The origin of baryon asymmetry and future CPV searches

Jing Shu

ITP-CAS

T. Liu, M. Ramsey-Musolf J. S, Phys. Rev. Lett. 108 (2012) 221301

J. S, Y. Zhang, Phys. Rev. Lett. 111 (2013) 091801

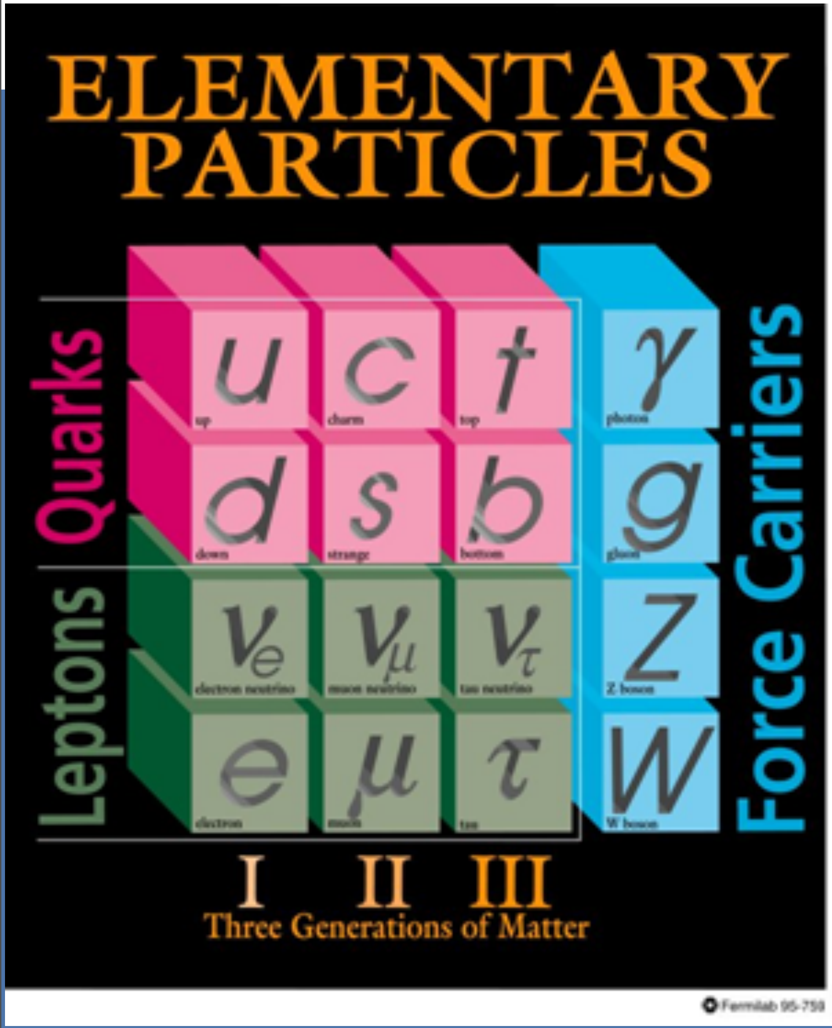
LG. Bian, T. Liu, J. S, Phys.Rev.Lett. 115 (2015) 021801

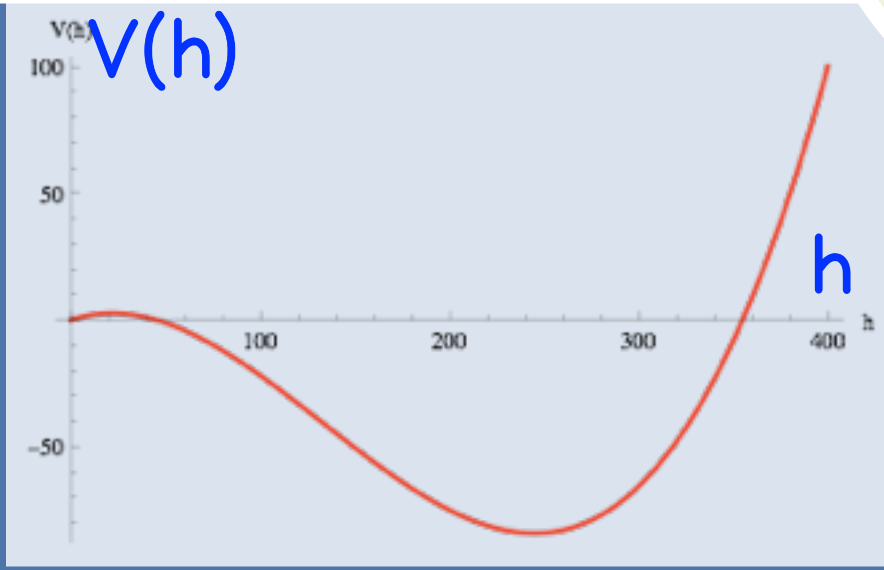
H. Guo, S. Hong, T. Liu, M. Ramsey-Musolf J. S, in progress

Outline

- Time to test EWBG (Connection between Higgs CPV & EWBG).
- Current situation of CPV & EDM constraints & indirect light/heavy Higgs constraints at the LHC.
- Future prospects of EWBG & CPV.
- Summary and outlook.

The origin of mass!





Higgs mechanism

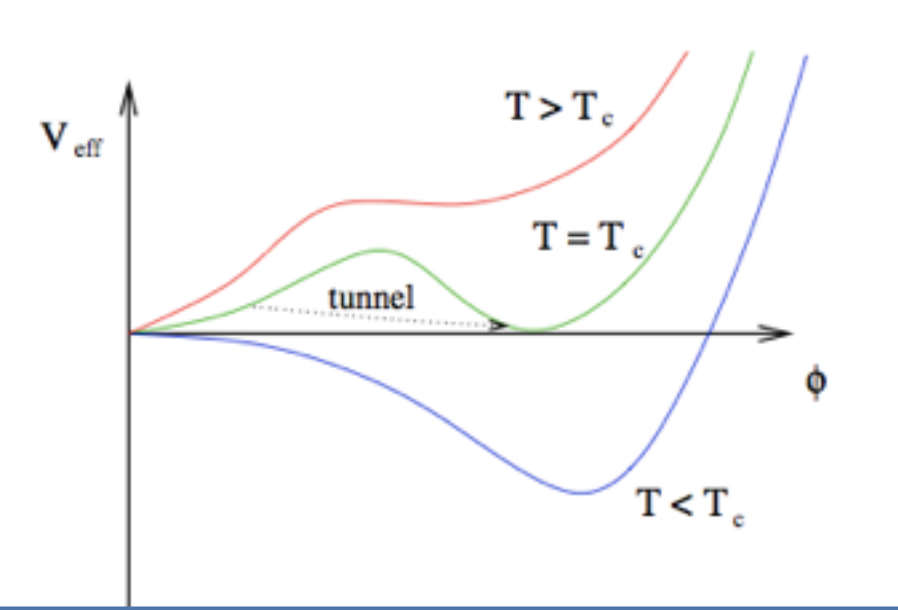
The origin of electroweak symmetry breaking

Higgs ???

What big questions can we learn from that?

The origin of matter

How mass is generated in our universe?



After the electroweak phase transition, the broken phase, all the masses are turning on.

How "positive" matter is generated in our universe?

Quite interesting if connected to the mass generation.

The EWBG

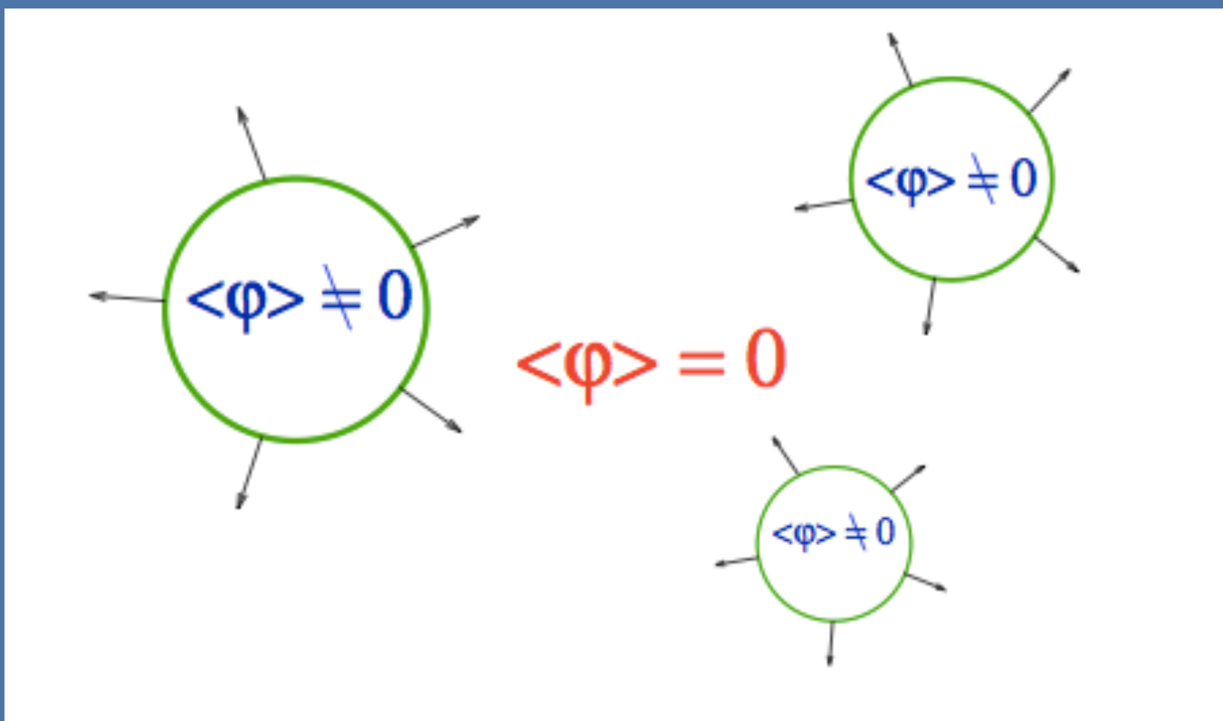
Electroweak baryogenesis: generate baryon asymmetry with particle mass generation at EW scale.

