Effective electroweak baryogenesis

with J. de Vries, J. van de Vis, and G. White
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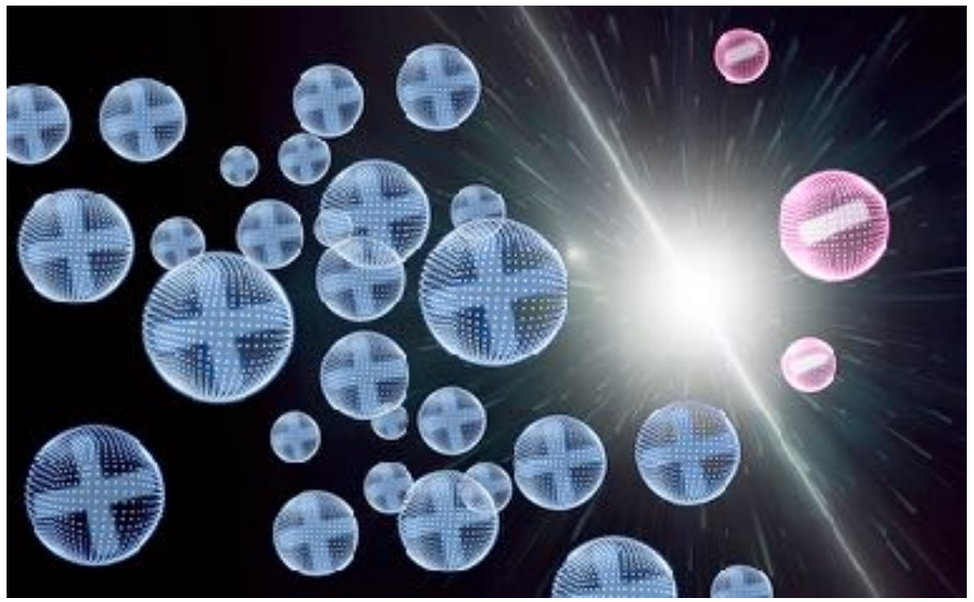
Cosmo18



Baryogenesis

Baryon asymmetry: $Y_b = \dfrac{n_b}{s} = 8.65 \pm 0.09 \times 10^{-11}$ (Planck)

Electroweak baryogenesis

Sakharov conditions:

