Baryogenesis in the 2HDM+a

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In collaboration with: Stephan Huber[1], Ken Mimasu[2], Jose Miguel No[3, 4]

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Challenges in EW Baryogenesis

Sakharov Conditions	SM	BSM
C & CP violation	Not enough	Severe EDM constraints
Departure from thermal equilibrium	2nd order	1st order via extra scalars
Baryon number violation	EW sphalerons	EW sphalerons

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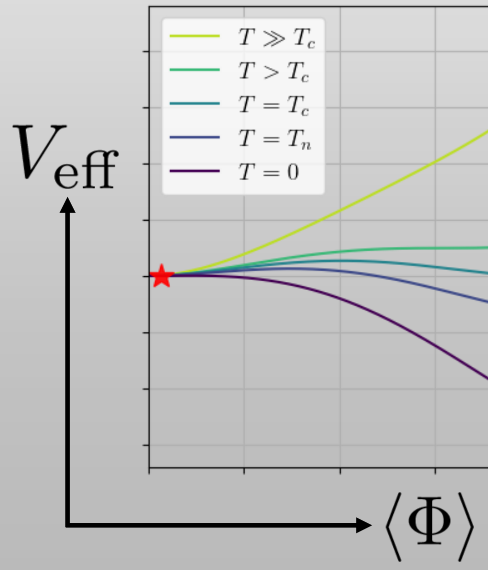

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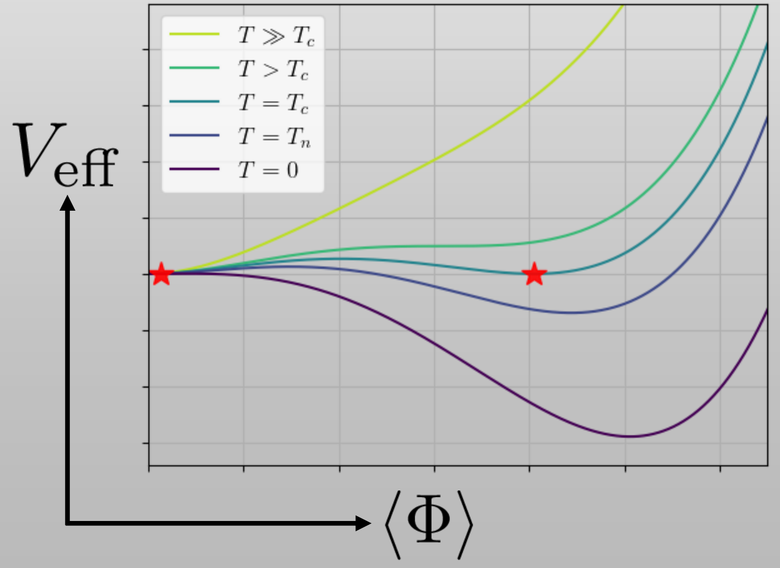

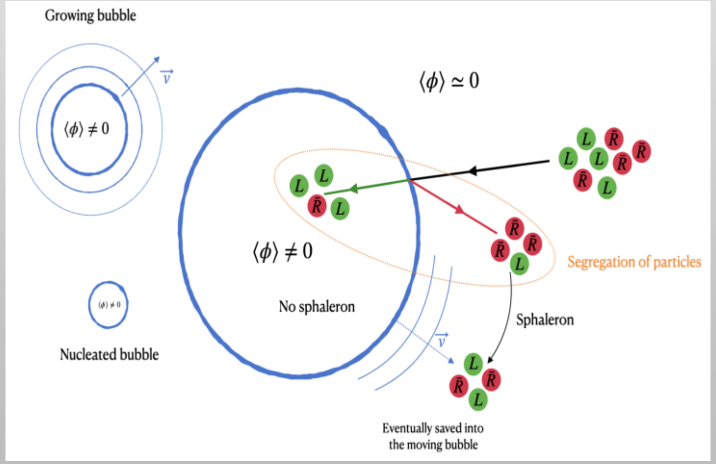

2HDM+a: Transitional CP-Violation

$$V_{\text{2HDM}} = \mu_{11}^2 \left|\Phi_1\right|^2 + \mu_{22}^2 \left|\Phi_2\right|^2 - \left(\mu_{12}^2\, \Phi_1^\dagger \Phi_2 + \text{h.c.}\right) + \frac{1}{2}\lambda_1 \left|\Phi_1\right|^4 + \frac{1}{2}\lambda_2 \left|\Phi_2\right|^4$$
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Two $SU(2)_L$ doublets

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3) Alignment limit $\Longrightarrow$ Identify SM Higgs.