Sakharov's condition (EWBG):

- baryon number violation (Sphaleron transitions)
- CP violation (SM CPV too small)
- Strongly 1st order PT (SM: crossover)

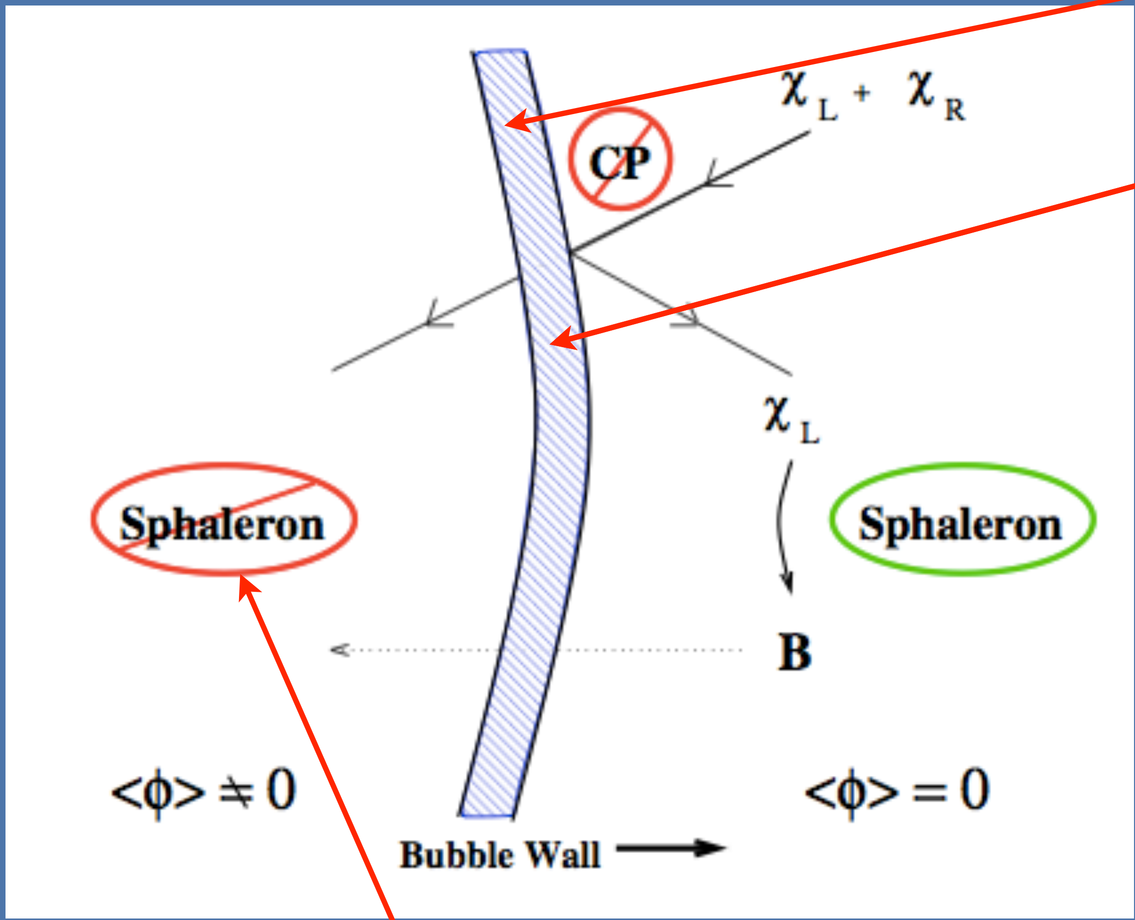
Strongly 1st order PT

When the universe is cooling down, if we have strongly1st order PT, then we have bubble expanding



Strongly first order phase transition

The EWBG



$m_\chi(v)e^{i\theta(v)}$

$\dot{\theta}$

CPV phase jump generate a net chiral charge inside the bubble wall

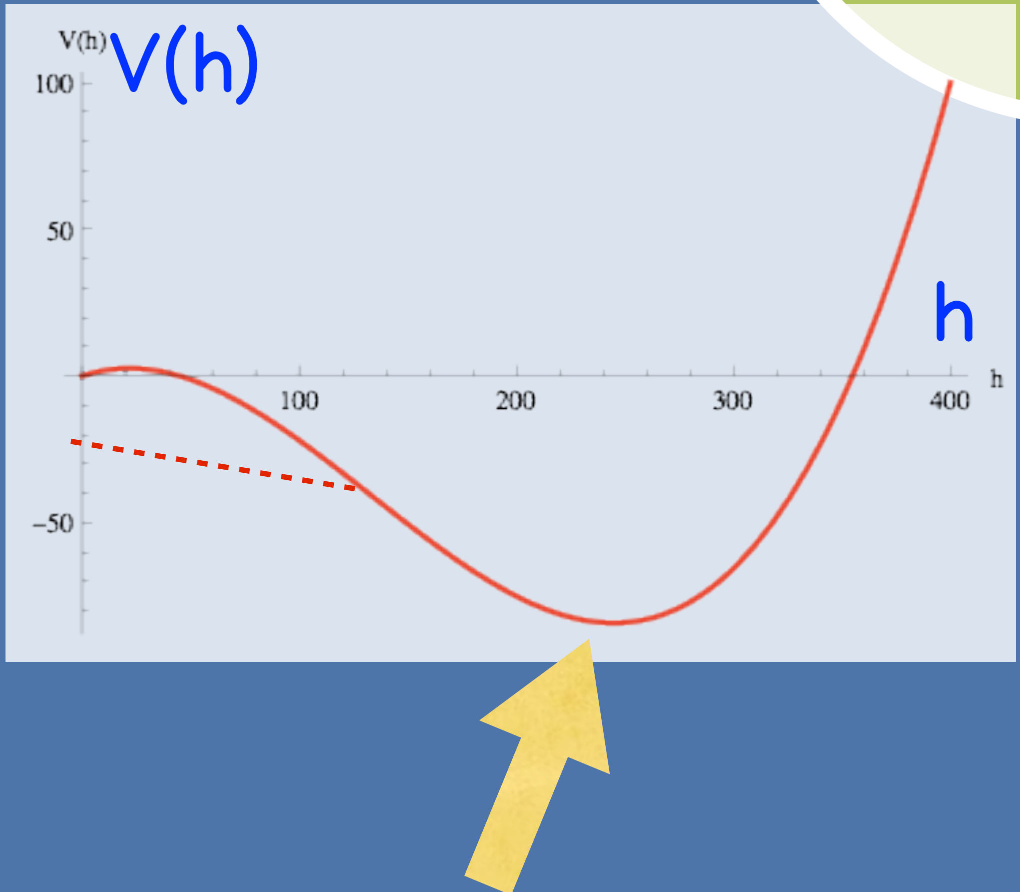
It diffuses into the bubble (broken phase) and then converted into net baryon density.

require strongly first order phase transition

Why focus on CPV?

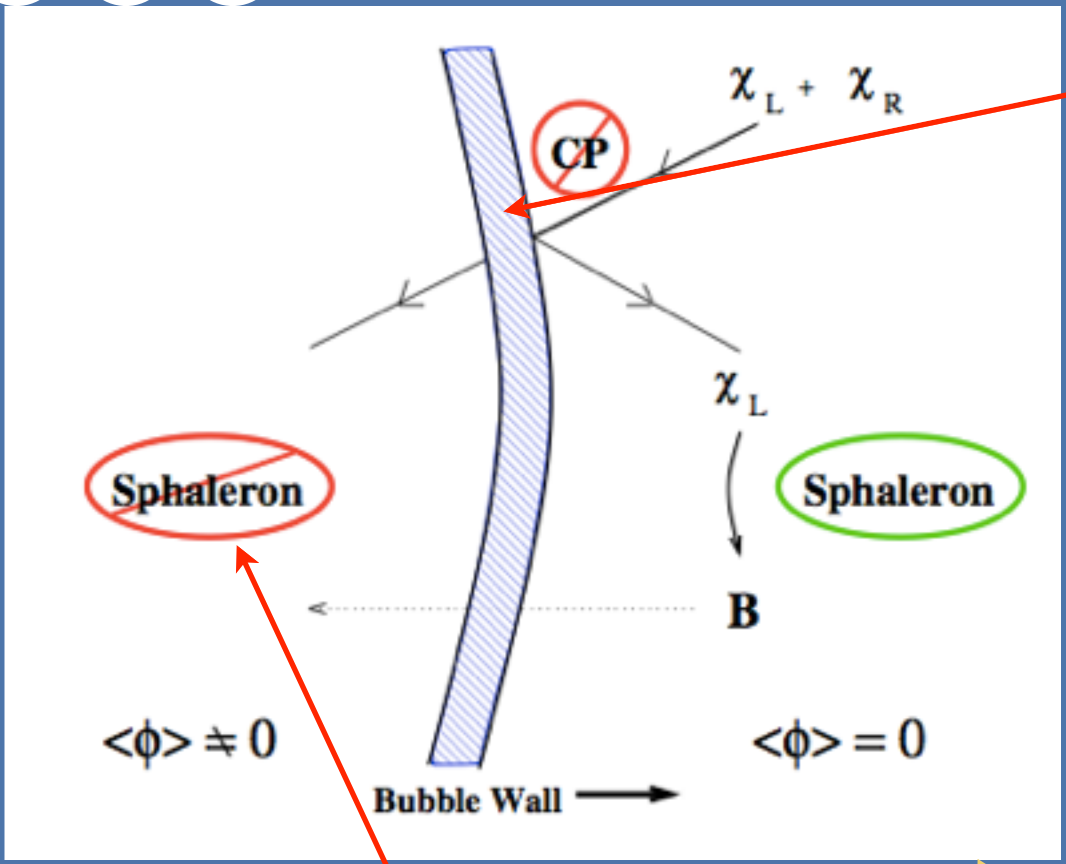
The two curves here would results very different EWPT.

Need knowledge of global behavior of Higgs potential in principle



What we learn from colliders or many other experiments is simply here (local behavior)

General connection



$$m_\chi(v)e^{i\xi(v)}$$

$$\mathcal{L}_X \sim (\partial_\mu \xi) J_X^\mu$$

$$\partial_t \xi = \partial_v \xi (\Delta v) v_w / L_w$$

Behave like a chemical potential term

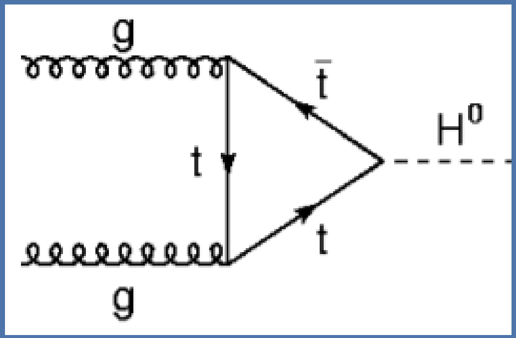
$$Q_X \sim g_*(\partial_t \xi) T^2/6 \sim (\partial_t \xi) T^2.$$

CPV phase jump generate a net chiral charge close to the bubble wall

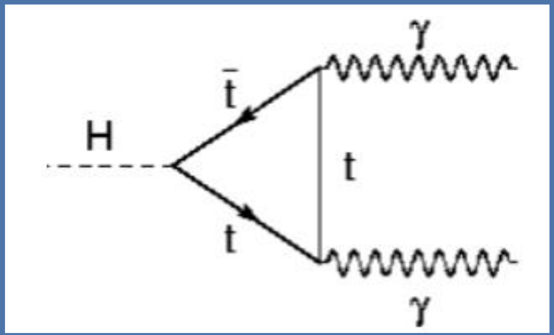
Converted to B by sphalerons inside the bubble wall

require strongly first order phase transition

LHC Higgs data: CPV source



if colored



if electric charged

χ as top quark

$$m_\chi(v)e^{i\theta(v)}$$

A complex mass term which has vev dependence

suggests that particle χ would contribute to hgg and $h\gamma\gamma$. vertex with CPV

J. S,Y. Zhang, Phys. Rev. Lett. 111 (2013) 091801

2HDM

In order to make a connection with baryogenesis, I must make a model.

$$V = \frac{\lambda_1}{2}(\phi_1^\dagger\phi_1)^2 + \frac{\lambda_2}{2}(\phi_2^\dagger\phi_2)^2 + \lambda_3(\phi_1^\dagger\phi_1)(\phi_2^\dagger\phi_2)$$
$$+ \ \lambda_4(\phi_1^\dagger\phi_2)(\phi_2^\dagger\phi_1) + \frac{1}{2}\left[\lambda_5(\phi_1^\dagger\phi_2)^2 + \text{h.c.}\right]$$
$$- \ \frac{1}{2}\left\{m_{11}^2(\phi_1^\dagger\phi_1) + \left[m_{12}^2(\phi_1^\dagger\phi_2) + \text{h.c.}\right] + m_{22}^2(\phi_2^\dagger\phi_2)\right\}.$$

There are two independent phases from m_{12} and λ_5.

$$\mathcal{L}_Y = \bar{Q}_L Y_D \phi_1 D_R + \bar{Q}_L Y_U (i\tau_2)\phi_2^* U_R + \bar{L}_L Y_E \phi_1 E_R$$

$$\langle\phi_1\rangle = \begin{pmatrix} 0 \\ v\cos\beta/\sqrt{2} \end{pmatrix}, \quad \langle\phi_2\rangle = \begin{pmatrix} 0 \\ v\sin\beta e^{i\xi}/\sqrt{2} \end{pmatrix}$$

Mass eigenstates:

$$\begin{pmatrix} h_1 \\ h_2 \\ h_3 \end{pmatrix} = \begin{pmatrix} -s_\alpha c_{\alpha_b} & c_\alpha c_{\alpha_b} & s_{\alpha_b} \\ s_\alpha s_{\alpha_b} s_{\alpha_c} - c_\alpha c_{\alpha_c} & -s_\alpha c_{\alpha_c} - c_\alpha s_{\alpha_b} s_{\alpha_c} & c_{\alpha_b} s_{\alpha_c} \\ s_\alpha s_{\alpha_b} c_{\alpha_c} + c_\alpha s_{\alpha_c} & s_\alpha s_{\alpha_c} - c_\alpha s_{\alpha_b} c_{\alpha_c} & c_{\alpha_b} c_{\alpha_c} \end{pmatrix} \begin{pmatrix} H_1 \\ H_2 \\ A \end{pmatrix}$$

2HDM

In order to make a connection with baryogenesis, I must make a model.

