9}{4} - \frac{M^2}{H^2}$$

$M \ll H$ | $k|\eta| \to 0$ | $\mathcal{O}(k|\eta|)$

Model - Details

- Two-point Function:

$$G(x,x') = \langle \hat{\Phi}_1(x)\hat{\Phi}_1(x')\rangle = \langle \hat{\Phi}_2(x)\hat{\Phi}_2(x')\rangle$$
$$= \int \frac{d^3\vec{k}}{(2\pi)^3}\Phi_k(\eta)\Phi_k^*(\eta')e^{i\vec{k}\cdot(\vec{x}-\vec{x}')}$$

- de-Sitter mode functions defined with Bunch-Davis vacuum

$$\Phi_k(\eta) = \sqrt{-\frac{\pi\eta}{4}}\, e^{i(\pi/2)(\nu-1/2)}H_\nu^{(1)}(-k\eta)$$
$$\nu^2 = \frac{9}{4} - \frac{M^2}{H^2}$$

$M \ll H$ | $k|\eta| \to 0$ | $\mathcal{O}(k|\eta|)$

Model - Details

- Two-point Function:

$$G(x,x') = \langle \hat{\Phi}_1(x)\hat{\Phi}_1(x')\rangle = \langle \hat{\Phi}_2(x)\hat{\Phi}_2(x')\rangle$$
$$= \int \frac{d^3\vec{k}}{(2\pi)^3}\Phi_k(\eta)\Phi_k^*(\eta')e^{i\vec{k}\cdot(\vec{x}-\vec{x}')}$$

- de-Sitter mode functions defined with Bunch-Davis vacuum

$$\Phi_k(\eta) = \sqrt{-\frac{\pi\eta}{4}}\, e^{i(\pi/2)(\nu-1/2)}H_\nu^{(1)}(-k\eta)$$
$$\nu^2 = \frac{9}{4} - \frac{M^2}{H^2}$$

$M \ll H$ | $k|\eta| \to 0$ | $\mathcal{O}(k|\eta|)$

Model - Details

- Two-point Function:

$$G(x,x') = \langle \hat{\Phi}_1(x)\hat{\Phi}_1(x')\rangle = \langle \hat{\Phi}_2(x)\hat{\Phi}_2(x')\rangle$$
$$= \int \frac{d^3\vec{k}}{(2\pi)^3}\Phi_k(\eta)\Phi_k^*(\eta')e^{i\vec{k}\cdot(\vec{x}-\vec{x}')}$$

- de-Sitter mode functions defined with Bunch-Davis vacuum

$$\Phi_k(\eta) = \sqrt{-\frac{\pi\eta}{4}}\, e^{i(\pi/2)(\nu-1/2)}H_\nu^{(1)}(-k\eta)$$
$$\nu^2 = \frac{9}{4} - \frac{M^2}{H^2}$$

$M \ll H$ | $k|\eta| \to 0$ | $\mathcal{O}(k|\eta|)$

Model - Results

- Quantum fluctuation of baryon/anti-baryon comoving number density

$$|\delta n_B| \equiv \bar{Q}_\ell \approx \frac{\sqrt{\kappa}}{4\sqrt{2}\pi^2}\frac{a_{\rm inf}H_{\rm inf}}{\ell^2} \qquad \kappa \approx 0.026$$

- Relate to baryon asymmetry parameter at the end of reheating

$$|\eta_B| = \frac{|\delta n_B|}{a_{\rm rh}^3 s} = \frac{45\sqrt{\kappa}}{8\sqrt{2}\pi^4\, g_*(T_{\rm rh})}\left(\frac{a_{\rm inf}}{a_{\rm rh}}\right)^3 \frac{1}{(a_{\rm inf}\ell)^2}\frac{H_{\rm inf}}{T_{\rm rh}^3}$$

- Comoving scale at the end of inflation

$$\ell = \left(\frac{a_{\rm rh}}{a_0}\right)\left(\frac{a_{\rm inf}}{a_{\rm rh}}\right)^{1/2}\frac{L_0}{a_0}$$

$g_*(T_{\rm rh}) \approx 100$ | $T_0 \approx 10^{-13} GeV$ | $L_0 \approx 1.6 \times 10^{41} GeV^{-1}$

- Quantum fluctuation of baryon/anti-baryon comoving number density

$$|\delta n_B| \equiv \bar{Q}_\ell \approx \frac{\sqrt{\kappa}}{4\sqrt{2}\pi^2}\frac{a_{\rm inf}H_{\rm inf}}{\ell^2} \qquad \kappa \approx 0.026$$

- Relate to baryon asymmetry parameter at the end of reheating

$$\begin{aligned} |\eta_B| &= \frac{|\delta n_B|}{a_{\rm rh}^3 s} \\ &= \frac{45\sqrt{\kappa}}{8\sqrt{2}\pi^4\, g_*(T_{\rm rh})}\left(\frac{a_{\rm inf}}{a_{\rm rh}}\right)^3 \frac{1}{(a_{\rm inf}\ell)^2}\frac{H_{\rm inf}}{T_{\rm rh}^3} \end{aligned}$$

