Baryogenesis in Spacetime Compacity Theory

Building upon the framework of Spacetime Compacity Theory (SCT), we now explore how variations in spacetime compacity (ρ_c) could provide a novel mechanism for baryogenesis—the process responsible for the matter-antimatter asymmetry observed in the universe.

0.1 The Baryon Asymmetry Problem

Observations indicate a significant imbalance between matter and antimatter in the universe. This asymmetry is quantified by the baryon-to-photon ratio, approximately $\eta \sim 10^{-10}$. Traditional baryogenesis theories, such as those involving Grand Unified Theories (GUTs) or electroweak sphalerons, aim to explain this disparity but often require conditions beyond the Standard Model of particle physics.

0.2 Sakharov Conditions

For any successful baryogenesis mechanism, the following Sakharov conditions must be satisfied:

1. Baryon Number Violation: Interactions that do not conserve baryon number. 2. C and CP Violation: Processes that violate charge conjugation (C) and charge-parity (CP) symmetries. 3. Departure from Thermal Equilibrium: Conditions where thermal equilibrium is not maintained, allowing asymmetries to develop.

0.3 Spacetime Compacity Variations and Baryon Number Violation

In SCT, fluctuations in spacetime compacity (ρ_c) can lead to localized regions where standard conservation laws, including baryon number conservation, may be violated. These variations could induce effective interactions that allow for baryon number-changing processes without introducing new particles or forces beyond the Standard Model.

0.4 C and CP Violation through Compacity Gradients

Compacity gradients in spacetime may interact differently with matter and antimatter, leading to effective C and CP violation. This asymmetry arises because variations in ρ_c could influence particle interactions in a manner that distinguishes between particles and antiparticles, thereby satisfying the second Sakharov condition.

0.5 Departure from Thermal Equilibrium via Dynamic Compacity Fields

Rapid changes in ρ_c during the early universe could drive the cosmos out of thermal equilibrium. For instance, phase transitions in the compacity field might create conditions where certain regions cool faster than others, preventing the maintenance of thermal equilibrium and allowing baryon asymmetries to freeze in.

0.6 Mathematical Framework

To model this mechanism, we consider an effective Lagrangian that includes interactions between the compacity field and baryonic currents:

$$\mathcal{L}_{\text{eff}} = \mathcal{L}_{\text{SM}} + \frac{1}{M_*} \partial_\mu \rho_c \cdot J_B^\mu$$

Here: - $\mathcal{L}_{\text{SM}}$ is the Standard Model Lagrangian. - M_* is a characteristic energy scale. - J_B^μ is the baryonic current.

The term $\partial_\mu \rho_c \cdot J_B^\mu$ represents the interaction between the spacetime compacity gradient and the baryon current, potentially leading to baryon number violation.

0.7 Implications and Experimental Signatures

If spacetime compacity variations are responsible for baryogenesis, we might expect:

- Spatial Variations in Baryon Asymmetry: Regions with different ρ_c histories could exhibit varying baryon-to-photon ratios. - Correlation with Large-Scale Structure: The distribution of galaxies and cosmic voids might reflect underlying compacity fluctuations from the early universe.

0.8 Challenges and Future Directions

To further develop this SCT-based baryogenesis model, several challenges must be addressed:

- Quantifying Compacity Fluctuations: Developing a robust theory for the dynamics of ρ_c in the early universe. - Consistency with Observations: Ensuring that the model's predictions align with cosmic microwave background measurements and nucleosynthesis constraints. - Integration with Particle Physics: Reconciling this mechanism with established particle physics frameworks and exploring potential observable consequences in current experiments.

Next: We investigate the implications of spacetime compacity variations on leptogenesis and the generation of neutrino masses.

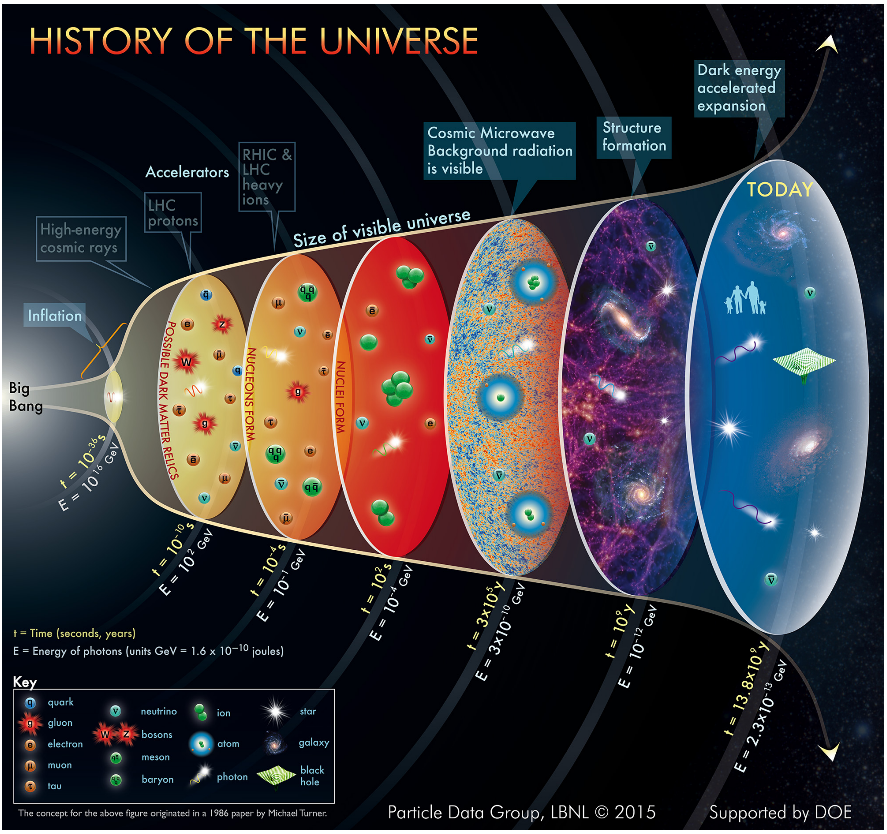

Figure 1: Formation of Matter - Baryogenesis