Limits on light primordial black holes from high-scale leptogenesis

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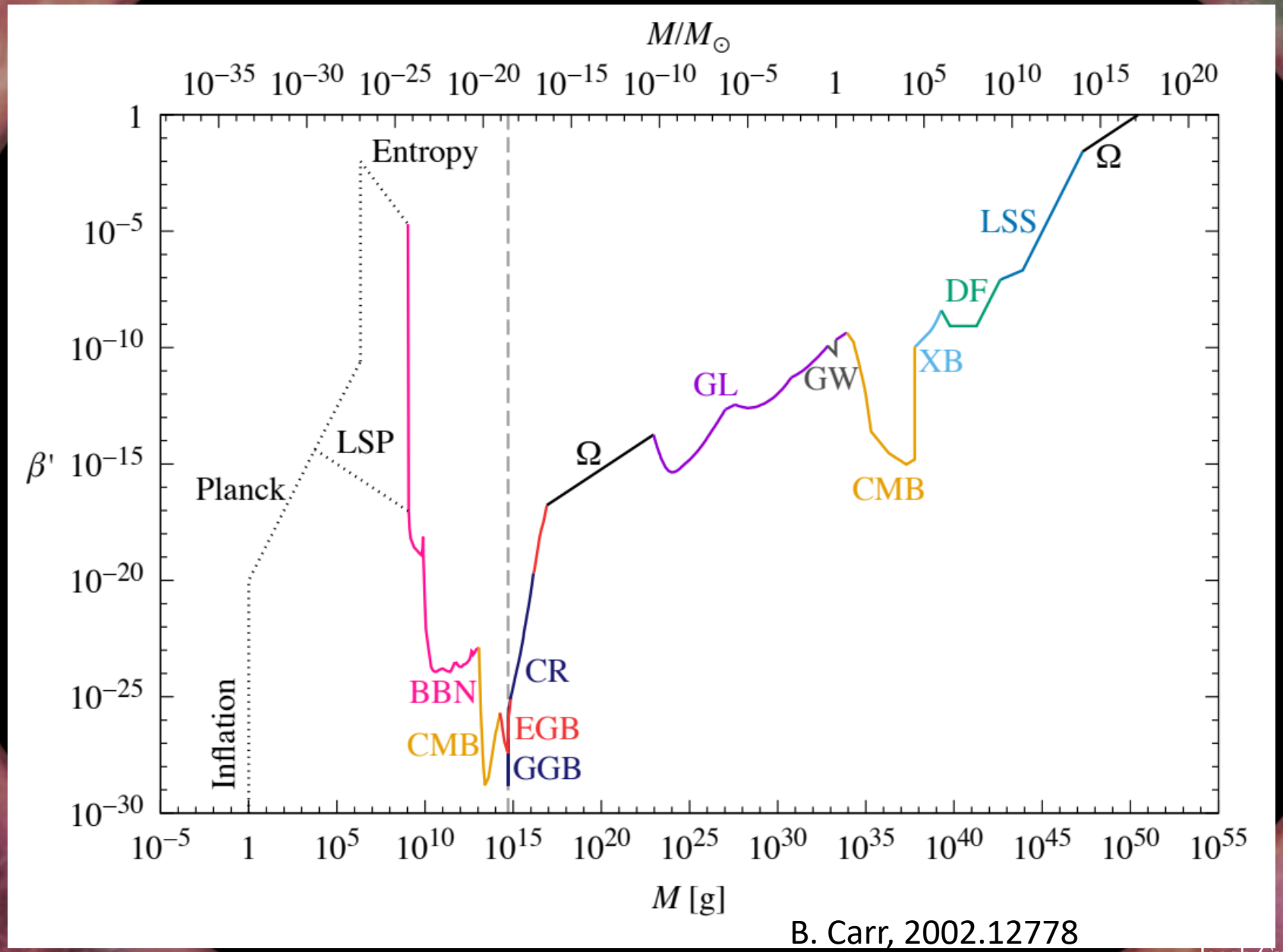
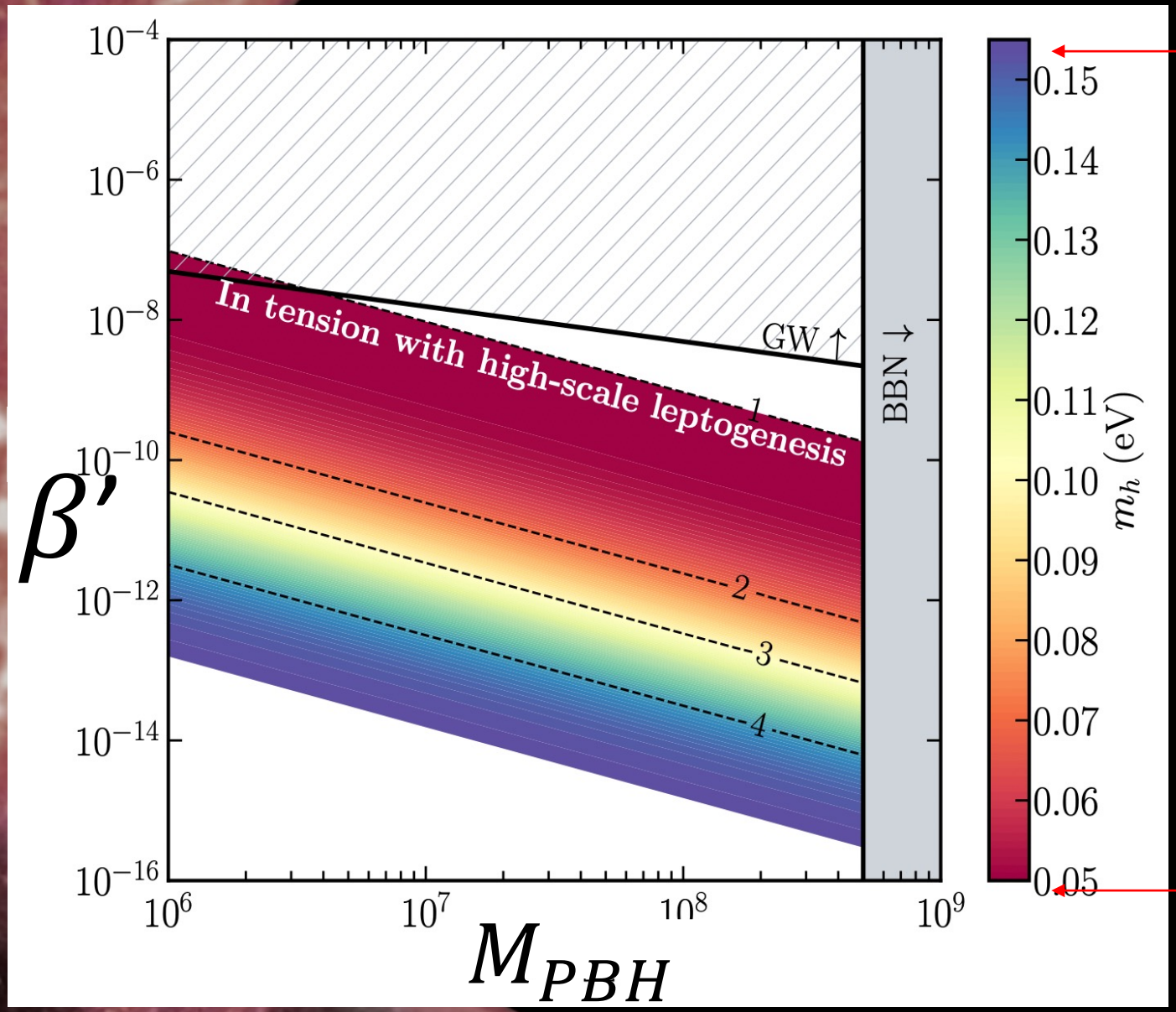
PBHs affecting Leptogenesis