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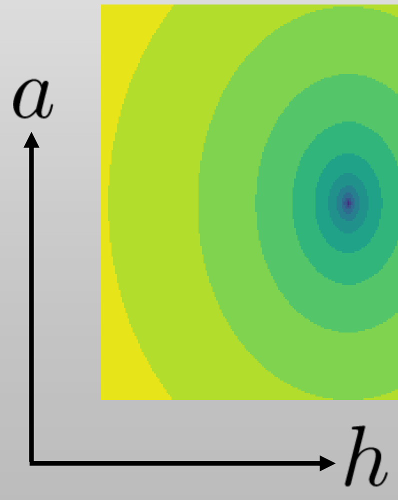

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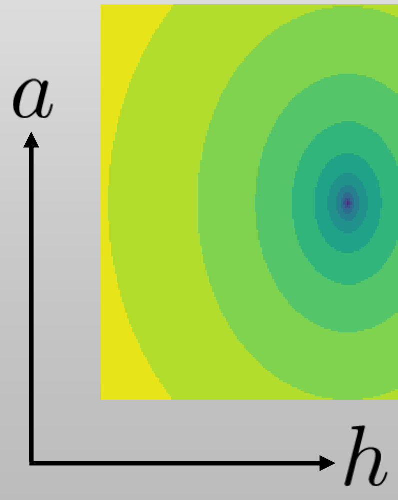

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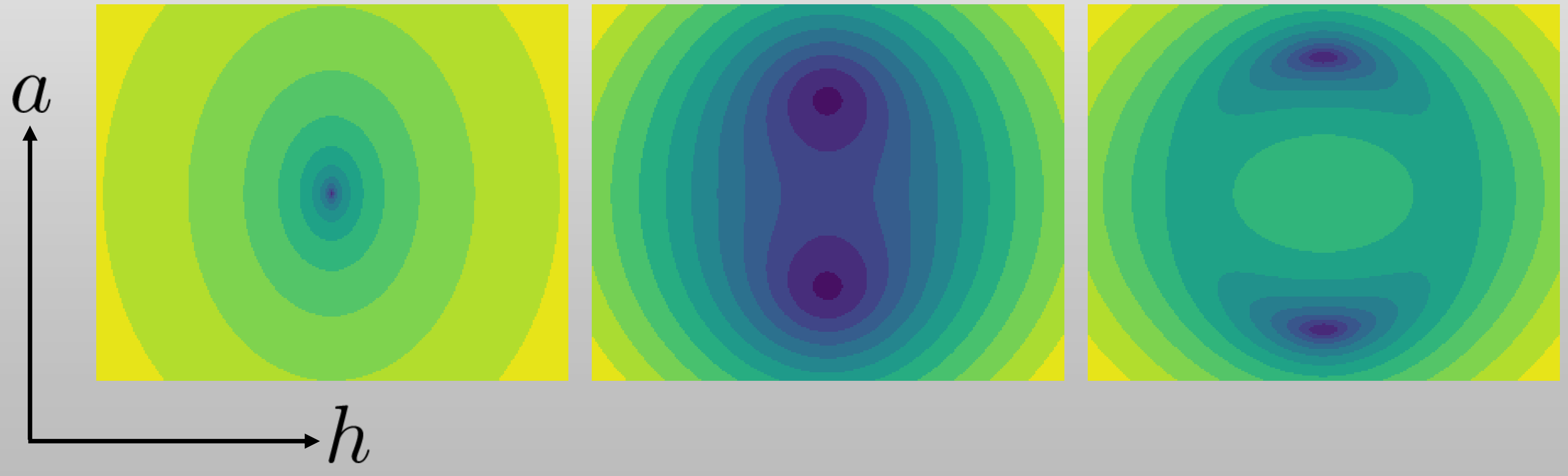