1. Baryon number violation ✓
2. C- ✓ and CP-violation ✗
3. Out of equilibrium ✗

Need physics beyond SM

Electroweak baryogenesis

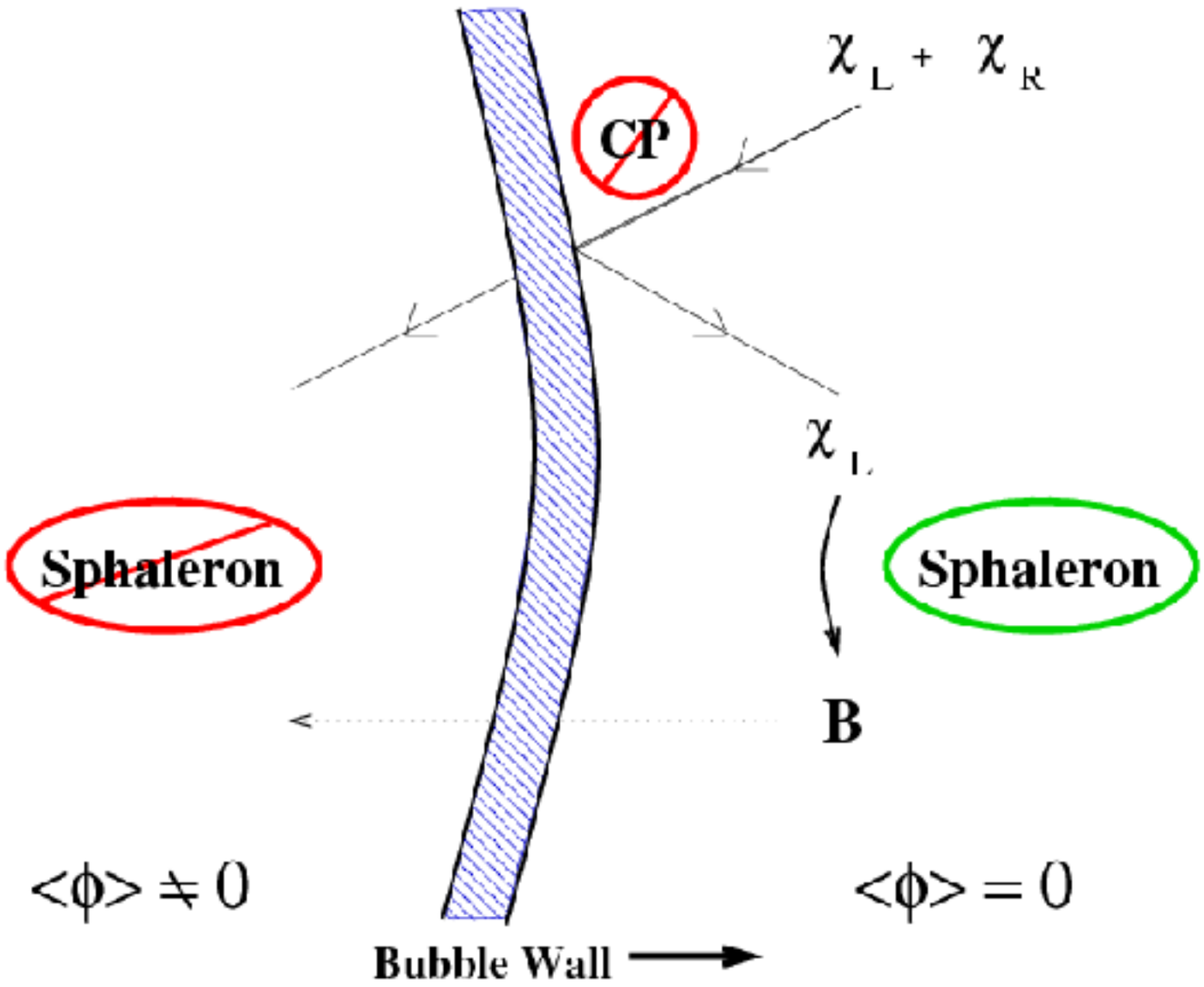
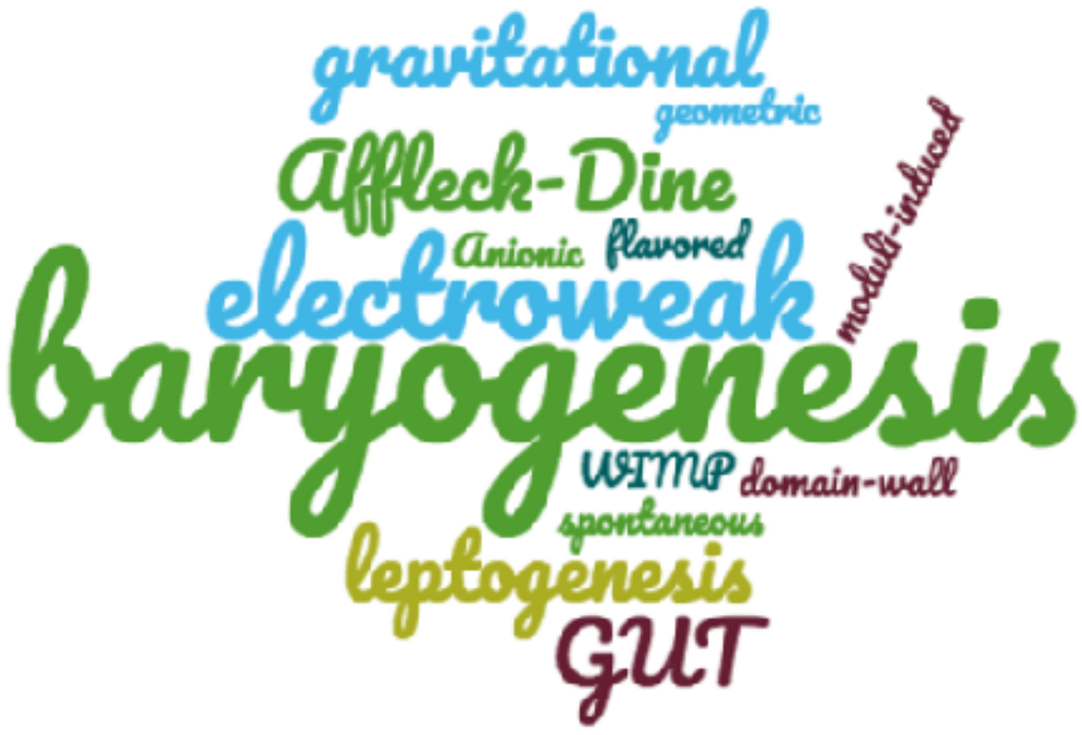


Fig. from Morrissey & Ramsey-Musolf ‘12

Electroweak baryogenesis

Motivation: can be probed by experiment



Effective electroweak baryogenesis

- can we test EWBG in a model independent way using effective field theory (SM-EFT) ?