B. Carr, 2002.12778

PBHs can exclude leptogenesis (and vice versa)

Calabrese et al. 2305.13369



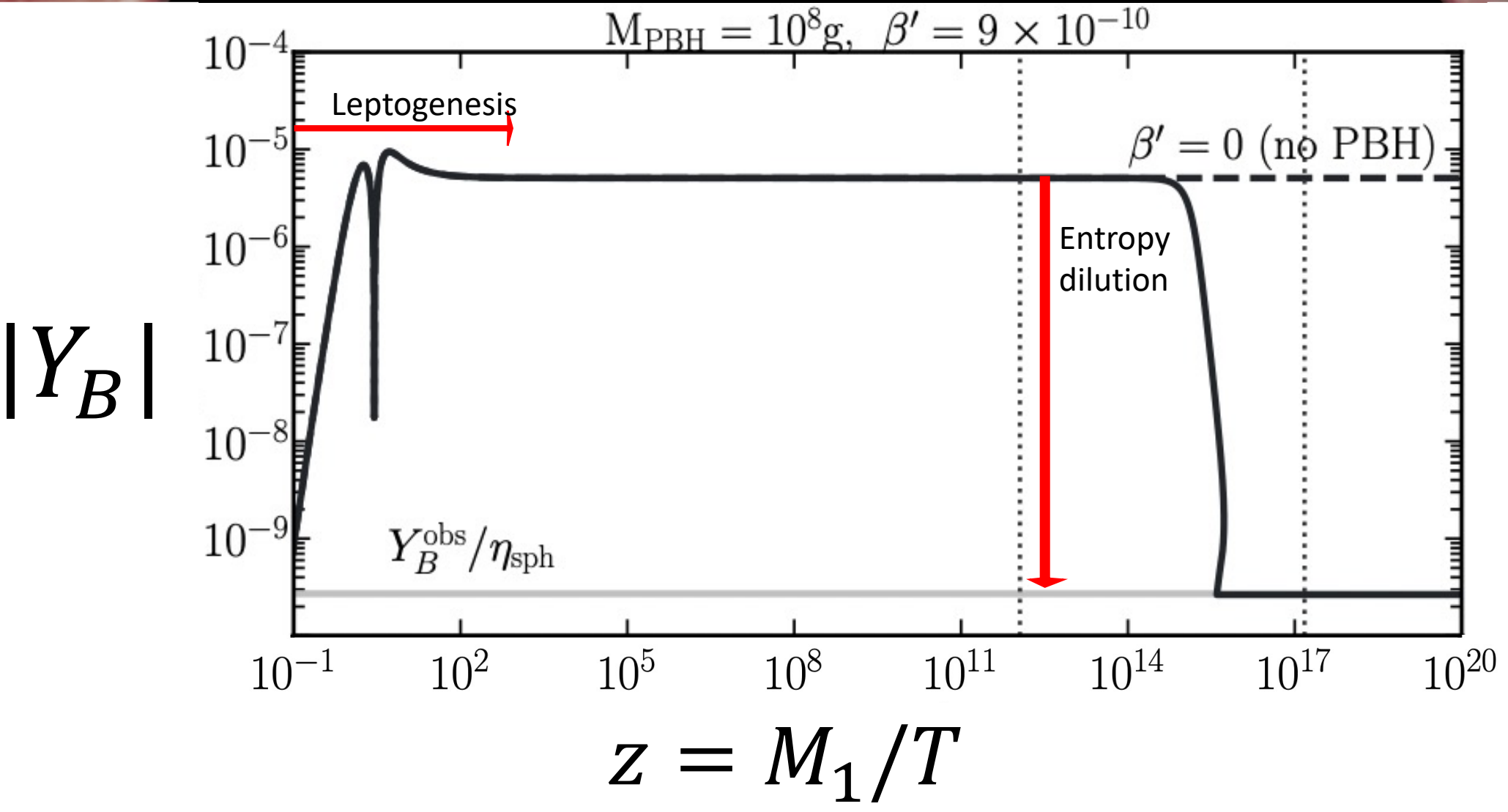
Upper bound for leptogenesis

The mutual exclusion limits become more severe with heavier active neutrino masses

