Baryogenesis via Leptogenesis
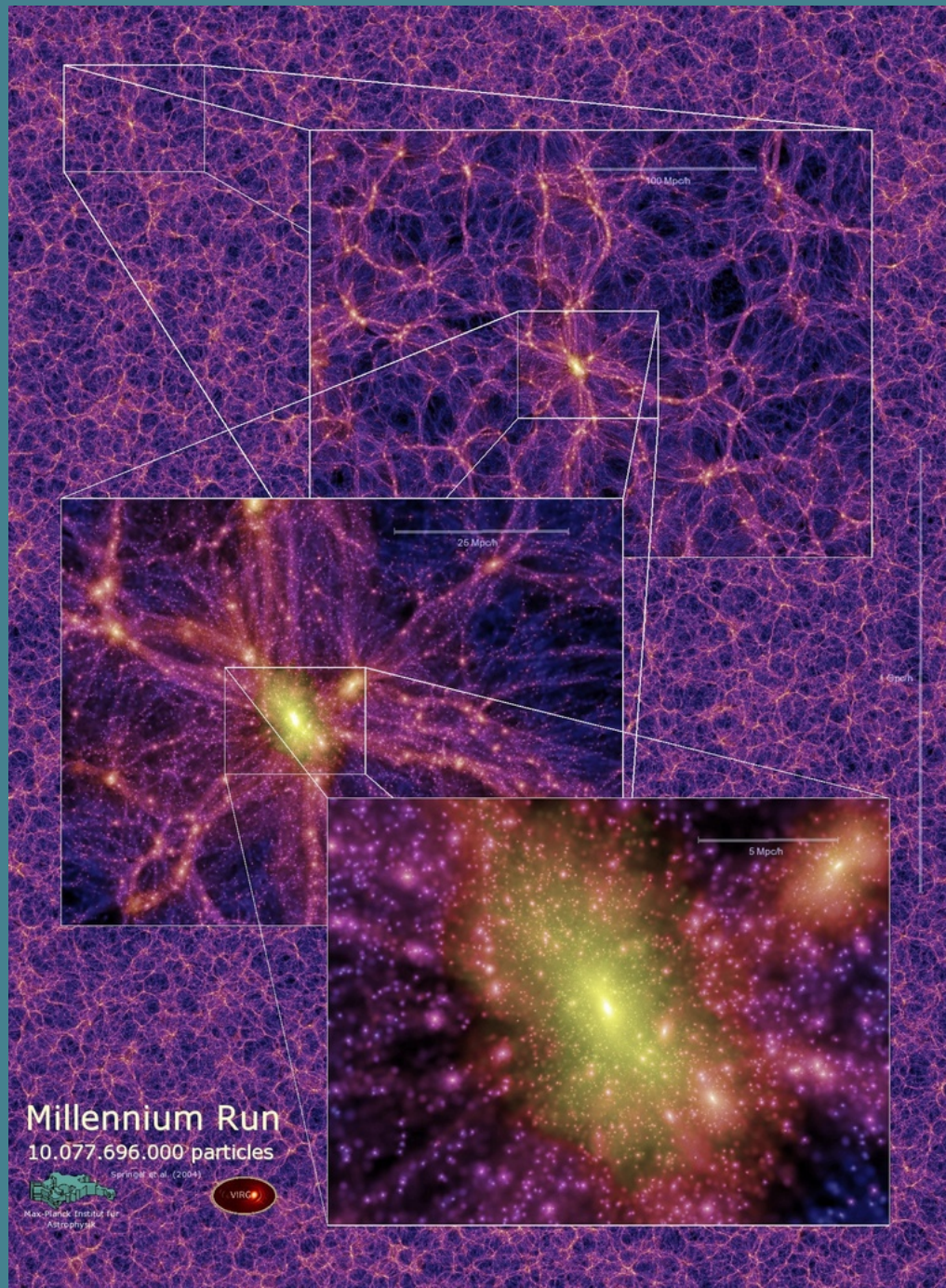
The Subtitle
Presented by Trevor Stavropoulos

What is Barygenesis/Leptogenesis

- The Generation of a non-zero Baryon Number
- Breaking of the Matter/Antimatter Symmetry
- The creation of more Matter than Antimatter in large-scale processes

Why Is This Necessary?