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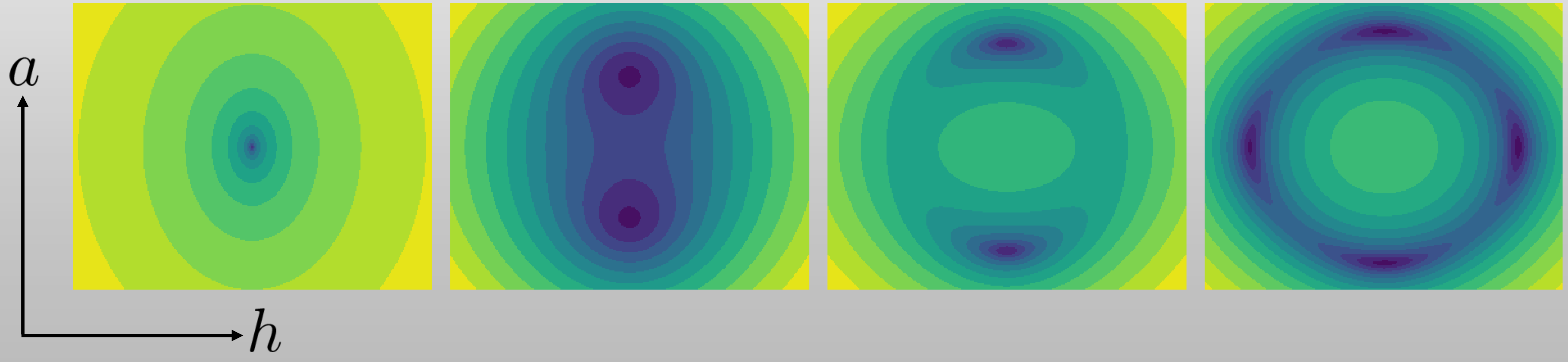

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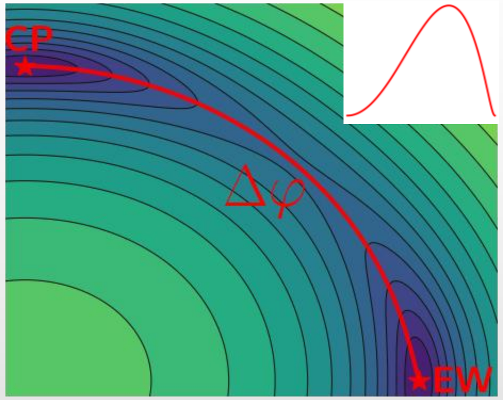

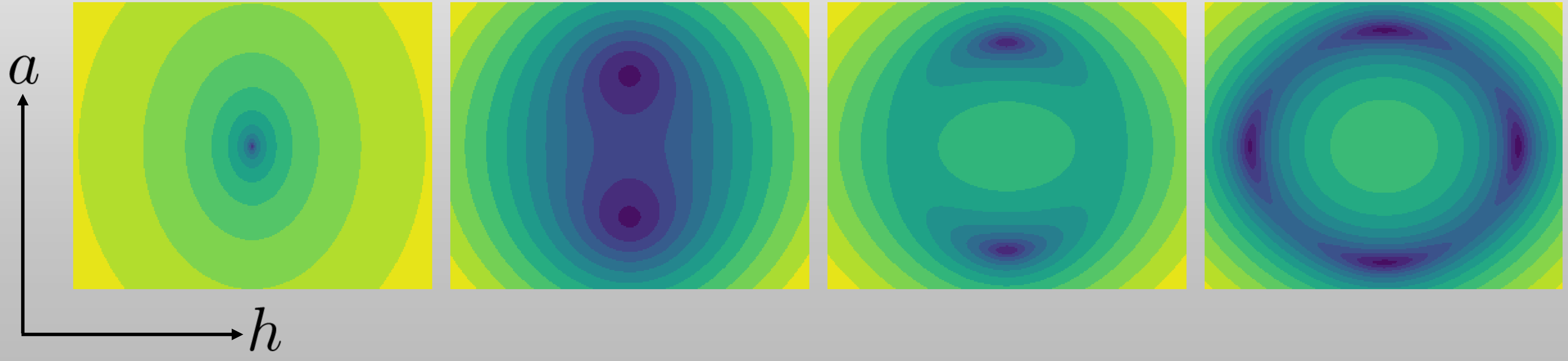

Spectrum and Parameters

CP + —

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Top Quark Phase: $\Delta\theta_t \approx \frac{\Delta\varphi}{1+t_\beta^2} \approx \frac{m_{a_2}^2 - m_{a_1}^2}{M^2}\frac{v_s(T)}{v}\frac{s_{2\theta}}{t_\beta}$

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- Apply relevant constraints — BFB, PU, Direct Searches, EWPO's etc.