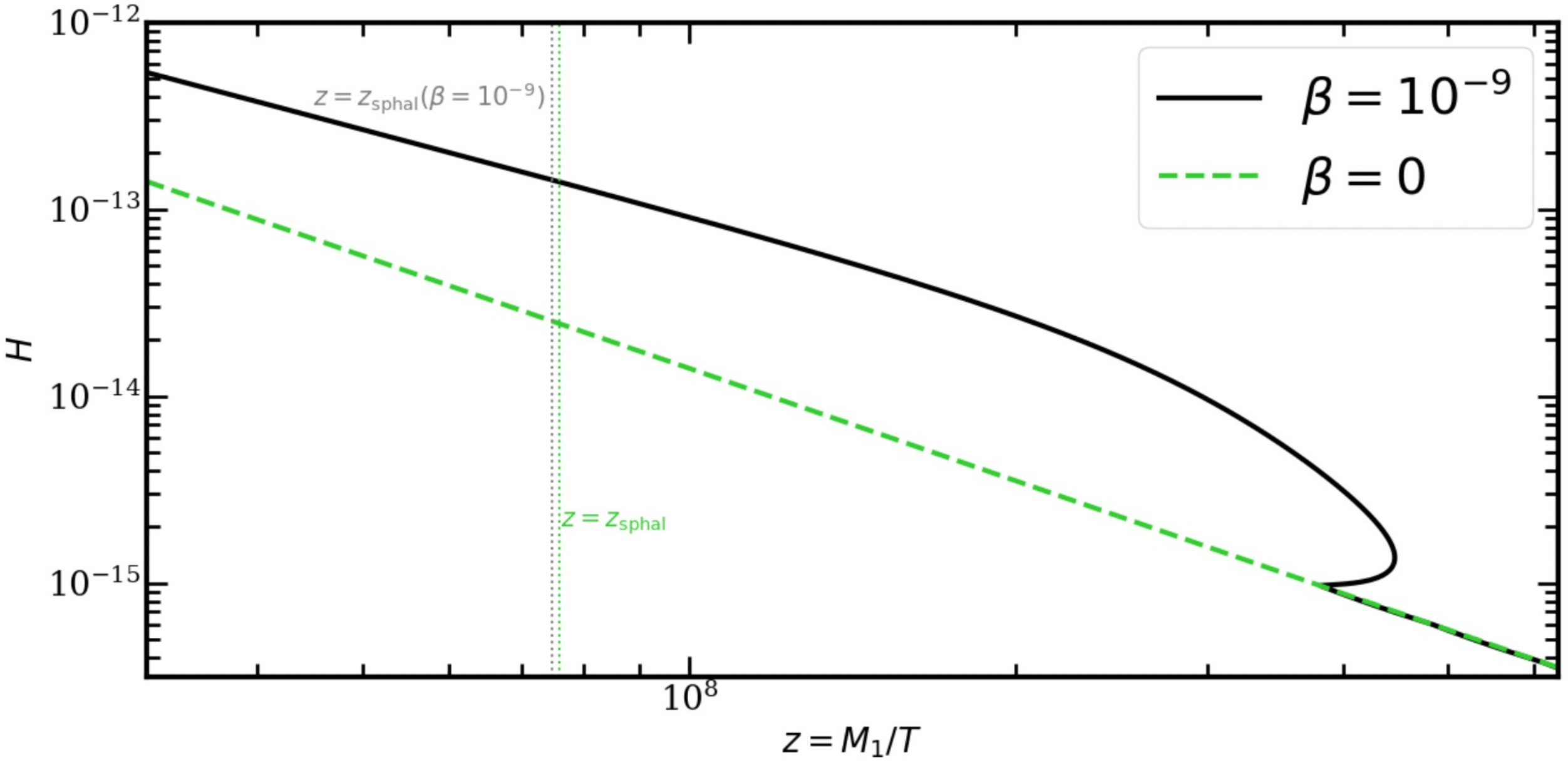
Oscillation data lower bound

The Mechanism

Primary effect: entropy injection