Higgs coupling

$$c_t = \frac{\cos\alpha}{\sin\beta}\cos\alpha_b\ , \quad c_b = -\frac{\sin\alpha}{\cos\beta}\cos\alpha_b$$

$$\tilde{c}_t = -\cot\beta\sin\alpha_b\ , \quad \tilde{c}_b = -\tan\beta\sin\alpha_b$$

α_b measures the CPV

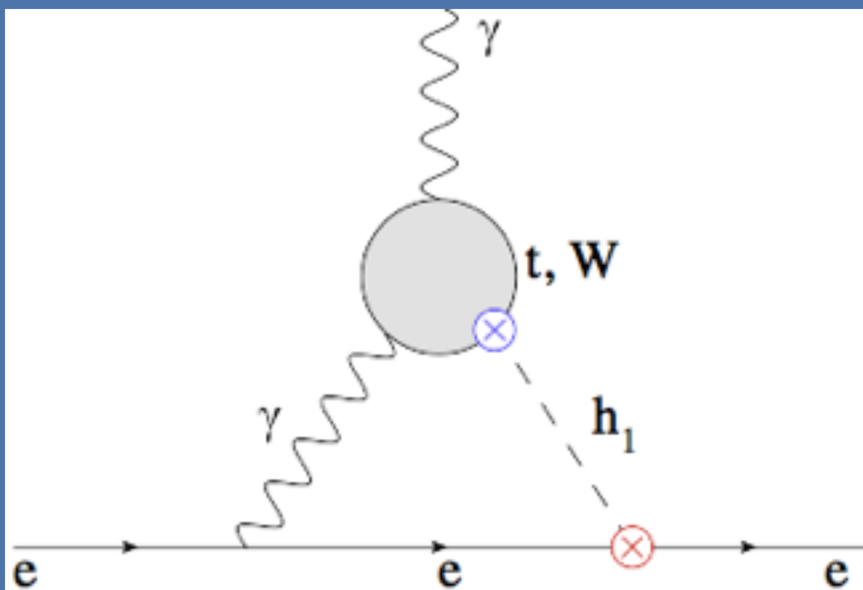
$$\tan\alpha_b \approx \frac{-\lambda_5\sin 2\xi\, v^2}{m_{h^+}^2 + (\lambda_4 - \lambda_5\cos 2\xi)v^2/2} \lesssim \xi$$

$$\mathcal{L}_{h_1VV} = \cos\alpha_b\sin(\beta-\alpha)\mathcal{L}_{hVV}^{\rm SM} \equiv a\mathcal{L}_{hVV}^{\rm SM}$$

	$\gamma\gamma$	WW^*	ZZ^*
ATLAS	1.17 ± 0.27 [20]	$0.99^{+0.31}_{-0.28}$ [22]	$1.44^{+0.40}_{-0.33}$ [24]
CMS	$1.14^{+0.26}_{-0.23}$ [21]	$0.72^{+0.20}_{-0.18}$ [23]	$0.93^{+0.29}_{-0.25}$ [25]
	bb	$\tau\tau$	
ATLAS	0.52 ± 0.40 [26]	$1.4^{+0.5}_{-0.4}$ [28]	
CMS	1.15 ± 0.62 [27]	0.78 ± 0.27 [29]	

LHC Higgs fit data after last summer

Bounds from EDM



D. McKeen, M. Pospelov, A. Ritz,
PRD, 86, 113004 (2012)

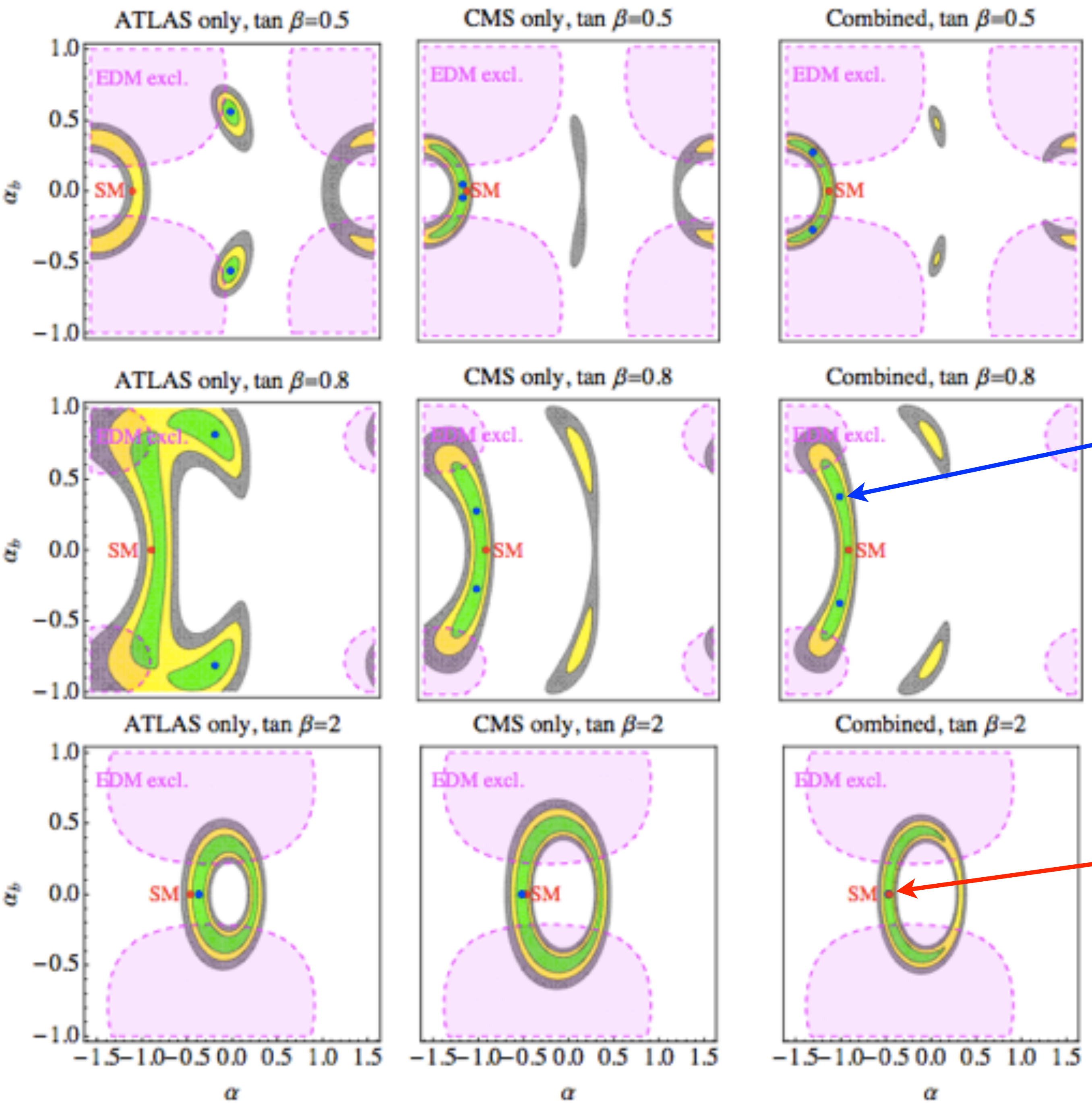
When there is a CP odd operator contributes to hgg or $h\gamma\gamma$.

The same operators would contribute to the EDM or CEDM

$$\tilde{c}_\gamma \sim \mathcal{O}(10^{-1}) - \mathcal{O}(10^{-2})$$

Bounds from neutron EDM and chromo-EDM (CEDM) are much weaker due to small u, d quark charge and Wilson coefficient in RG running.

Second region



Blue points: best fits

sweet spot around $\tan\beta \sim 1$

SM

J. S,Y. Zhang, Phys. Rev. Lett. 111 (2013) 091801

New ACME results

Much Tighter constraints than before:

$|d_e| < 8.7 \times 10^{-29} e\mathrm{cm}$ at 90% C. L.