Why Is This Necessary?

- Cosmological Motivation
  - What we think we know
  - Why we think we know what we think we know

Millennium Run
10.077.696.000 particles

http://www.mpa-garching.mpg.de/galform/millennium/poster_half.jpg

Why Is This Necessary?

- Cosmological Motivation
  - What we think we know
  - Why we think we know what we think we know
- Particle Physics Matter/Antimatter Symmetry

Three Necessary Ingredients
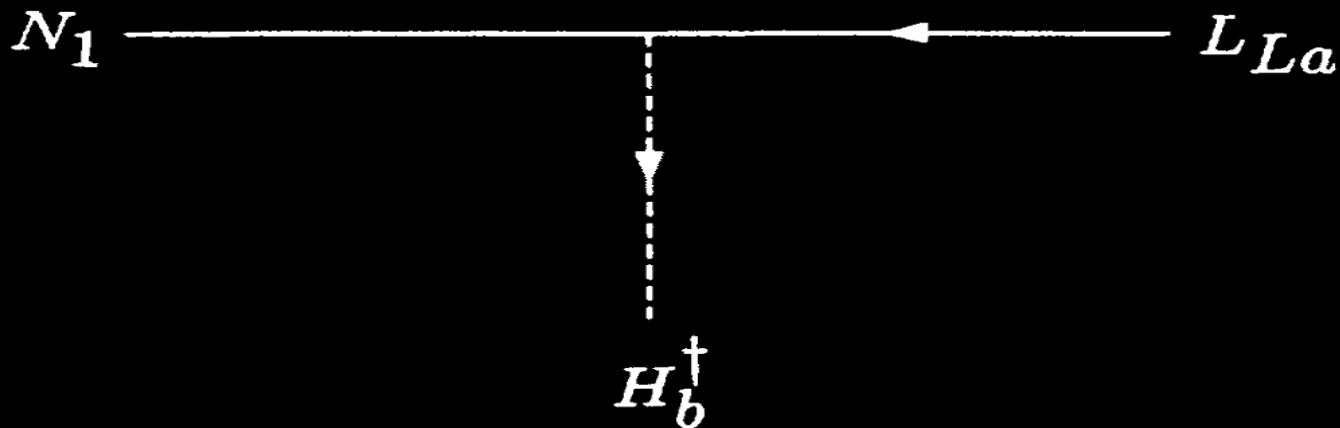
Baryon Number Violation