Leptogenesis is unaffected



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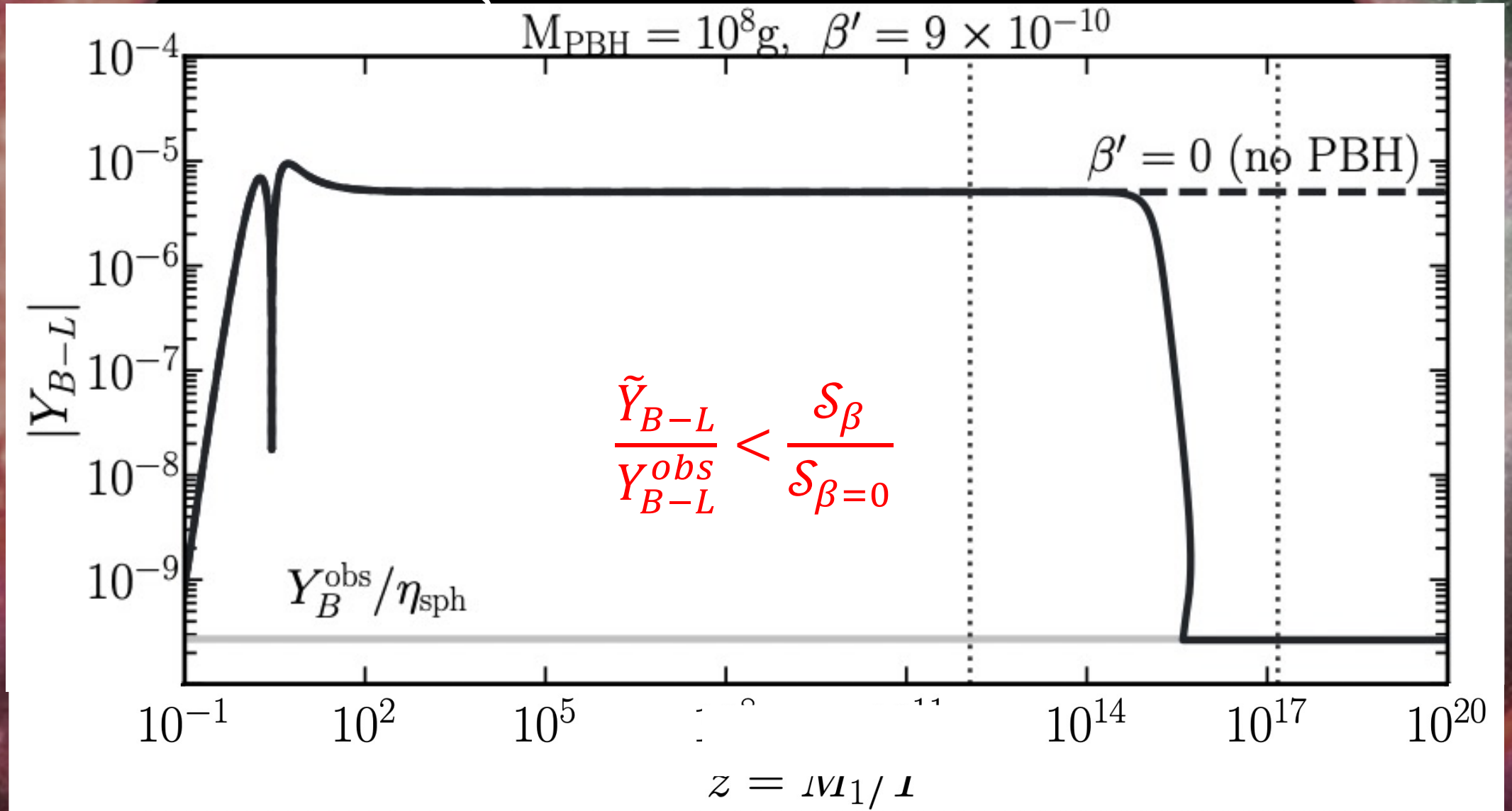
Entropy dilution