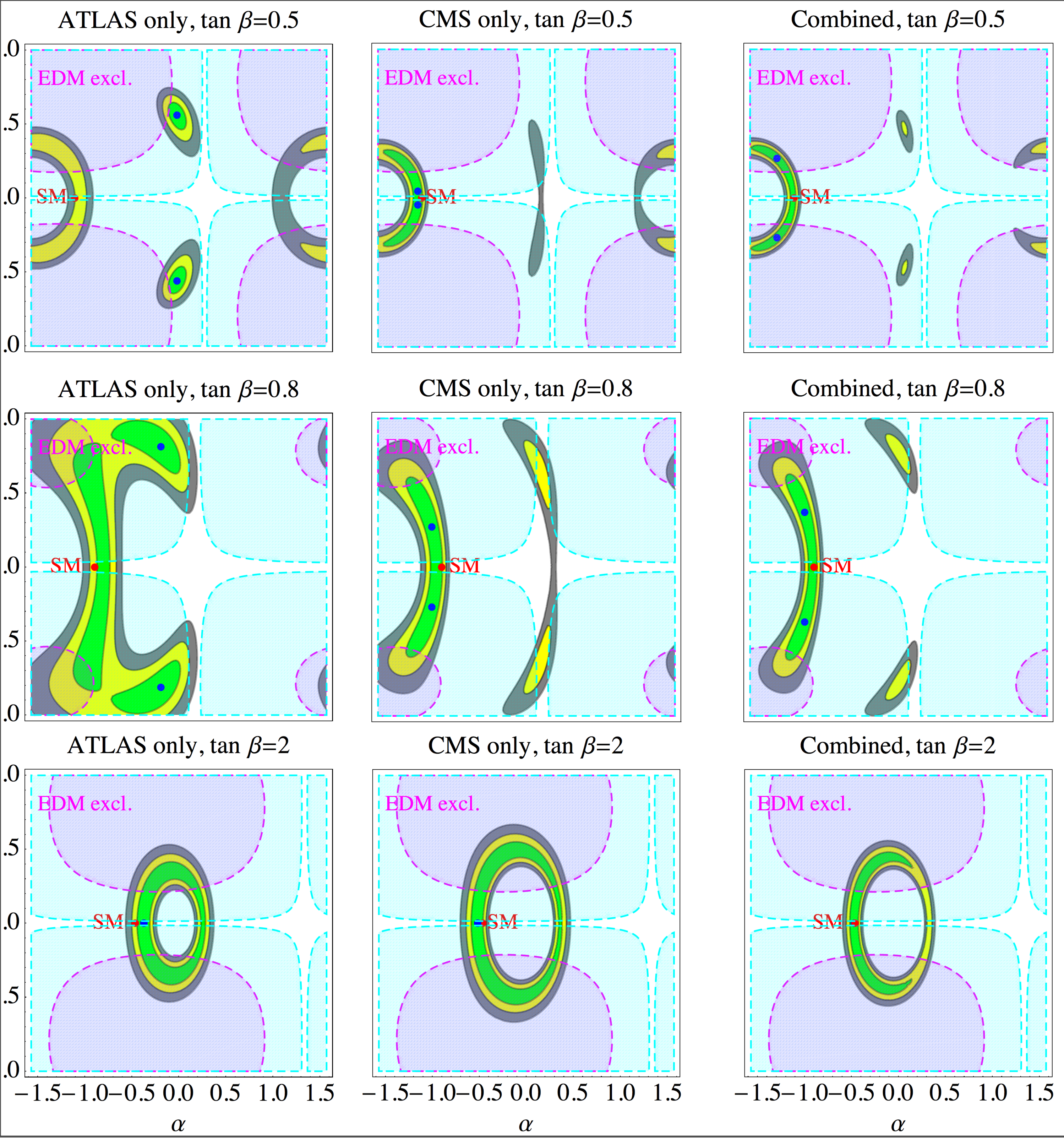
More than one order improvements

Naively constraints $\tilde{c}_\gamma \sim \mathcal{O}(10^{-2}) - \mathcal{O}(10^{-3})$

J. Brod; U. Haisch and J. Zupan, JHEP, 1311, 180 (2013)

But is that really the general case? No need for CPV direct search?

Where are the room for direct CPV searches?



ılts

Much Tightly constrained than before:

J. S, Y. Zhang, Phys. Rev. Lett. 111 (2013) 091801

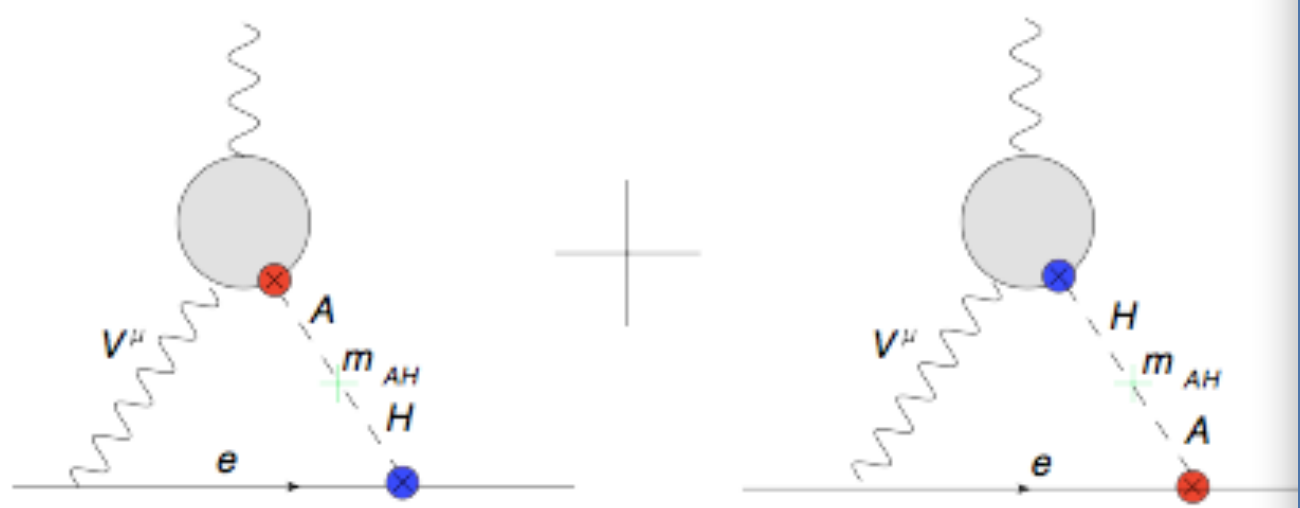
2HDM case

$$\mathcal{L}_{\rm eff} = \frac{m_f}{v} h \bar{f} \left(c_f + i\tilde{c}_f \gamma^5\right) f + \frac{\alpha}{\pi v} h \left(c_\gamma F^{\mu\nu} V_{\mu\nu} + \tilde{c}_\gamma F^{\mu\nu} \tilde{V}_{\mu\nu}\right),$$

$$\mathcal{L}_{\rm eff} = -i d_e \bar{e} \sigma^{\mu\nu} \gamma_5 e \partial_\mu A_\nu$$

$$\frac{d_e}{e} = \frac{\alpha m_e}{4\pi^3 v^2} \left[-c_e \tilde{c}_\gamma \log\left(\frac{\tilde{\Lambda}^2_{{\rm UV},\,i}}{m^2_{h_i}}\right) + \tilde{c}_e c_\gamma \log\left(\frac{\Lambda^2_{{\rm UV},\,i}}{m^2_{h_i}}\right) \right]$$

EFT only for illustration

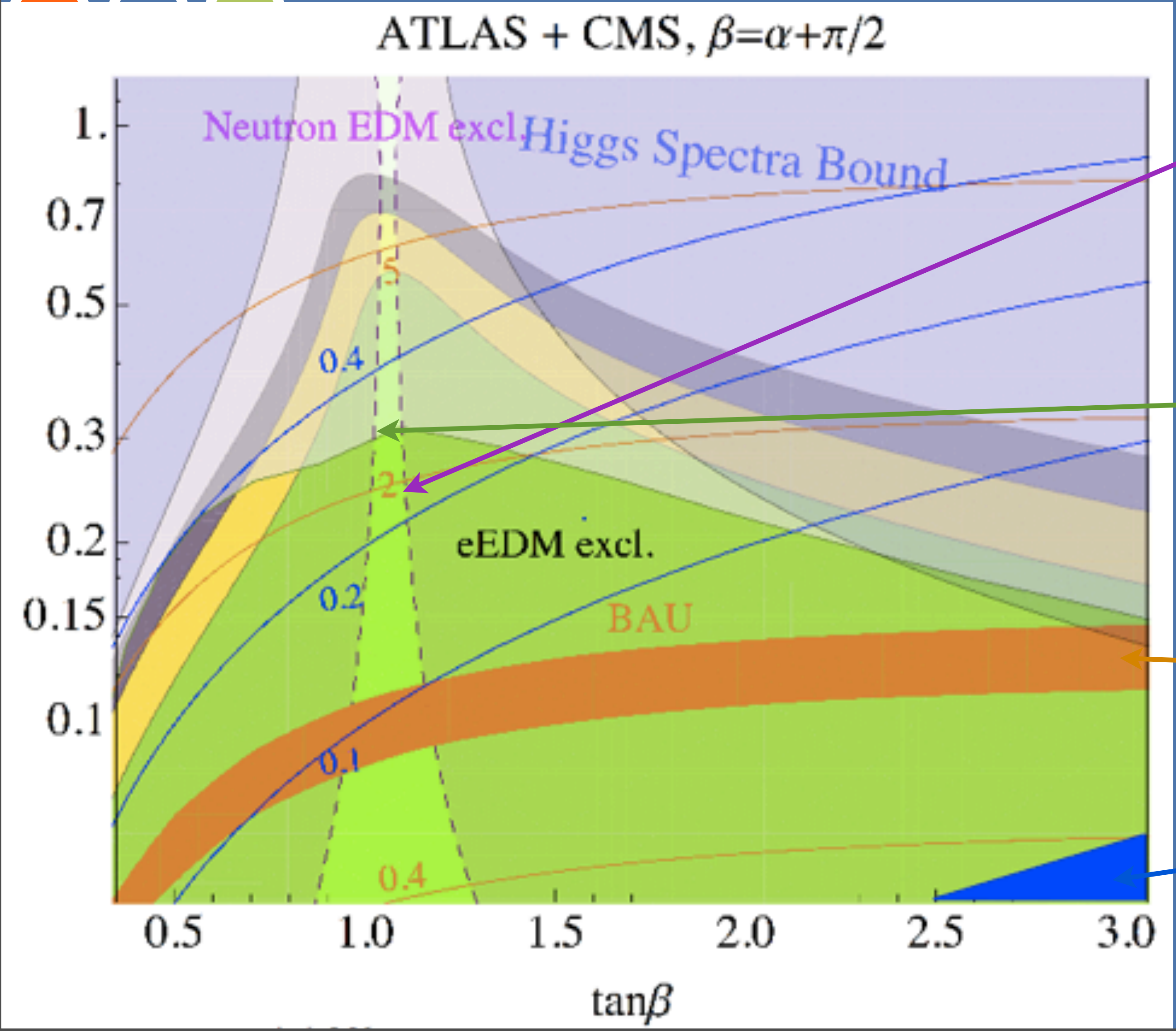


The two pieces can naturally cancel each other

The Higgs is a CP mixture!

2HDM case

Final Results



ACME bound

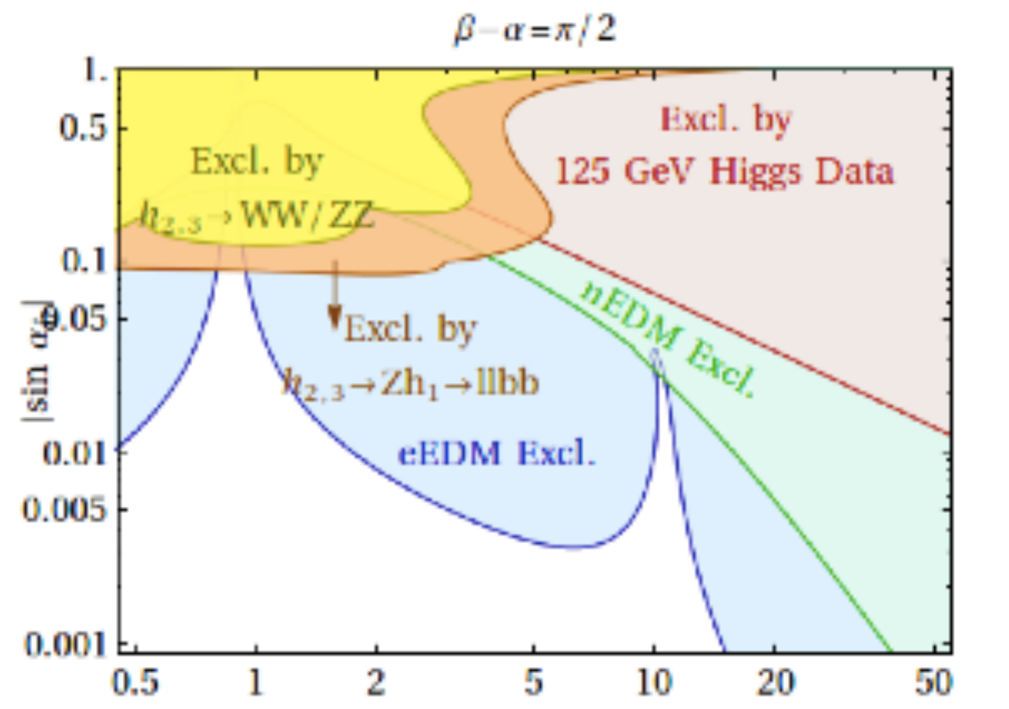
Future Neutron EDM bound will probe this region