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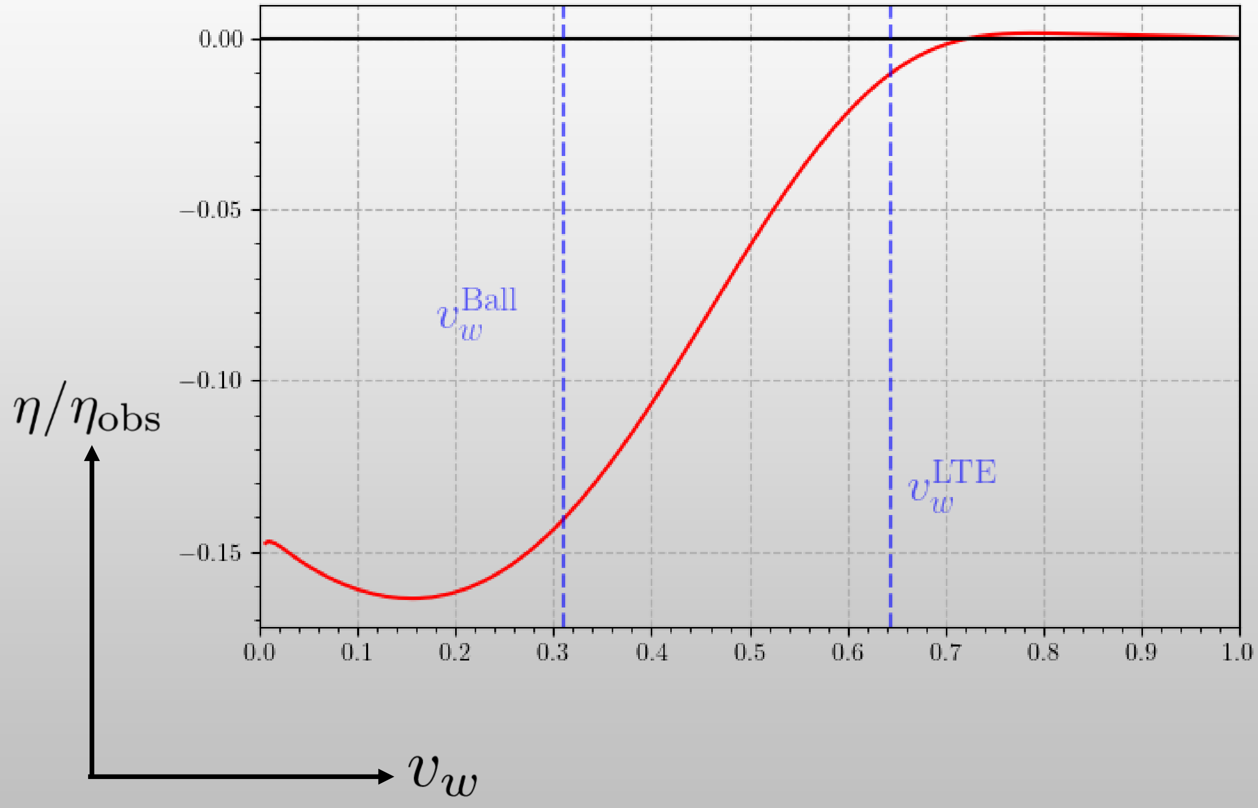