- Comoving scale at the end of inflation

$$\ell = \left(\frac{a_{\rm rh}}{a_0}\right)\left(\frac{a_{\rm inf}}{a_{\rm rh}}\right)^{1/2}\frac{L_0}{a_0}$$

$g_*(T_{\rm rh}) \approx 100$ | $T_0 \approx 10^{-13} GeV$ | $L_0 \approx 1.6 \times 10^{41} GeV^{-1}$

Model - Results

- Quantum fluctuation of baryon/anti-baryon comoving number density

$$|\delta n_B| \equiv \bar{Q}_\ell \approx \frac{\sqrt{\kappa}}{4\sqrt{2}\pi^2}\frac{a_{\rm inf}H_{\rm inf}}{\ell^2} \quad \kappa \approx 0.026$$

- Relate to baryon asymmetry parameter at the end of reheating

$$\begin{aligned}|\eta_B| &= \frac{|\delta n_B|}{a_{\rm rh}^3 s} \\ &= \frac{45\sqrt{\kappa}}{8\sqrt{2}\pi^4\, g_*(T_{\rm rh})}\left(\frac{a_{\rm inf}}{a_{\rm rh}}\right)^3 \frac{1}{(a_{\rm inf}\ell)^2}\frac{H_{\rm inf}}{T_{\rm rh}^3}\end{aligned}$$

- Comoving scale at the end of inflation

$$\ell = \left(\frac{a_{\rm rh}}{a_0}\right)\left(\frac{a_{\rm inf}}{a_{\rm rh}}\right)^{1/2}\frac{L_0}{a_0}$$

$g_*(T_{\rm rh}) \approx 100$ | $T_0 \approx 10^{-13} GeV$ | $L_0 \approx 1.6 \times 10^{41} GeV^{-1}$

Model - Results

- Quantum fluctuation of baryon/anti-baryon comoving number density

$$|\delta n_B| \equiv \bar{Q}_\ell \approx \frac{\sqrt{\kappa}}{4\sqrt{2}\pi^2}\frac{a_{\rm inf}H_{\rm inf}}{\ell^2} \qquad \kappa \approx 0.026$$

- Relate to baryon asymmetry parameter at the end of reheating

$$\begin{aligned} |\eta_B| &= \frac{|\delta n_B|}{a_{\rm rh}^3 s} \\ &= \frac{45\sqrt{\kappa}}{8\sqrt{2}\pi^4 g_*(T_{\rm rh})}\left(\frac{a_{\rm inf}}{a_{\rm rh}}\right)^3 \frac{1}{(a_{\rm inf}\ell)^2}\frac{H_{\rm inf}}{T_{\rm rh}^3} \end{aligned}$$

- Comoving scale at the end of inflation

$$\ell = \left(\frac{a_{\rm rh}}{a_0}\right)\left(\frac{a_{\rm inf}}{a_{\rm rh}}\right)^{1/2}\frac{L_0}{a_0}$$

$g_*(T_{\rm rh}) \approx 100$ | $T_0 \approx 10^{-13} GeV$ | $L_0 \approx 1.6 \times 10^{41} GeV^{-1}$

- Quantum fluctuation of baryon/anti-baryon comoving number density

$$|\delta n_B| \equiv \bar{Q}_\ell \approx \frac{\sqrt{\kappa}}{4\sqrt{2}\pi^2} \frac{a_{\rm inf} H_{\rm inf}}{\ell^2} \qquad \kappa \approx 0.026$$

- Relate to baryon asymmetry parameter at the end of reheating

$$\begin{aligned} |\eta_B| &= \frac{|\delta n_B|}{a_{\rm rh}^3 s} \\ &= \frac{45\sqrt{\kappa}}{8\sqrt{2}\pi^4 g_*(T_{\rm rh})} \left(\frac{a_{\rm inf}}{a_{\rm rh}}\right)^3 \frac{1}{(a_{\rm inf}\ell)^2} \frac{H_{\rm inf}}{T_{\rm rh}^3} \end{aligned}$$

- Comoving scale at the end of inflation

$$\ell = \left(\frac{a_{\rm rh}}{a_0}\right) \left(\frac{a_{\rm inf}}{a_{\rm rh}}\right)^{1/2} \frac{L_0}{a_0}$$

$g_*(T_{\rm rh}) \approx 100$ | $T_0 \approx 10^{-13} GeV$ | $L_0 \approx 1.6 \times 10^{41} GeV^{-1}$

Model - Results

- Quantum fluctuation of baryon/anti-baryon comoving number density

$$|\delta n_B| \equiv \bar{Q}_\ell \approx \frac{\sqrt{\kappa}}{4\sqrt{2}\pi^2}\frac{a_{\rm inf}H_{\rm inf}}{\ell^2} \qquad \kappa \approx 0.026$$