- is EWBG an effective mechanism the produce the baryon asymmetry?

SM-EFT

Effective Lagrangian: $$\mathcal{L}_{\text{eff}} = \mathcal{L}_{\text{SM}} + \sum_i \frac{1}{\Lambda^{d_i-1}} c_i \mathcal{O}_i$$

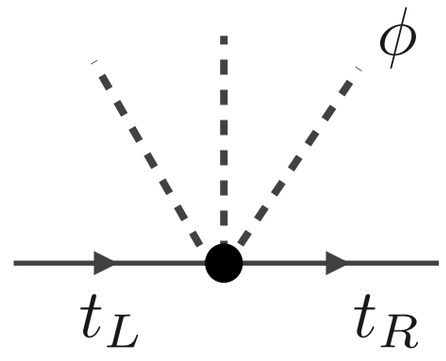
scale of new physics

light SM d.o.f's

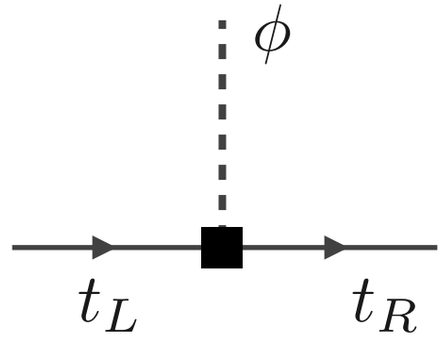
Requirement: separation of scales

SM-EFT

- 1st order phase transition $\mathcal{L}_{6,\mathrm{PT}} = \dfrac{1}{\Lambda^2}(\phi^\dagger\phi)^3$ $\Lambda \sim 800\,\mathrm{GeV}$
- Two scenarios for $\not{C}\not{P}$ $\Lambda_{\mathrm{CP}} \gtrsim 2.5\,\mathrm{TeV}$
  - $\mathcal{L}_{6,\mathrm{A}} = \dfrac{iy_t}{\Lambda^2_{\mathrm{CP}}}\bar{Q}_L\tilde{\phi}t_R(\phi^\dagger\phi) + \mathrm{h.c.} \quad \Rightarrow$



  - $\mathcal{L}_{6,\mathrm{B}} = \dfrac{i\alpha}{\Lambda^2_{\mathrm{CP}}}\bar{Q}_L D^2\tilde{\phi}t_R + \mathrm{h.c.} \quad \Rightarrow$

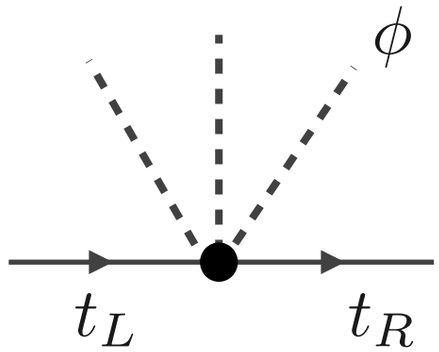


SM-EFT

- 1st order phase transition $\mathcal{L}_{6,\mathrm{PT}} = \dfrac{1}{\Lambda^2}(\phi^\dagger\phi)^3$

EFT valid: $\mathcal{L}_{6,\mathrm{B}} \overset{\mathrm{eom}}{=} \mathcal{L}_{6,\mathrm{A}} + \cancel{\dfrac{c_8}{\Lambda^2\Lambda^2_{\mathrm{CP}}}\mathcal{O}_8}$

- Two scenarios for $\not{C}\not{P}$
  - $\mathcal{L}_{6,\mathrm{A}} = \dfrac{iy_t}{\Lambda^2_{\mathrm{CP}}}\bar{Q}_L\tilde{\phi}t_R(\phi^\dagger\phi) + \mathrm{h.c.} \quad \Rightarrow$