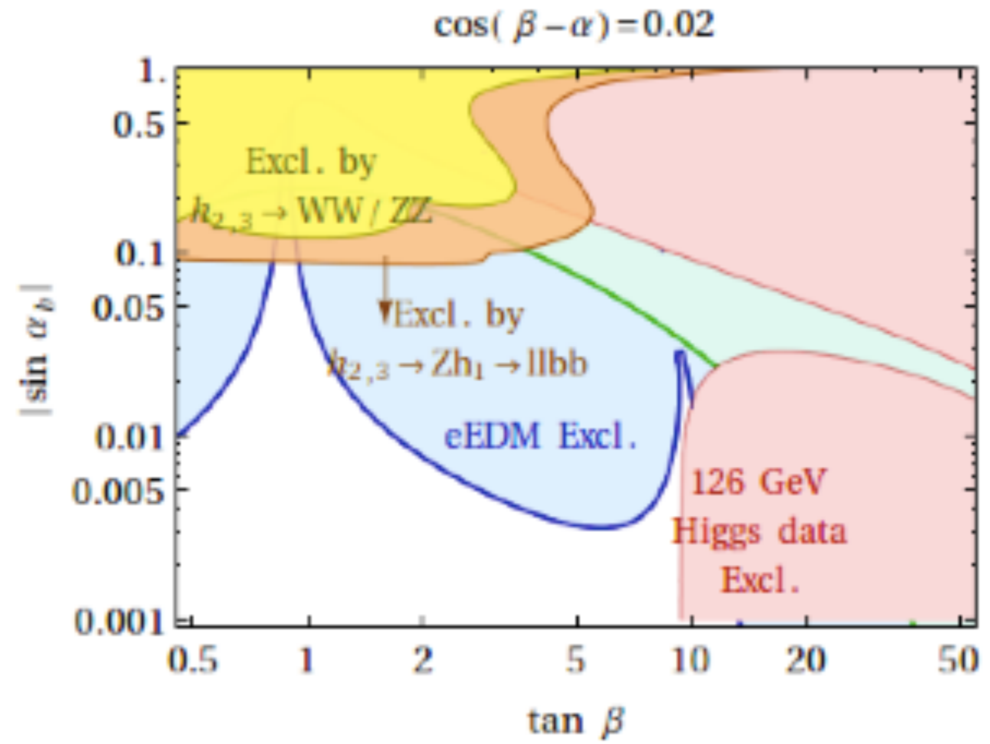
Preferred by EWBG

$\tilde{c}_\gamma \sim \mathcal{O}(10^{-2})$

LG. Bian, T. Liu, J. S,
Phys.Rev.Lett. 115 (2015) 021801

Heavy Higgs Searches





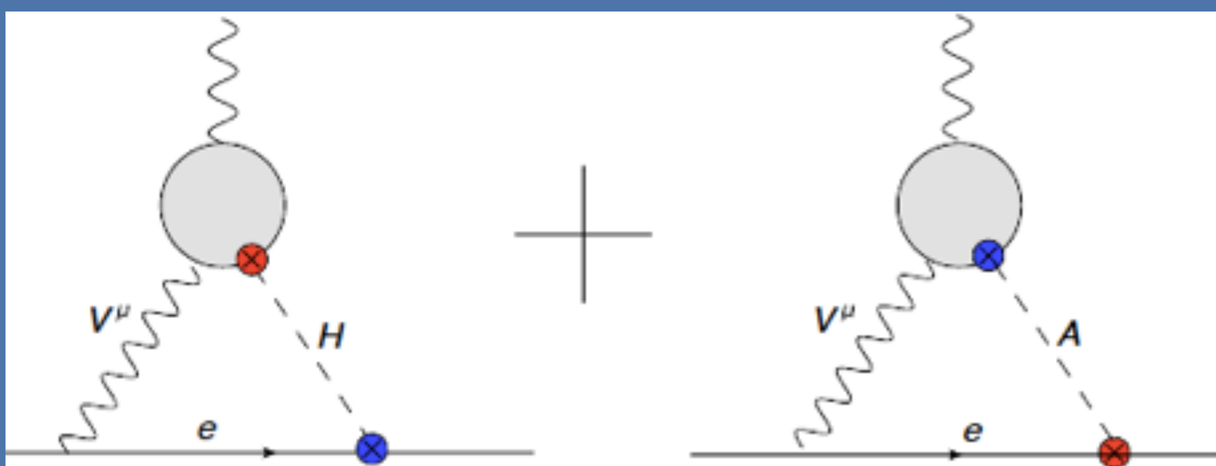
C-Y. Chen, S. Dawson, Y. Zhang, 1503.01114

There are also heavy Higgs searches bound (strong in the cancellation region)

MSSM case

$$\left[\frac{de}{e}\right] \approx C\tilde{c}_e^A \sum_{j=1,2}\left(c_\gamma^{\tilde{\chi}_j^\pm}\ln\frac{1}{z^A_{\tilde{\chi}_j^\pm}} + c_\gamma^{\tilde{\tau}_j^\pm}\ln\frac{1}{z^A_{\tilde{\tau}_j^\pm}}\right) - Cc_e^H\sum_{j=1,2}\tilde{c}_\gamma^{\tilde{\chi}_j^\pm}\ln\frac{1}{z^H_{\tilde{\chi}_j^\pm}}$$

EFT only for illustration



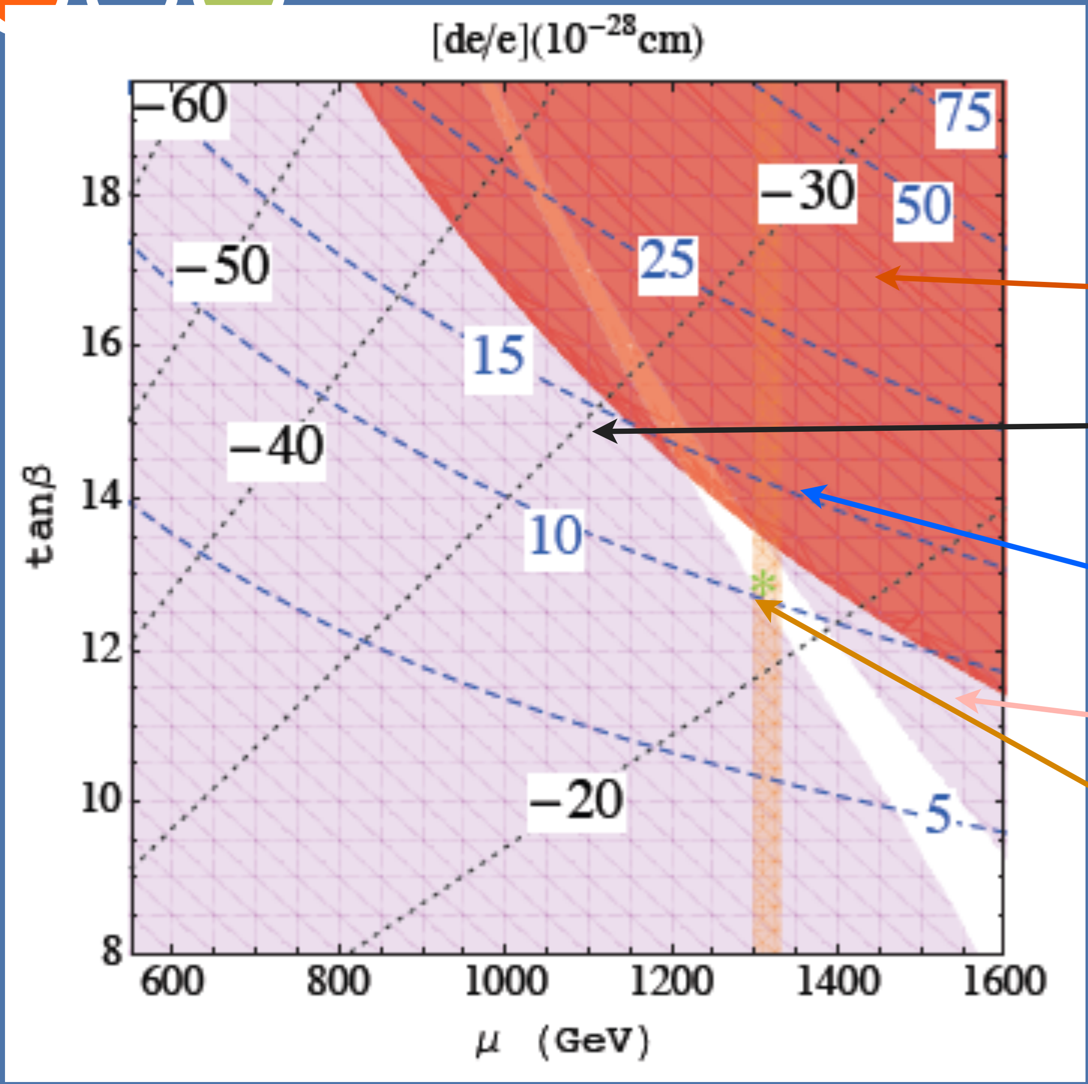
MSSM with chargino & staus

Negligible CPV in the Higgs sector

Heavy Higgs coupling enhanced by tan beta

Non-standard Higgs mediate the cancellation

Change in the CPSuperH



Open the Heavy Higgs CPV search

Mercury exclusion

Chargino contour

Stau contour

ACME exclusion

Preferred by EWBG

LG. Bian, T. Liu, J. S,
Phys.Rev.Lett. 115 (2015) 021801

Correction in CPSuperH

- A sign mistake in the anomalous D of the dipole operator (smaller EDMs at low energy).
- No operator mixing effects are considered
- Detailed RG running in the Mercury & other EDMs
- Update the matrix elements (factor of 10 difference)
- W boson loop included in the Barr-Zee diagram.

The bounds with QCDs are much weaker

Correction in CPSuperH

$$\gamma_s = \begin{bmatrix} +8C_F & 0 & 0 \\ +8C_F & +16C_F - 4N & 0 \\ 0 & +2N & N + 2n_f + \beta_0 \end{bmatrix}, \quad (36)$$

$$\gamma_f = \left[-12C_F + 6\right], \quad (37)$$

$$\gamma'_f = \begin{bmatrix} -12C_F & 0 \\ 0 & -12C_F \end{bmatrix}, \quad (38)$$

and

$$\gamma_{sf} = \begin{bmatrix} +4 & +4 & 0 \\ 0 & 0 & 0 \end{bmatrix}, \quad (39)$$

where $N = 3$, $C_F = (N^2 - 1)/(2N) = 4/3$, $\beta_0 = (11N - 2n_f)/3$ and n_f is the flavor number.

Now, we explore details of the RG running.

Firstly, we need to use the $n_f = 5$ version of the above RGE for running from Λ(we use M_H in our analysis) to m_b. In which, CP-odd four-fermion operators (33) play a significant role. For our case, we one consider the operators containing the bottom quark for $\tan\beta$ enhancement effects. In addition to coefficients $C_{b(u,d)}$, $C_{(u,d)b}$ that contribute to the light quark CEDM through RGE operator mixing, we also considered the coefficient C_{bb} which mixes with and contributes to the b-quark CEDM. Keeping only the leading logarithmic terms that make additional contributions to the CEDMs of bottom and light quarks at the matching scale $\mu = m_b$, we have

bellow m_c scale we use 3 flavors version of RGE.