C and CP Violation
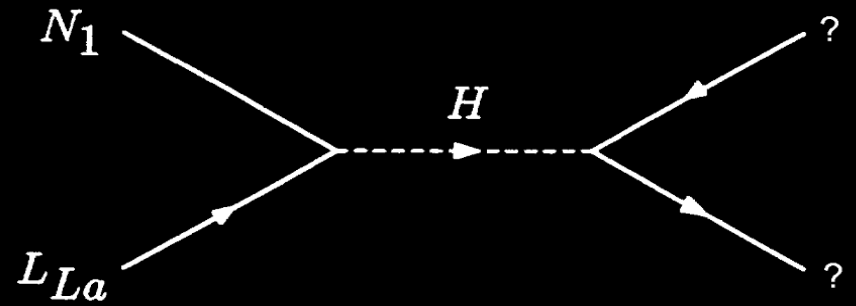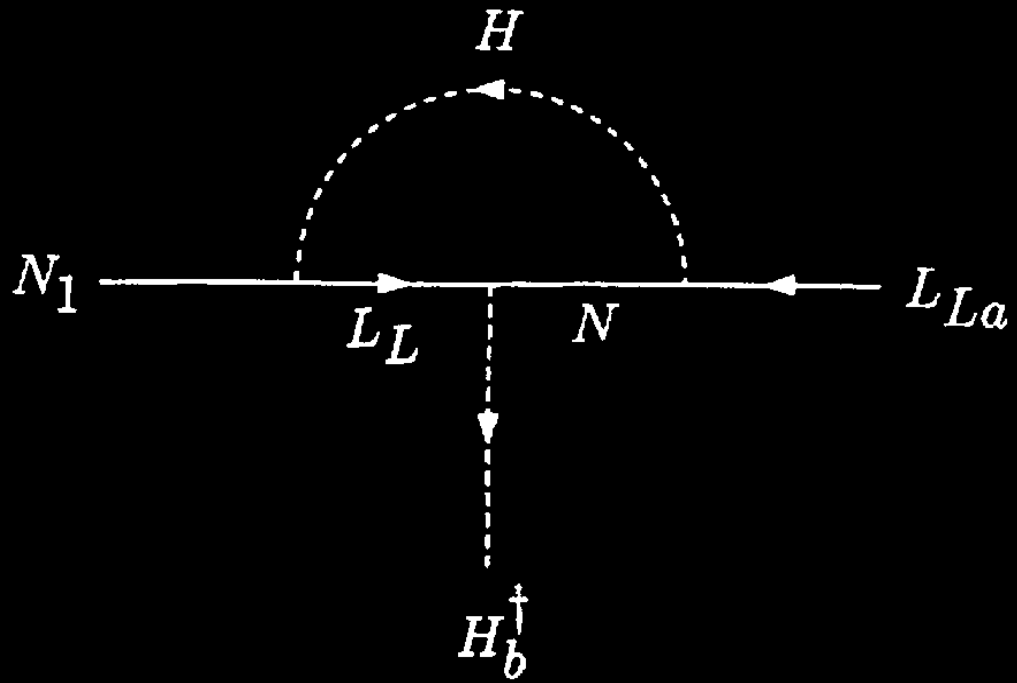
B-Violating Processes Need to be Out of Equilibrium

How Do We Fix This?

Hypothesize a Right-Handed Majorana Neutrino with the following interaction:

$$\mathcal{L}_{\text{int}} = h_{jk}(\bar{L}_{Lj}H)N_{Rk} + \textbf{H.c.}$$

Majorana Trees

CP Asymmetry

Decay Rate:
$$\Gamma_D = \frac{(h^\dagger h)_{11}}{16\pi} M_{N_1}$$

$$|\mathcal{A}(N_1 \rightarrow \nu_1 h^{0*})|^2 = |\mathcal{A}(N_1 \rightarrow \bar{\nu}_1 h^0)|^2 = \epsilon |\mathcal{A}|^2$$

$$\epsilon = \frac{1}{\pi(h^\dagger h)_{11}} \sum_j \mathrm{Im}[(h^\dagger h)_{1j}(h^T h^*)_{j1}] f(M_{Nj}^2 / M_{N1}^2)$$