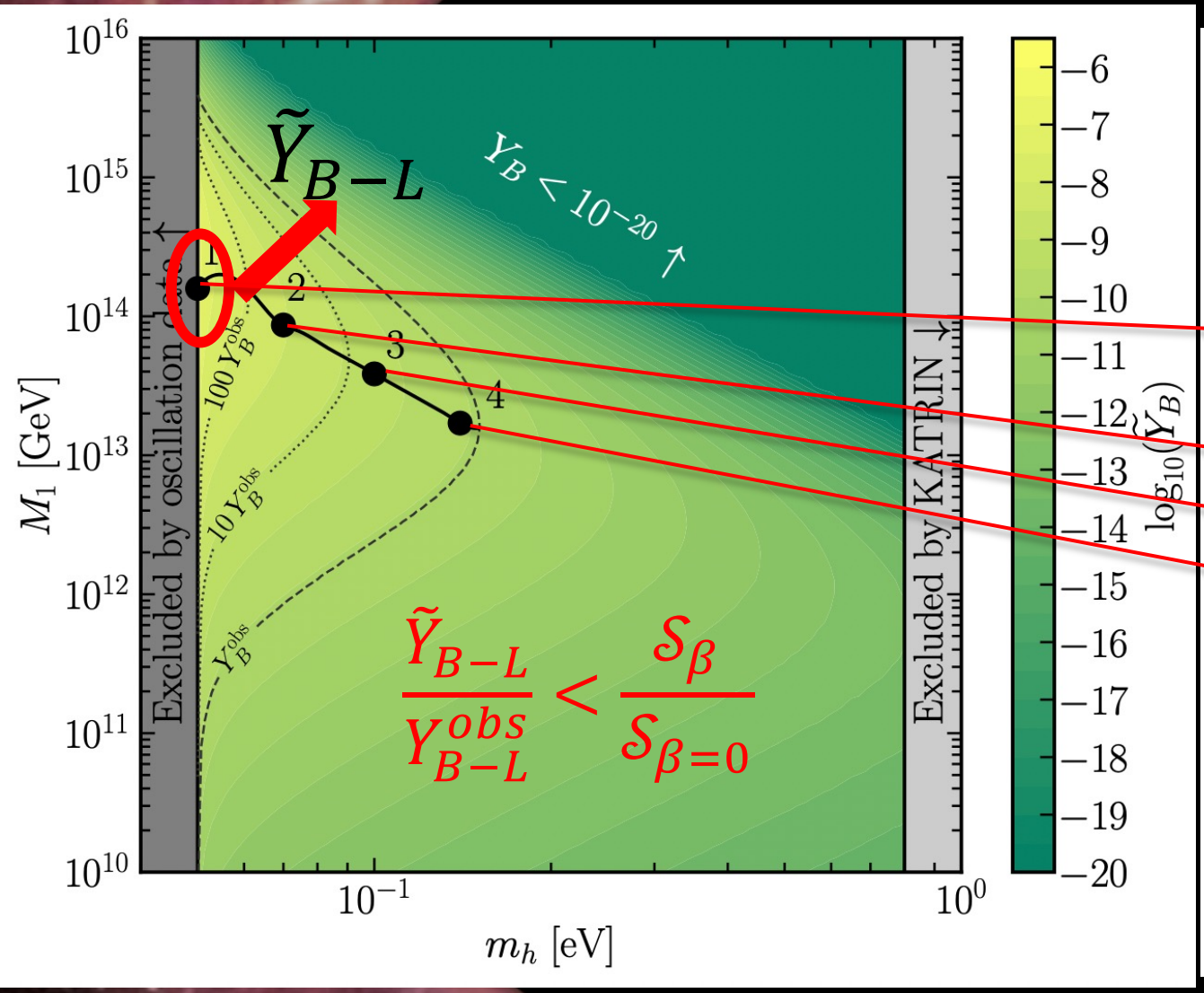
$$Y_{B-L} \equiv \frac{\mathcal{N}_{B-L}}{\mathcal{S}}$$