After above processes, we have the neutron EDM

$$d_n = \left(e\zeta_n^u\delta_u + e\zeta_n^d\delta_d\right) + \left(e\tilde{\zeta}_n^u\tilde{\delta}_u + e\tilde{\zeta}_n^d\tilde{\delta}_d\right) + \beta_n^G C_{\tilde{G}}, \quad (44)$$

with update hadronic matrix elements $\zeta_n^u = 0.82 \times 10^{-8}$, $\zeta_n^d = -3.3 \times 10^{-8}$, $\tilde{\zeta}_n^u = 0.82 \times 10^{-8}$, $\tilde{\zeta}_n^d = 1.63 \times 10^{-8}$ and $\beta_n^G = 2 \times 10^{-20}\, e\,\mathrm{cm}$ [45].

(2) Mercury EDM

Though the contributions from d_e^E and from the CP-odd electron-nucleon interactions

$$\mathcal{L} = C_S \bar{e} i\gamma_5 e \bar{N} N + C_P \bar{e} e \bar{N} i\gamma_5 N + C'_P \bar{e} e \bar{N} i\gamma_5 \tau_3 N, \quad (45)$$

are also incorporated in the CPsuperH, the mercury EDM is mainly contributed by the nuclear Schiff moment (S). The Schiff moment is generated by long-range, pion-exchange mediated P- and T-violating nucleon-nucleon interactions,

$$\mathcal{L}_{\pi NN}^{\mathrm{TVPV}} = \bar{N}\left[\bar{g}_\pi^{(0)}\vec{\tau}\cdot\vec{\pi} + \bar{g}_\pi^{(1)}\pi^0 + \bar{g}_\pi^{(2)}(2\tau_3\pi^0 - \vec{\tau}\cdot\vec{\pi})\right] N \quad (46)$$

In a general context, the isoscalar and isovector couplings $\bar{g}_\pi^{(0)}$, $\bar{g}_\pi^{(1)}$ are dominant over the isotensor coupling $\bar{g}_\pi^{(2)}$ [45], so the mercury EDM is approximately given by [45],

$$d_{\mathrm{Hg}} = \kappa_S S \approx \kappa_S \frac{2m_N g_A}{F_\pi}\left(a_0\bar{g}_\pi^{(0)} + a_1\bar{g}_\pi^{(1)}\right), \quad (47)$$

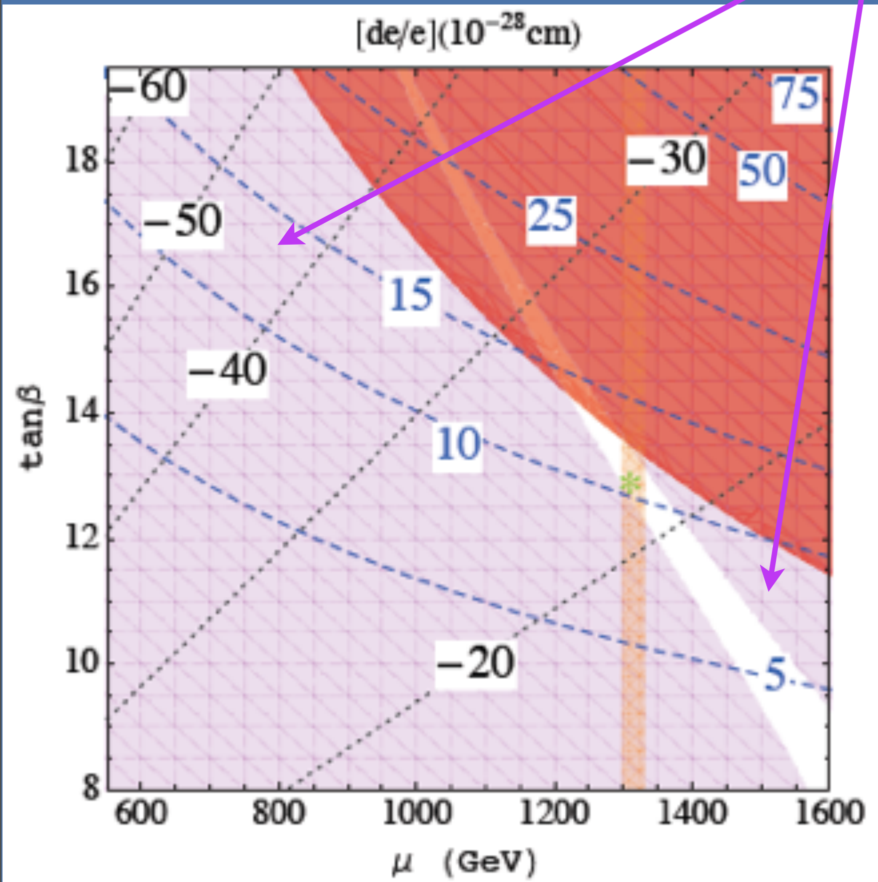
See

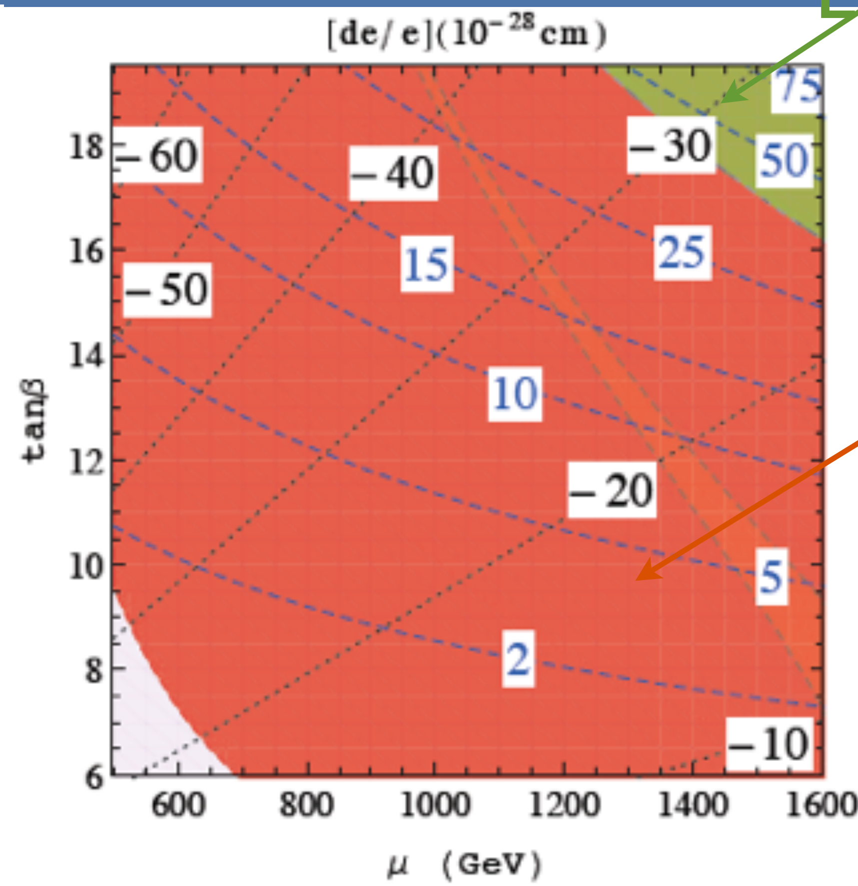
LG. Bian, T. Liu, J. S, 1411.6695

Codes will be updated in the web soon

Correction in CPSuperH

After correction: ACME Before correction: Neutron EDM bound:





Mercury

LG. Bian, T. Liu, J. S, Phys.Rev.Lett. 115 (2015) 021801

Future of EDMs

Category	EDM Limit ($e \cdot$cm)	Experiment	Standard Model value ($e \cdot$cm)
Electron	8.7×10^{-29}	ThO molecules in a beam [12]	10^{-38}
Neutron	2.9×10^{-26}	Ultracold neutrons in a bottle [11]	10^{-31}
Nucleus	3.1×10^{-29}	^{199}Hg atoms in a vapor cell [13]	10^{-33}

K Kumar, Z-T. Lu, M. R-Musolf 1312.5416

TRIUMF:

The long-term goal, to be reached in 2018 and beyond, is $d_n < 1 \times 10^{-28}$ $e \cdot$cm.

Proton ring: $\sim 1 \times 10^{-29} e \cdot cm$

Mercury improve by 1~2 orders soon

a projected sensitivity of $10^{-28} - 10^{-29} e \cdot$cm for ^{225}Ra, $\sim$ $10^{-31} - 10^{-32} e \cdot$cm for ^{199}Hg.

1~3 orders of magnitude, close the cancellation region

Sth is up in the air?

Category	EDM Limit ($e\cdot$cm)	Experiment	Standard Model value ($e\cdot$cm)
Electron	8.7×10^{-29}	ThO molecules in a beam [12]	10^{-38}
Neutron	2.9×10^{-26}	Ultracold neutrons in a bottle [11]	10^{-31}
Nucleus	3.1×10^{-29}	^{199}Hg atoms in a vapor cell [13]	10^{-33}

K Kumar, Z-T. Lu, M. R-Musolf 1312.5416

If we take this "over-optimistic" case

a projected sensitivity of $10^{-28} - 10^{-29} e\cdot$cm for ^{225}Ra, $\sim$ $10^{-31} - 10^{-32} e\cdot$cm for ^{199}Hg.

We are approaching the SM results! (Notice nuclear uncertainties are also shrinking nowadays)

Think more!

If one of those experiments are before the end of LHC (including HL-LHC)

Do we need direct LHC CPV searches?

or even CPV searches in the future lepton colliders such as CEPC in China?