Where:
$$f(x) = \sqrt{x}\left[1 - (1+x)\ln\frac{1+x}{x}\right]$$

Boltzmann Equations

$$\dot{n}_{N_1} + 3Hn_{N_1} = \left[\frac{n_{N_1}}{n_{N_1}^{\text{eq}}} - 1 \right] (\gamma_D + \gamma_{H_t} + \gamma_{H_s}) \equiv -C_N$$
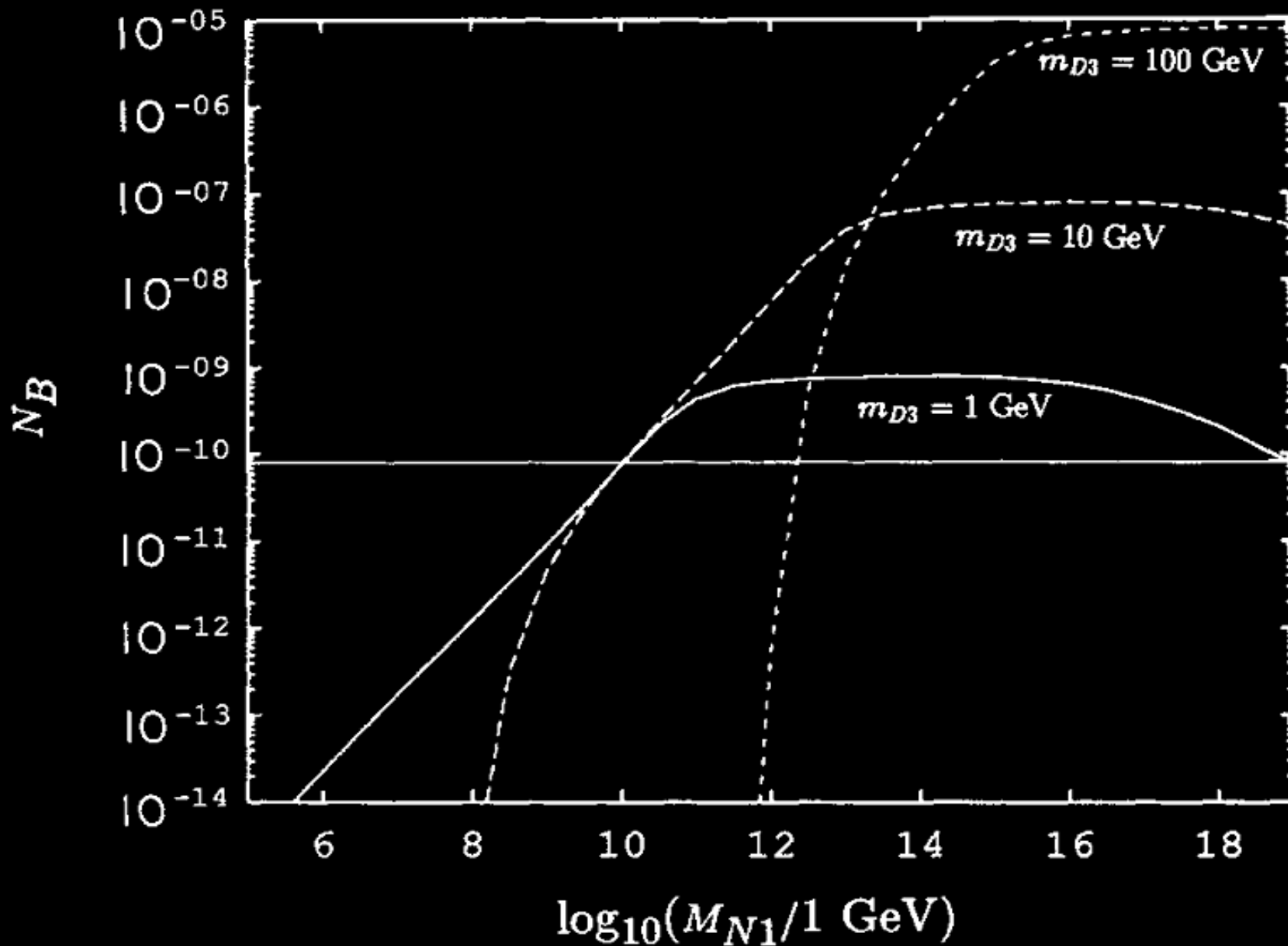
$$\dot{n}_{B-L} + 3Hn_{B-L} = \epsilon \left[\frac{n_{N_1}}{n_{N_1}^{\text{eq}}} - 1 \right] \gamma_D$$