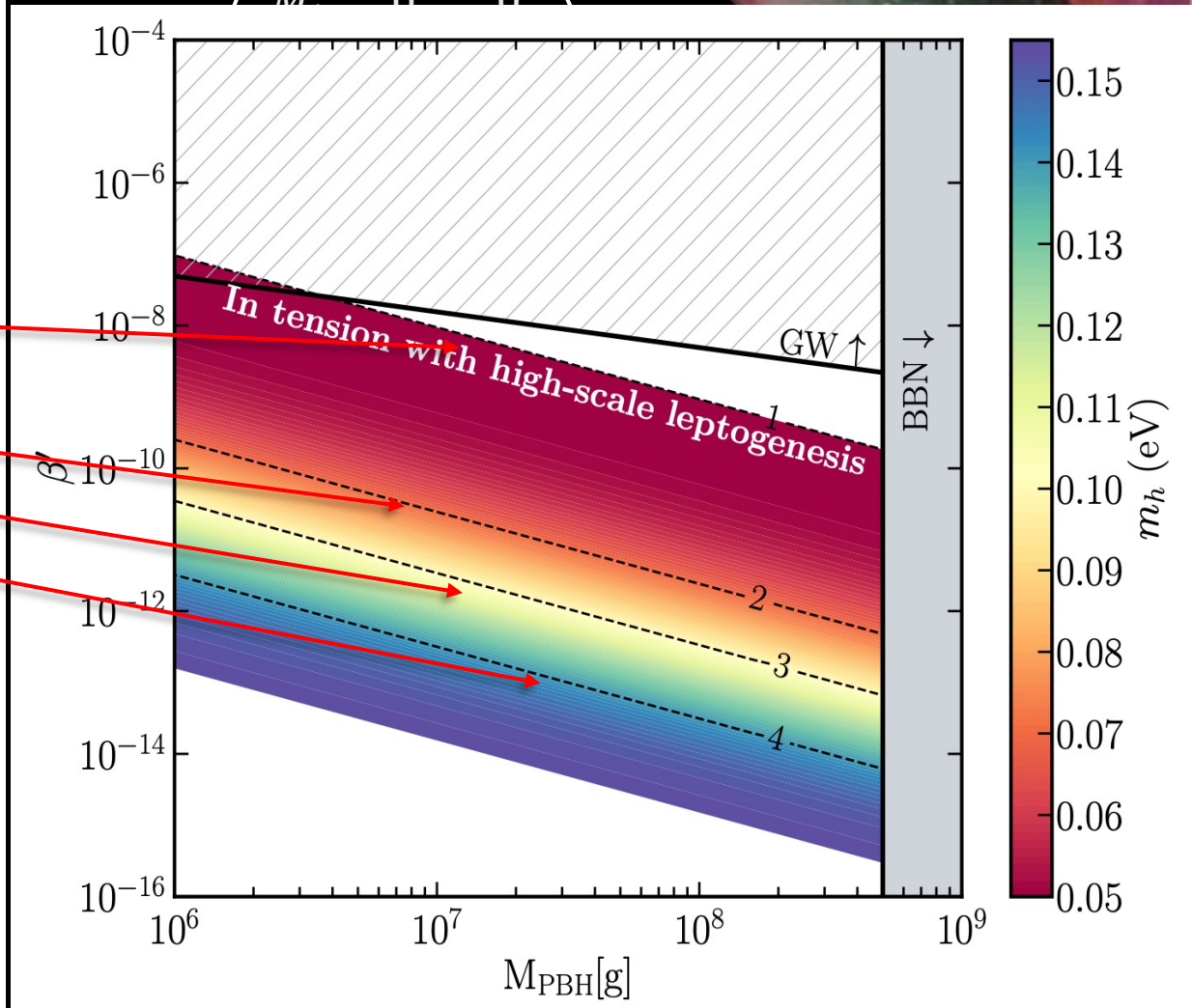
$$\mathcal{S}_\beta / \mathcal{S}_{\beta=0}(\beta, M_{PBH})$$