EDM experiments are simply electron or proton constitutes

This means CPV, if exsits, might be flavorful

EWBG from CPV in Bs

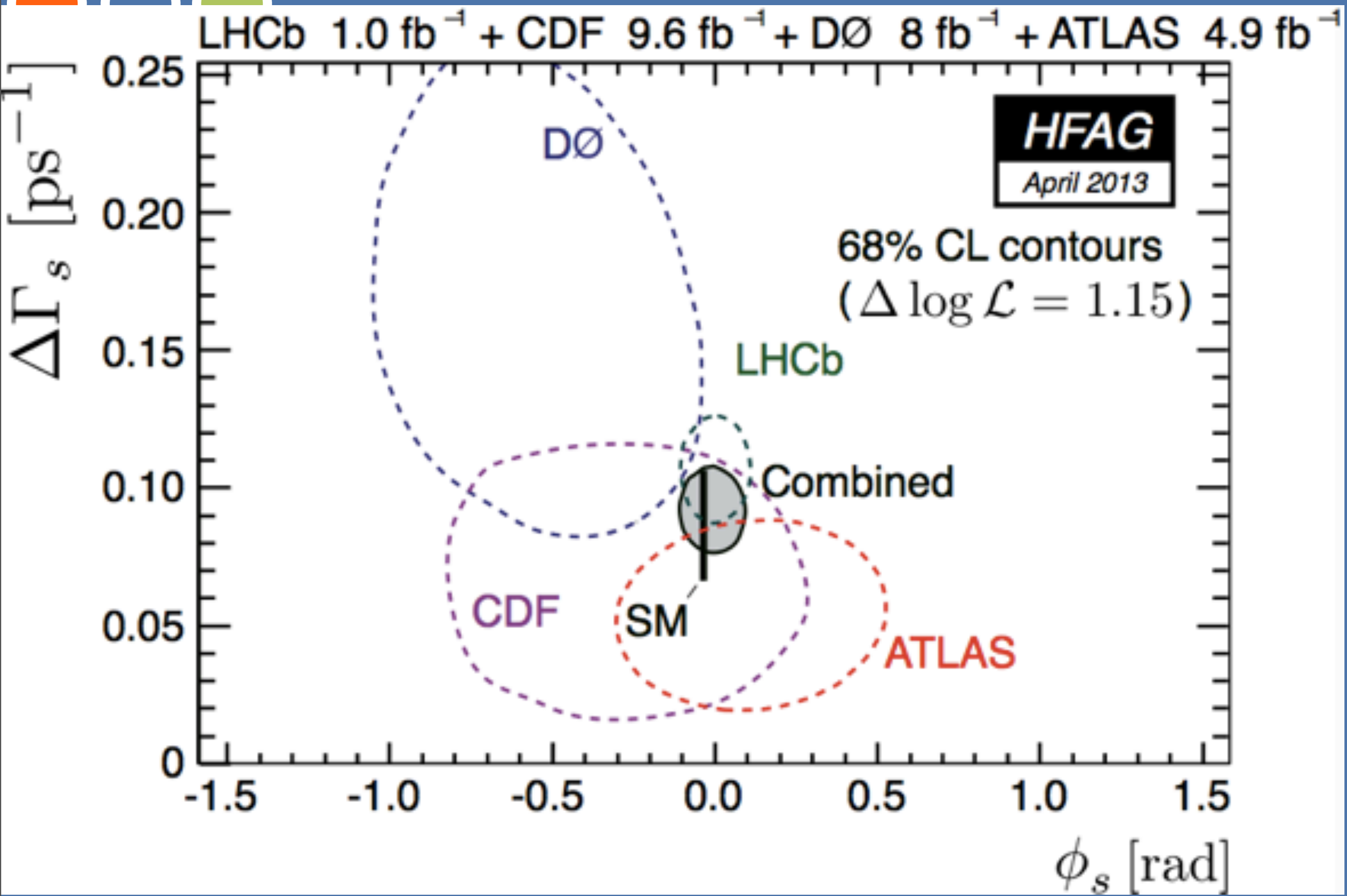
CP violation in the B system → Generate baryons

How ?

A common CP violating phase.

Electroweak Beautygenesis

Bs mixing data



Di-muon anomaly is gone, B meson CPV phases is still measured

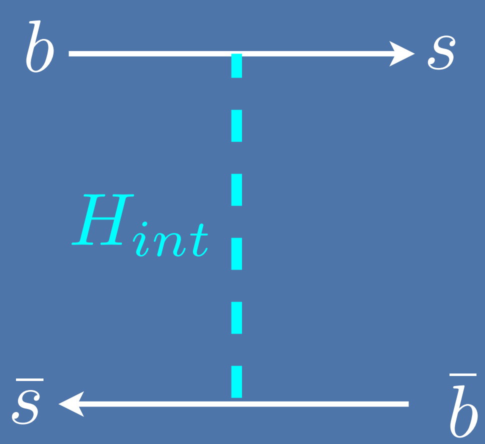
Motivations for the future tests!

Precision improvement crucial for further test of

Electroweak Beautygenesis

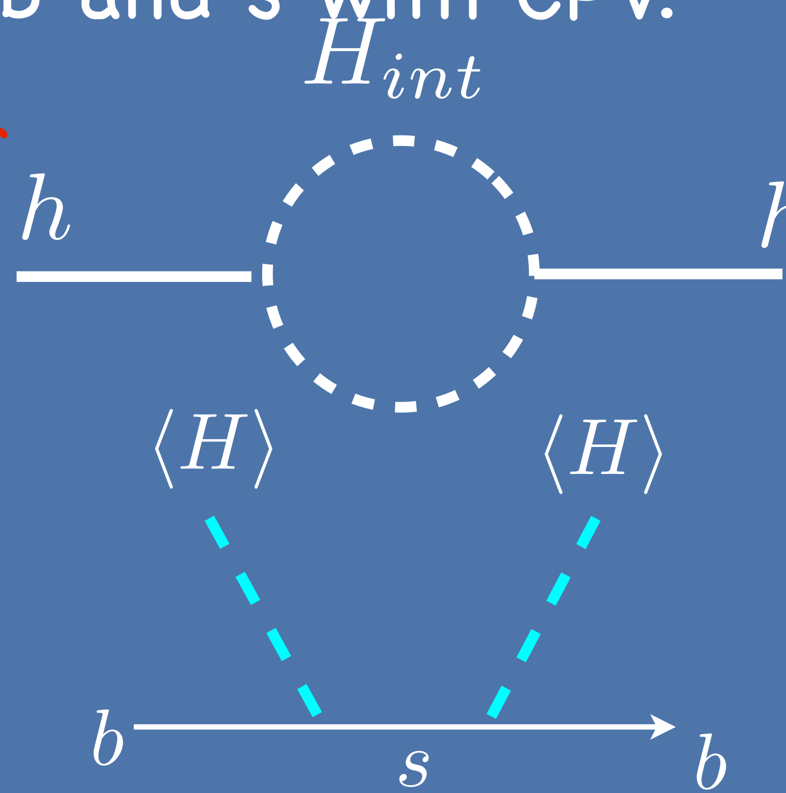
The key idea is to consider extra inert scalars which dominantly couples to b and s with CPV.

New source for CPV in Bs mixing



An extra scalar triggers 1st order EWPT.

CPV in b,s in the Higgs background



T. Liu, M. Ramsey-Musolf J. S, Phys. Rev. Lett. 108 (2012) 221301

EW Beautigenesis:

Consider a type III 2HDM:

$$\mathscr{L}_{\text{Yukawa}} = -\overline{Q_L}\left[\sum_{j=1}^{2}\Phi_j Y_j^D\right]D_R - \overline{Q_L}\left[\sum_{j=1}^{2}\widetilde{\Phi_j} Y_j^U\right]U_R + h.c$$

For b-s system, consider Yukawa couplings below:

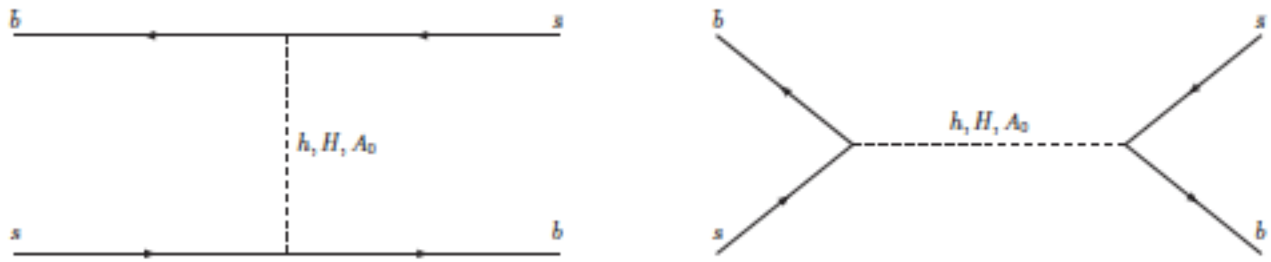
$$M_D(\bar{z}) = \frac{1}{\sqrt{2}}\left[v_1(\bar{z})\begin{pmatrix}0 & 0 & 0\\ 0 & 0 & 0\\ 0 & (Y_1^D)_{32} & (Y_1^D)_{33}\end{pmatrix} + v_2(\bar{z})\begin{pmatrix}0 & 0 & 0\\ 0 & 0 & 0\\ 0 & (Y_2^D)_{32} & (Y_2^D)_{33}\end{pmatrix}\right]$$

$$(M_D)_{ij} = \frac{v s_\beta}{\sqrt{2}} Y_{2,ij}^D\left[1 + \cot\beta\, sgn(Y_{2,ij}^D) r_{ij}^D e^{i\phi_{ij}^D}\right],$$

$$|(M_D)_{32}|^2 + |(M_D)_{33}|^2 = m_s^2 + m_b^2$$

$Y_{32}^D, \phi_{32}^D, r_{32}^D (\equiv 1) \Rightarrow$ CP, BAU, FCNC

B meson mixing



$$\mathcal{H}_{\rm eff}^{\Delta B=2} = -\sum_{i=(h,)H,A_0} \frac{1}{m_i^2 v^2}\left[(\kappa_{sb}^{i*})^2(\bar{s}P_L d)(\bar{s}P_L d) + (\kappa_{bs}^{i})^2(\bar{s}P_R d)(\bar{s}P_R d) + 2\kappa_{sb}^{i*}\kappa_{bs}^{i}(\bar{s}P_L d)(\bar{s}P_R d)\right]$$

$$C_1^{\rm SLL} = -\sum_{i=(h,)H,A_0} \frac{(\kappa_{sb}^{i*})^2}{m_i^2 v^2}$$

$$C_1^{\rm SRR} = -\sum_{i=(h,)H,A_0} \frac{(\kappa_{bs})^2}{m_i^2 v^2}$$

$$C_2^{\rm LR} = -\sum_{i=(h,)H,A_0} \frac{2\kappa_{sb}^{i*}\kappa_{bs}^{i}}{m_i^2 v^2}$$

RG running are also included

$$\Delta M_s = 2|M_{12}^s| = 2|\langle \overline{B}_s^0|\mathcal{H}_{\rm SM,eff}^{\Delta B=2}(\mu_b)|B_s^0\rangle| = \frac{2}{3} m_B F_B^2 [2.46 C_2^{\rm LR} - 1.47(C_1^{\rm SLL} + C_1^{\rm SRR})]$$

Flavor constrains

	H	h	A_0
κ	$s_{\beta-\alpha}\frac{1}{\sqrt{2}}N'_D$	$-c_{\beta-\alpha}\frac{1}{\sqrt{2}}N'_D$	$-\frac{iN'_D}{\sqrt{2}}$

H & A effect cancels in the "alignment" limit

One loop: suppressed by $(m_W/m_{H,A_0})^4$ compared with SM diagrams.