$$- \frac{n_{B-L}}{n_l^{\text{eq}}} \left[\gamma_N + \frac{n_{N_1}}{n_{N_1}^{\text{eq}}} \gamma_{H_s} + \gamma_{H_t} \right] \equiv -C_{B-L}$$
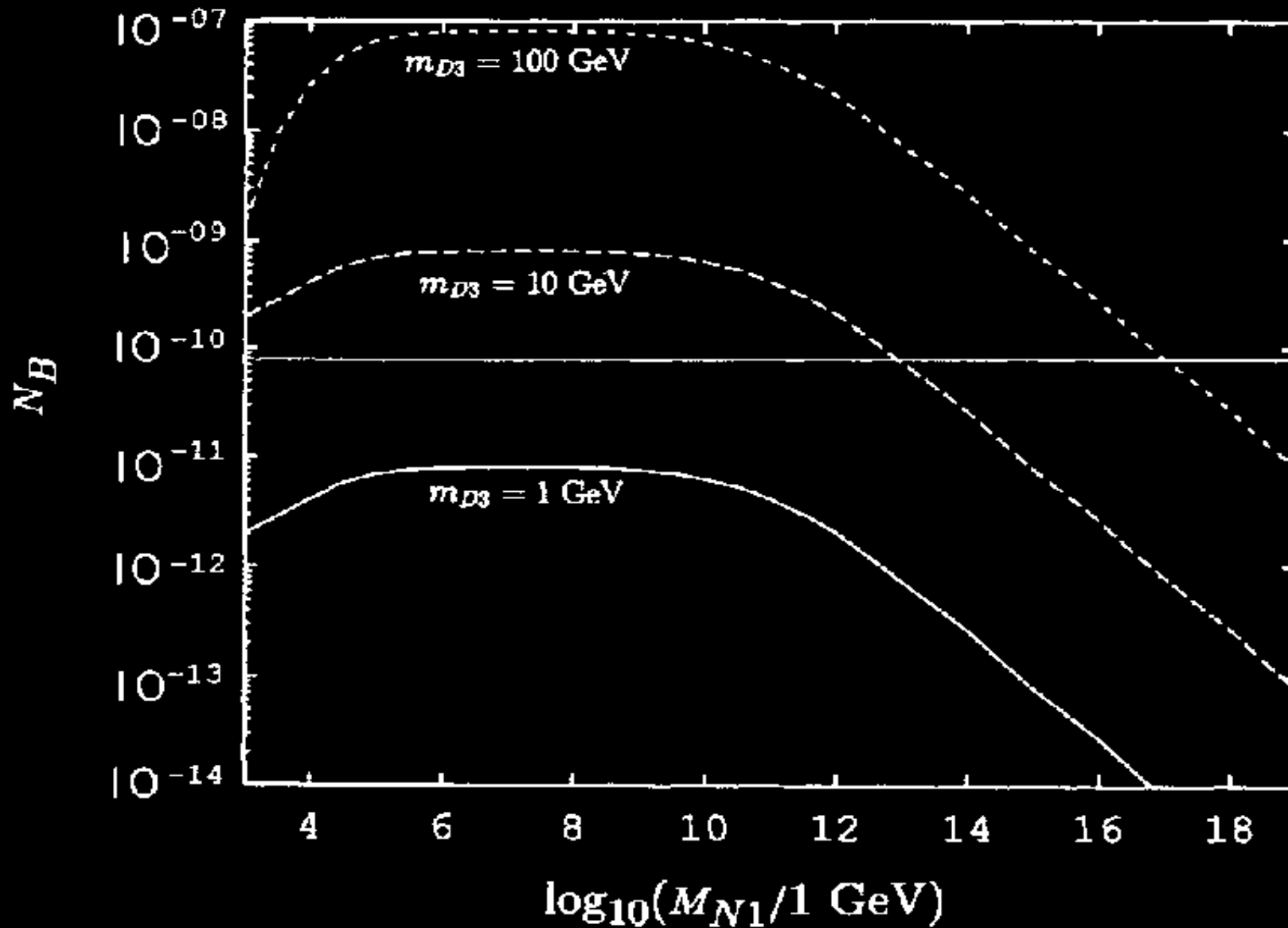
Yet Further Assumptions