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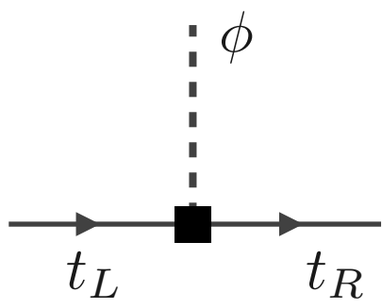
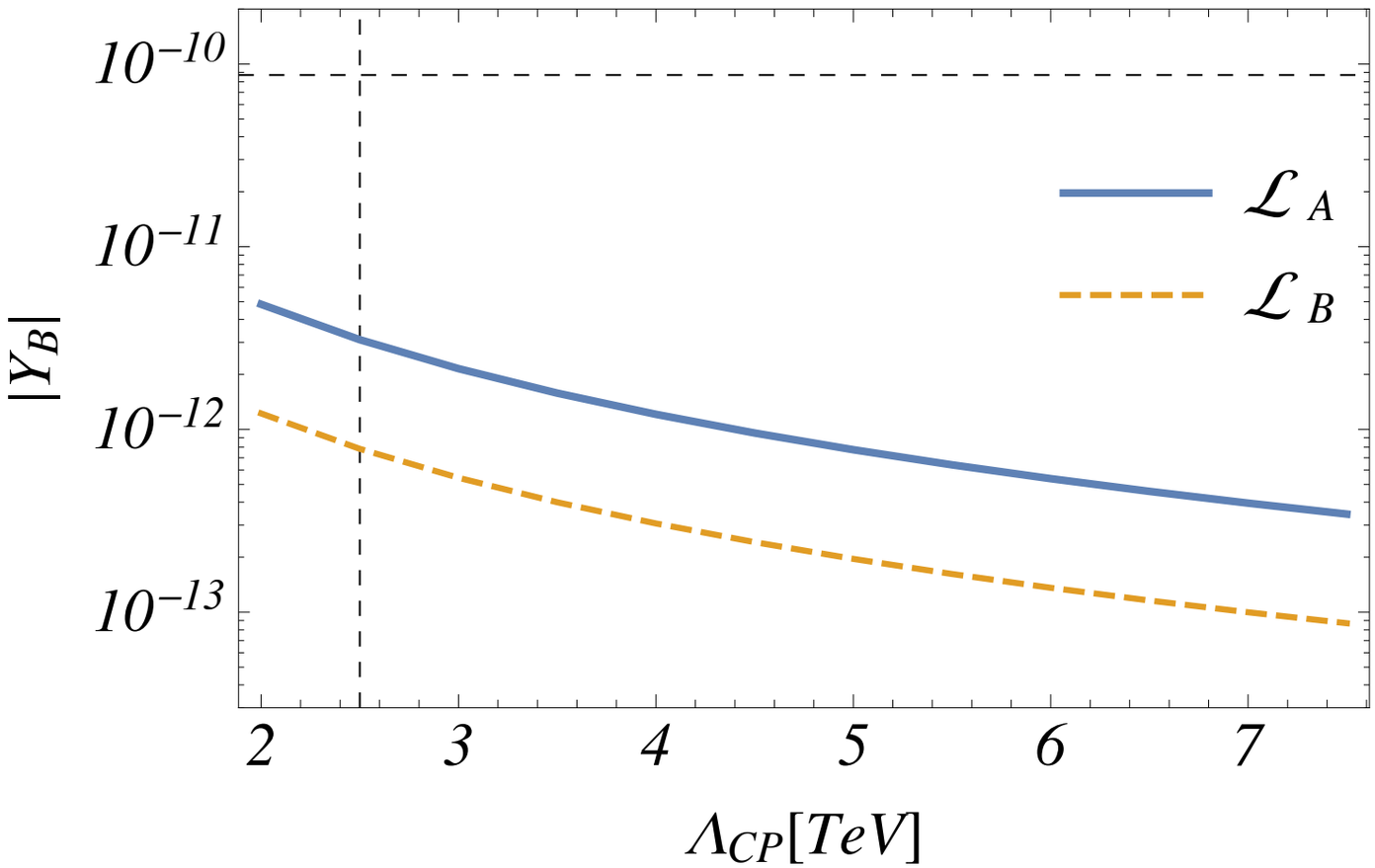