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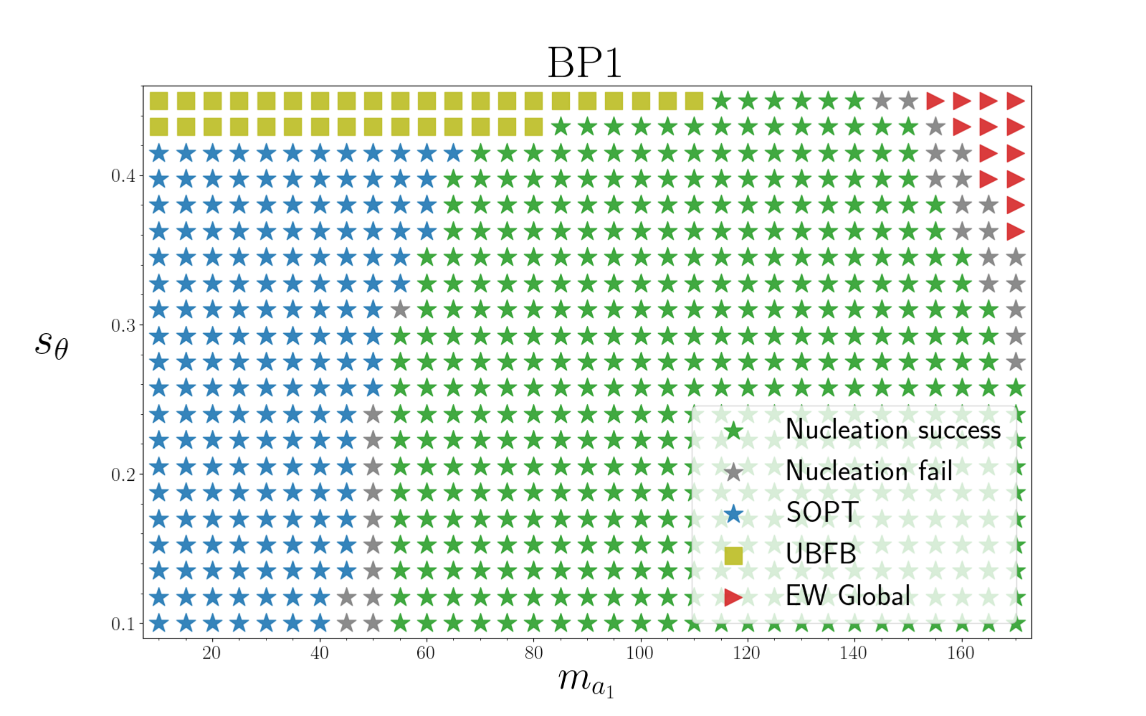
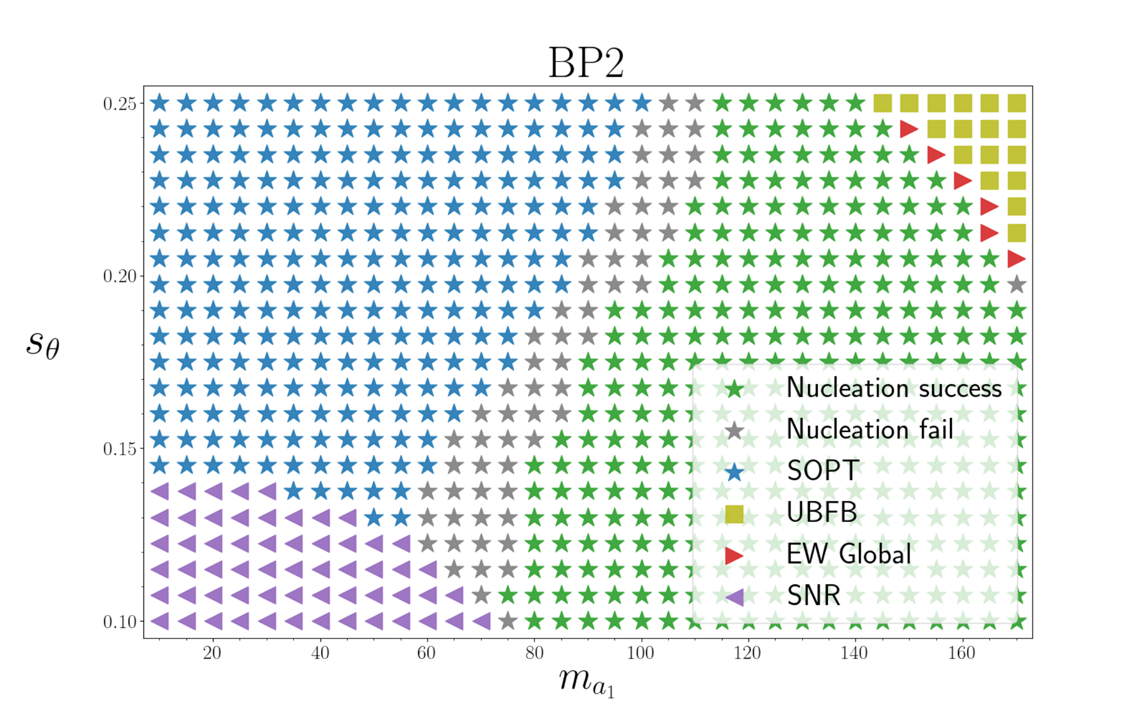
BP2	2.0	110	600	600	600	680	1.4	1.6