$$m_D \sim \begin{bmatrix} \eta^2 & \eta^2 & \eta^2 \\ \eta^2 & \eta & \eta \\ \eta^2 & \eta & 1 \end{bmatrix} m_{D3}$$
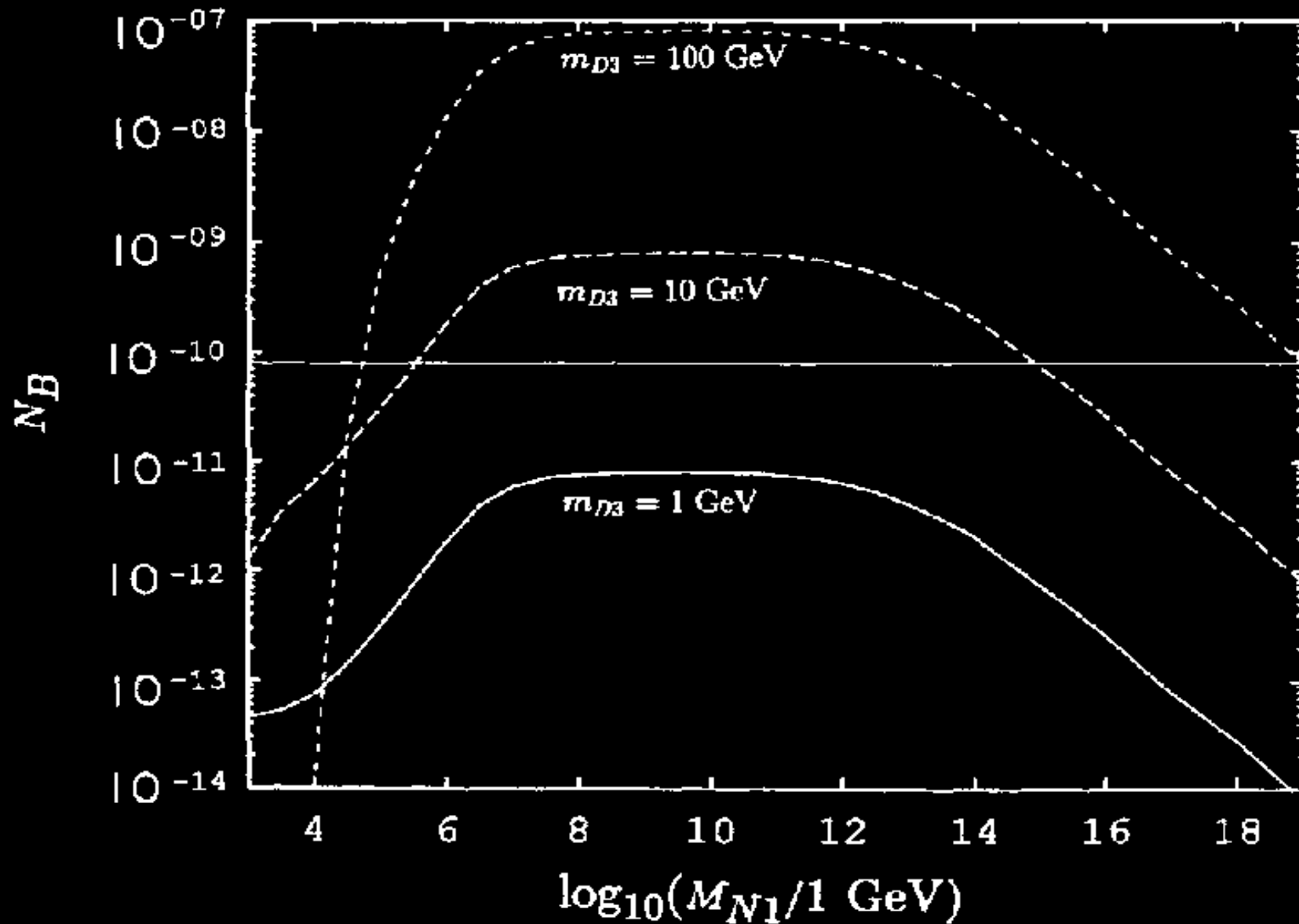
Democratic Results

Correlated Results 1

The plot shows N_B on the vertical axis versus $\log_{10}(M_{N1}/1\text{ GeV})$ on the horizontal axis, with three curves labeled $m_{D3} = 100$ GeV, $m_{D3} = 10$ GeV, and $m_{D3} = 1$ GeV.

Correlated Results 2

M Luty, "Baryogenesis via Leptogenesis." Phy Rev D. 45 455