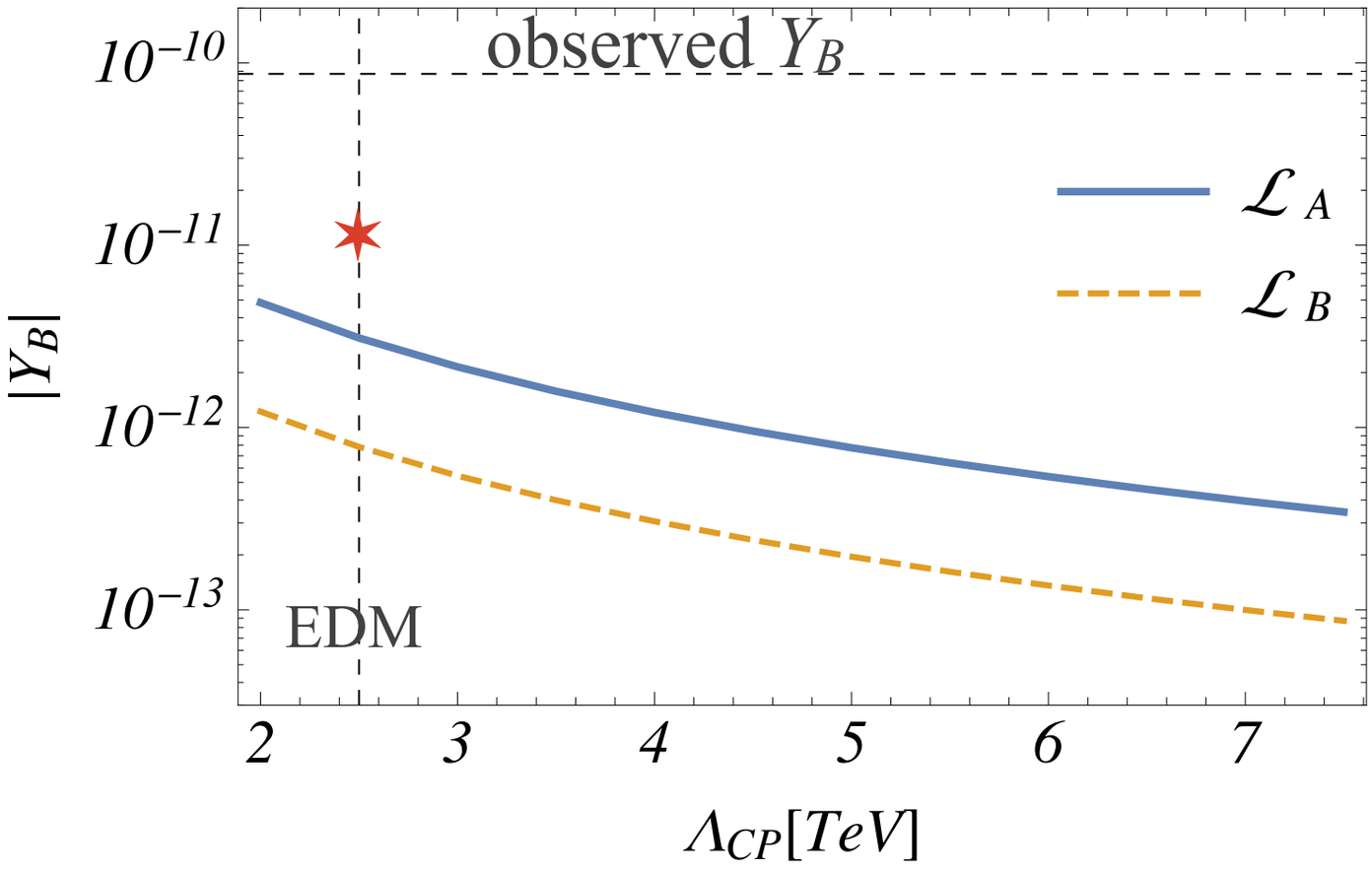
Results



EFT description?

- No! $\mathcal{L}_A \neq \mathcal{L}_B$
- Reason: no separation of scales in Higgs sector
- Difference with EDMs: 2pnt vs. 3pnt interactions

Results



Enough asymmetry?

- Model dependent
- Difficult
- Approximations:

  mass treated perturbatively, high T expansion, collective plasma effects, leptons…

Conclusions

- can we test EWBG in a model independent way using effective field theory (SM-EFT) ?

No!

- is EWBG an effective mechanism the produce the baryon asymmetry?

Model dependent, not w/ our dim-6 operator