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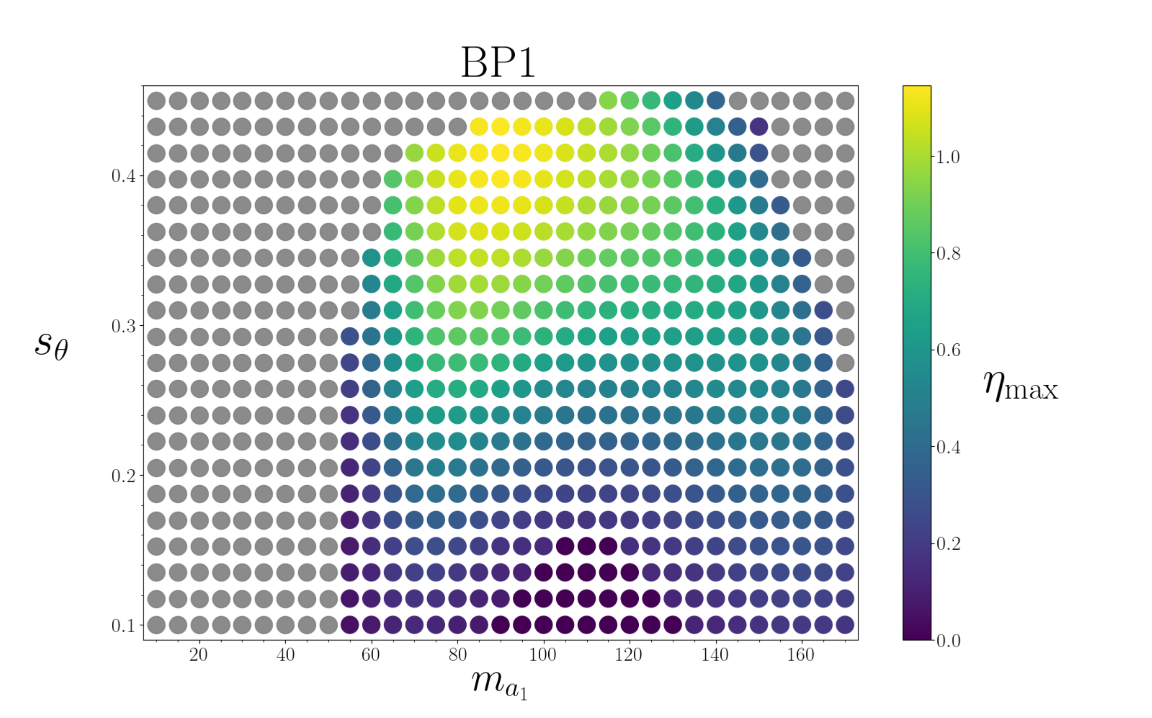