- Relate to baryon asymmetry parameter at the end of reheating

$$\begin{aligned}|\eta_B| &= \frac{|\delta n_B|}{a_{\rm rh}^3 s} \\ &= \frac{45\sqrt{\kappa}}{8\sqrt{2}\pi^4\, g_*(T_{\rm rh})}\left(\frac{a_{\rm inf}}{a_{\rm rh}}\right)^3 \frac{1}{(a_{\rm inf}\ell)^2}\frac{H_{\rm inf}}{T_{\rm rh}^3}\end{aligned}$$

- Comoving scale at the end of inflation

$$\ell = \left(\frac{a_{\rm rh}}{a_0}\right)\left(\frac{a_{\rm inf}}{a_{\rm rh}}\right)^{1/2}\frac{L_0}{a_0}$$

$g_*(T_{\rm rh}) \approx 100$

$T_0 \approx 10^{-13} GeV$

$L_0 \approx 1.6 \times 10^{41} GeV^{-1}$

Model - Results

$$|\eta_B| \approx 10^{-10} \left(\frac{H_{\rm inf}}{2 \times 10^{11} \mathrm{GeV}} \right) \left(\frac{T_{\rm rh}}{2 \times 10^{11} \mathrm{GeV}} \right)$$

- For realistic reheating and hubble rates, we can generate the required asymmetry
- This will also generate sub horizon fluctuations
- Expect the generated asymmetry to be homogeneously distributed after annihilation of sub horizon patches
- This asymmetry should remain intact at subsequent epochs, essentially seeding BBN

Model - Results

$$|\eta_B| \approx 10^{-10} \left(\frac{H_{\rm inf}}{2 \times 10^{11}\rm GeV} \right) \left(\frac{T_{\rm rh}}{2 \times 10^{11}\rm GeV} \right)$$

- For realistic reheating and hubble rates, we can generate the required asymmetry
- This will also generate sub horizon fluctuations
- Expect the generated asymmetry to be homogeneously distributed after annihilation of sub horizon patches
- This asymmetry should remain intact at subsequent epochs, essentially seeding BBN

Model - Results

$$|\eta_B| \approx 10^{-10} \left(\frac{H_{\rm inf}}{2 \times 10^{11}\mathrm{GeV}} \right) \left(\frac{T_{\rm rh}}{2 \times 10^{11}\mathrm{GeV}} \right)$$

- For realistic reheating and hubble rates, we can generate the required asymmetry
- This will also generate sub horizon fluctuations
- Expect the generated asymmetry to be homogeneously distributed after annihilation of sub horizon patches
- This asymmetry should remain intact at subsequent epochs, essentially seeding BBN

Model - Results

$$|\eta_B| \approx 10^{-10} \left(\frac{H_{\text{inf}}}{2 \times 10^{11}\text{GeV}} \right) \left(\frac{T_{\text{rh}}}{2 \times 10^{11}\text{GeV}} \right)$$

- For realistic reheating and hubble rates, we can generate the required asymmetry
- This will also generate sub horizon fluctuations
- Expect the generated asymmetry to be homogeneously distributed after annihilation of sub horizon patches
- This asymmetry should remain intact at subsequent epochs, essentially seeding BBN

Model - Results

$$|\eta_B| \approx 10^{-10} \left(\frac{H_{\rm inf}}{2\times 10^{11}\mathrm{GeV}}\right)\left(\frac{T_{\rm rh}}{2\times 10^{11}\mathrm{GeV}}\right)$$

- For realistic reheating and hubble rates, we can generate the required asymmetry
- This will also generate sub horizon fluctuations
- Expect the generated asymmetry to be homogeneously distributed after annihilation of sub horizon patches
- This asymmetry should remain intact at subsequent epochs, essentially seeding BBN

SUMMARY

Proposed a new mechanism for generating the observed baryon asymmetry which does not require Sakharov's conditions

Baryon asymmetry originates as a large scale quantum fluctuation of baryonic charge during the inflationary epoch

Tested the plausibility with a toy model

- Introduce a complex scalar field with an unbroken $U(1)_B$ symmetry - Baryon number remains conserved
- Estimated the charge variance over a volume the size of the particle horizon at the end of inflation
- Showed that this variance is large enough to account for the observable baryon asymmetry

SUMMARY

Proposed a new mechanism for generating the observed baryon asymmetry which does not require Sakharov's conditions

Baryon asymmetry originates as a large scale quantum fluctuation of baryonic charge during the inflationary epoch

Tested the plausibility with a toy model

- Introduce a complex scalar field with an unbroken $U(1)_B$ symmetry - Baryon number remains conserved
- Estimated the charge variance over a volume the size of the particle horizon at the end of inflation
- Showed that this variance is large enough to account for the observable baryon asymmetry

Summary

Proposed a new mechanism for generating the observed baryon asymmetry which does not require Sakharov's conditions

Baryon asymmetry originates as a large scale quantum fluctuation of baryonic charge during the inflationary epoch

Tested the plausibility with a toy model

- Introduce a complex scalar field with an unbroken $U(1)_B$ symmetry - Baryon number remains conserved
- Estimated the charge variance over a volume the size of the particle horizon at the end of inflation
- Showed that this variance is large enough to account for the observable baryon asymmetry

Thank You