$$\frac{\tilde{Y}_{B-L}}{Y_{B-L}^{obs}} < \frac{\mathcal{S}_\beta}{\mathcal{S}_{\beta=0}}$$

The maximum asymmetry





Conclusions

PBHs in the mass range $10^6 g \leq M_{PBH} < 10^9 g$ do evaporate long after leptogenesis concludes

Their evaporation is assosciated with a sudden and potentially huge injection of entropy

High scale leptogenesis has a maximum achievable asymmetry

If the PBHs inject enough entropy to dilute away this maximum, the PBHs and leptogenesis are in tension

We show that even tiny populations of PBHs can be excluded by leptogenesis and vice versa

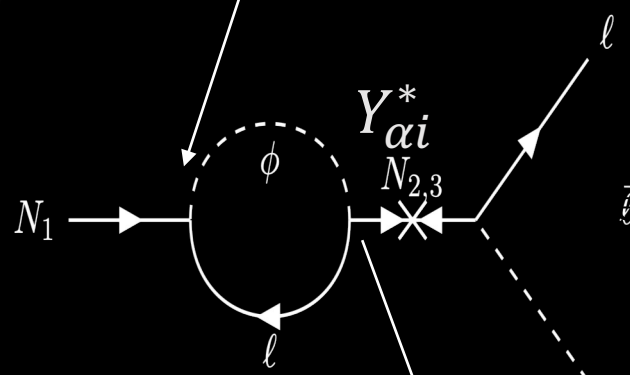
High scale leptogenesis

The SM is extended by 3 singlet fermions

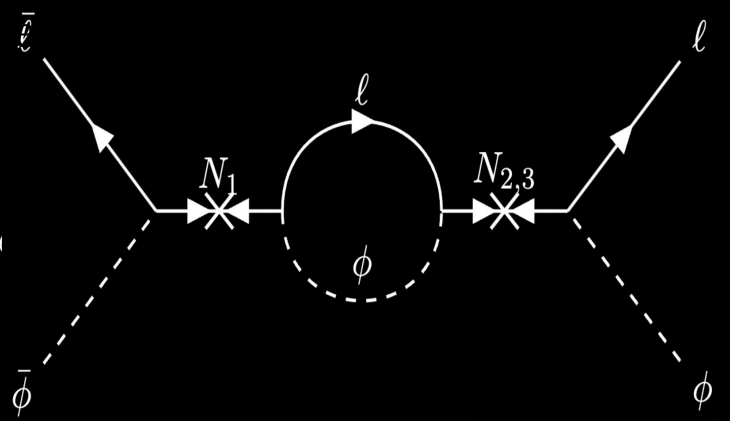
$$\mathcal{L}_N = -\frac{1}{2}\bar{N}^c \hat{M} N \; - Y \bar{\ell} \tilde{\Phi} N + h.c.$$

$$\begin{pmatrix} M_1 & 0 & 0 \\ 0 & M_2 & 0 \\ 0 & 0 & M_3 \end{pmatrix}$$

$M_1 \ll M_{2,3}$



Washout processes work to erase the asymmetry



$$Y = \frac{1}{v_{EW}} \sqrt{\hat{M}} \cdot R \cdot \sqrt{\hat{m}_\nu} \cdot U^\dagger_{PMNS}$$

Casas-Ibarra parameterisation,

we take $\Delta m^2{}_{sol} \ll \Delta m^2{}_{atm}$

$R = R_{13}(\theta_{13} = x + iy)$