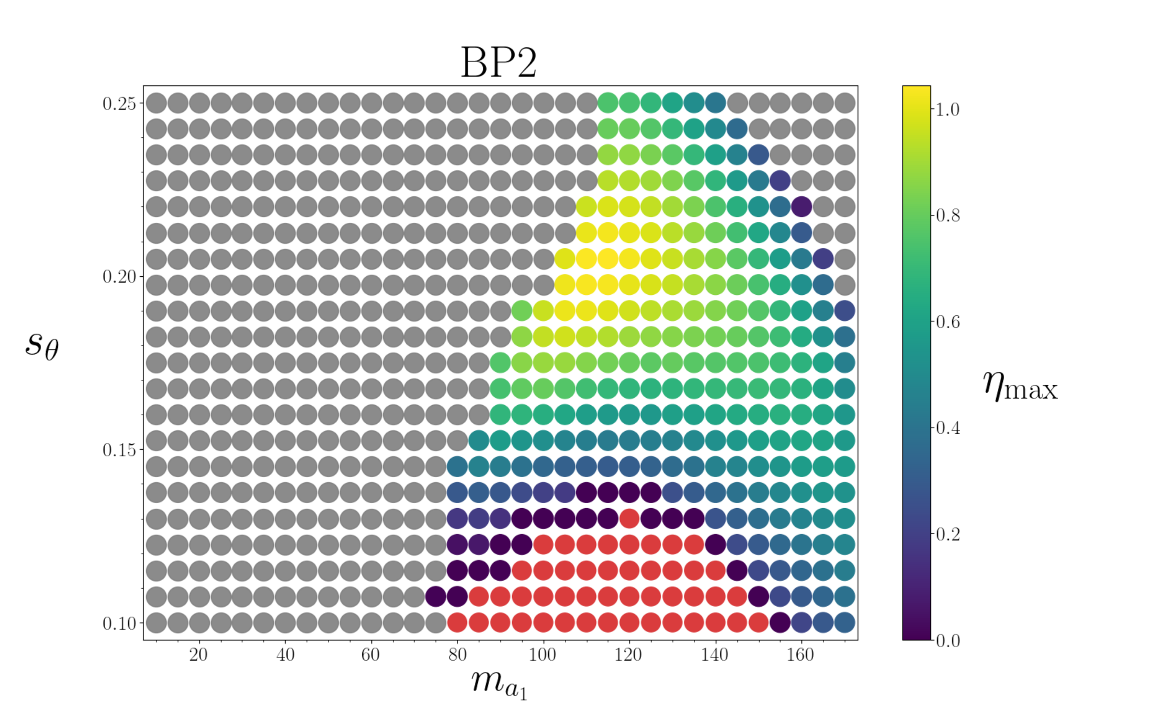

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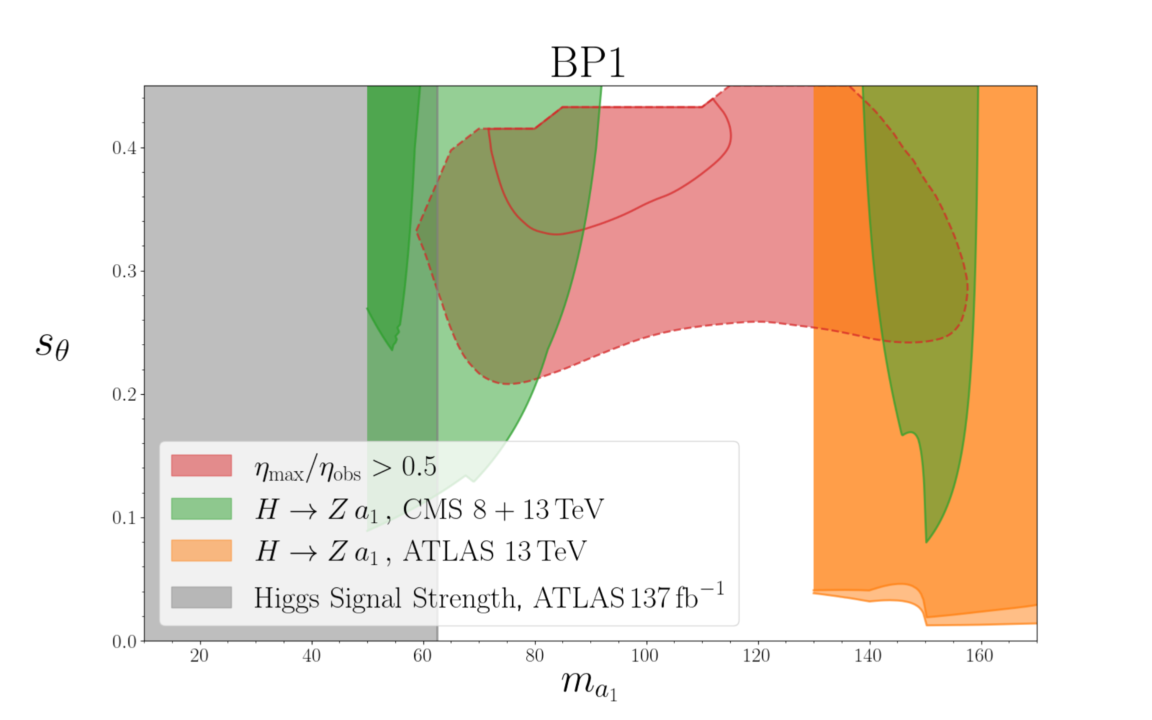

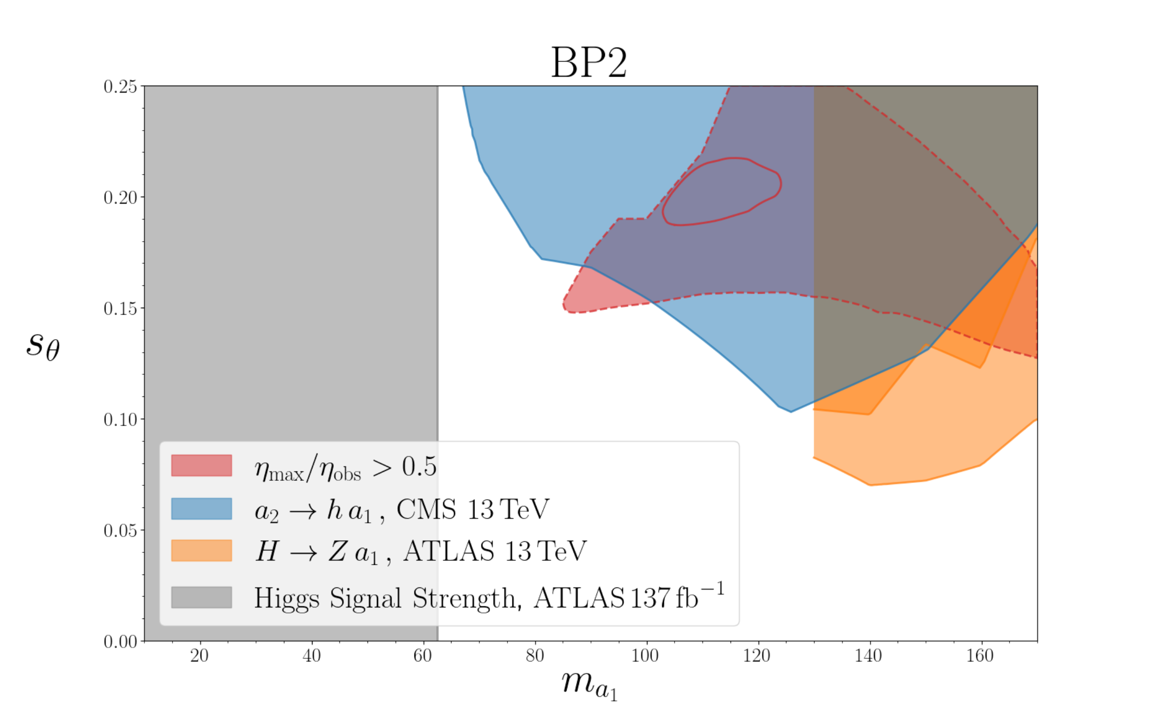

Conclusions & Outlook

- ✓ Baryogenesis via transitional CP-violation avoids severe EDM constraints!
- ✓ Implemented novel wall velocity and baryogenesis bounds.
- ✓ Tightly constraining experimental constraint, $a_2 \to h\, a_1$
- ✓ Insights into BAU transport equations.
- ✓ Wider parameter space scan wanted from ATLAS/CMS.

- ❖ Baryogenesis more difficult than we thought?
- ❖ Full wall velocity computation?
- ❖ Simultaneous CP and EWSB?
- ❖ Is this only qualitative?

Thank You!

Questions?