B to s gamma:

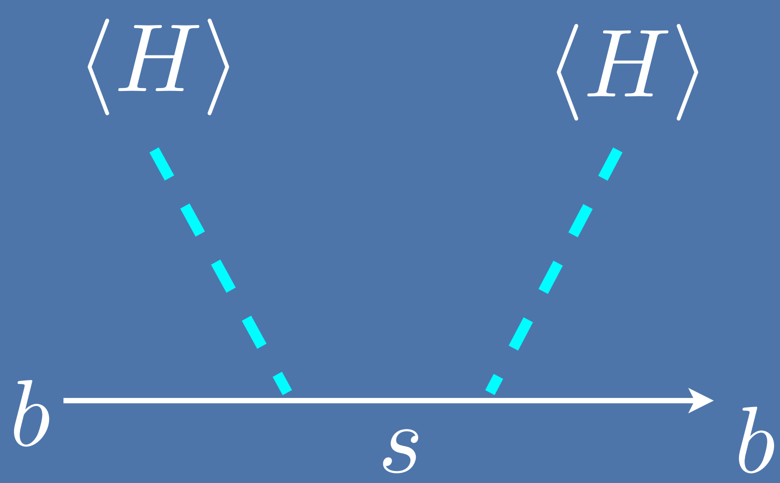
$$Br(B \to X_s\gamma)^{exp}_{E_\gamma>1.6\mathrm{GeV}} = (355 \pm 24 \pm 9) \times 10^{-6}, \ \chi^2/\mathrm{DOF} = 0.85/5, \quad \mathrm{HFAG\ 2012.}$$

$$Br(B \to X_s\gamma)^{\mathrm{SM,\ NNLO}}_{|E_\gamma>1.6\mathrm{GeV}} = (315 \pm 23) \times 10^{-6}.$$

Practically the effect is small

Baryon generation

CPV sources in the Higgs background



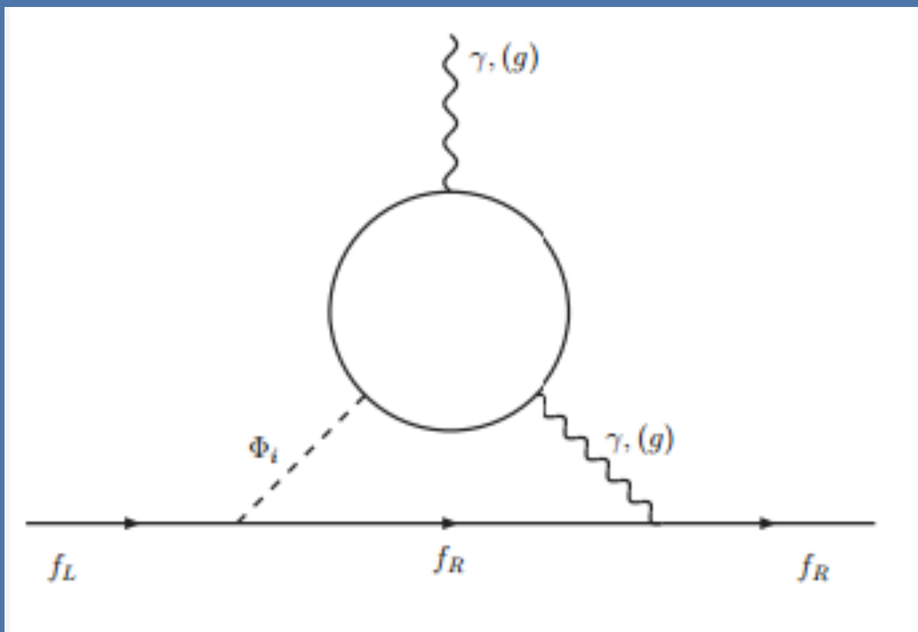
Using the thermal mass

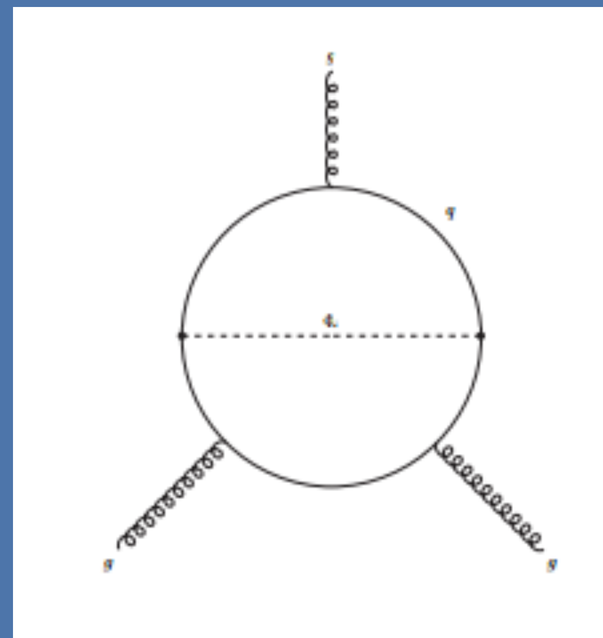
$$S^{\not{C}\!P}_{b_L} = \frac{N_c \Delta(\bar{z})^2}{\pi^2} \dot{\theta}(\bar{z}) \int_0^\infty \frac{dk\, k^2}{\omega_{b_L} \omega_{s_R}} \times \mathrm{Im}\left\{ \frac{(\mathcal{E}^*_{b_L} \mathcal{E}_{s_R} - k^2)(n_F(\mathcal{E}_{s_R}) - n_F(\mathcal{E}^*_{b_L}))}{(\mathcal{E}_{s_R} - \mathcal{E}^*_{b_L})^2} + \frac{(\mathcal{E}_{b_L} \mathcal{E}_{s_R} + k^2)(n_F(\mathcal{E}_{s_R}) + n_F(\mathcal{E}_{b_L}))}{(\mathcal{E}_{s_R} + \mathcal{E}_{b_L})^2} \right\}$$

Invariant CP phase:

$$\theta_{ij}^{D\prime} = -\frac{v^2(\bar{z})\beta'(\bar{z})}{2|M_{ij}^D|^2} |Y^D_{1,ij}||Y^D_{2,ij}| \sin\left[\arg(v_1 v_2^* Y^D_{1,ij} Y^{D\,*}_{2,ij})\right]$$

EDMs

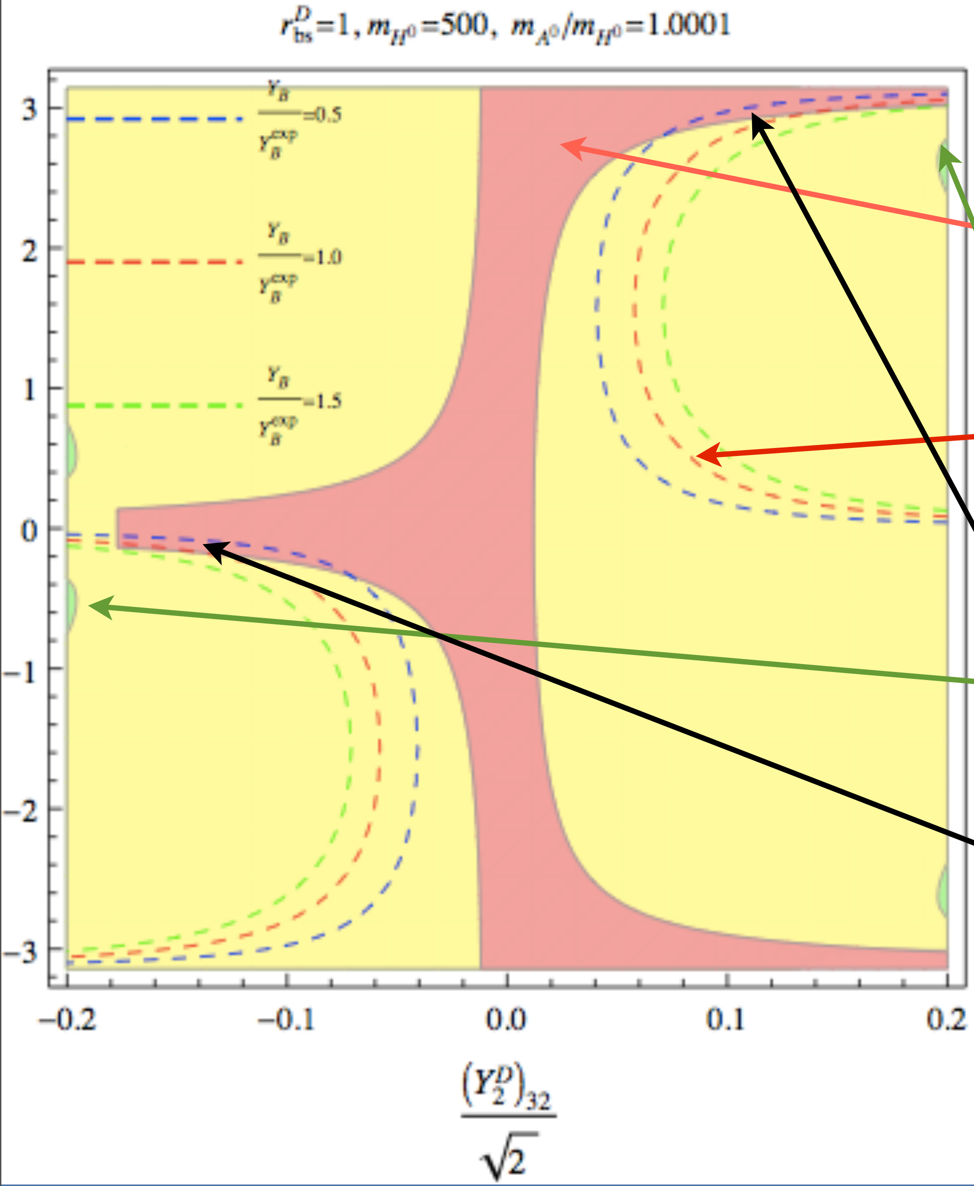




No direct Barr-Zee diagram contributions

Weinberg operator contributions are small due to small bottom quark mass

Bs --> Xs Gamma



Bottom mass constrain

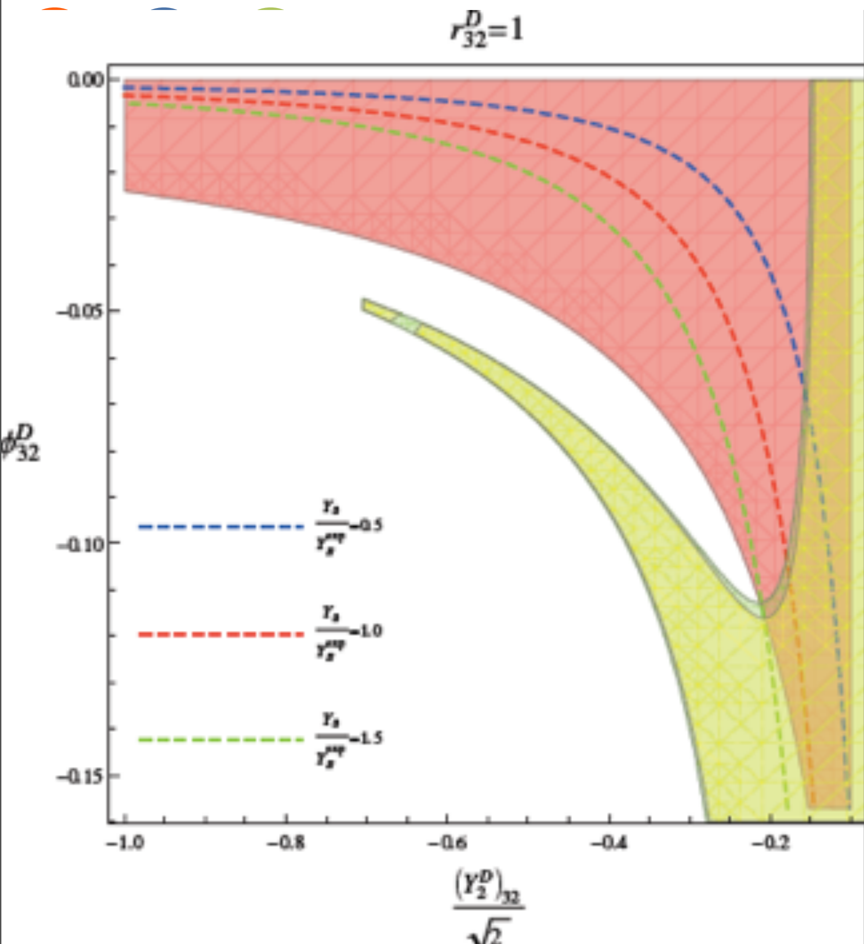
Baryon asymmetry

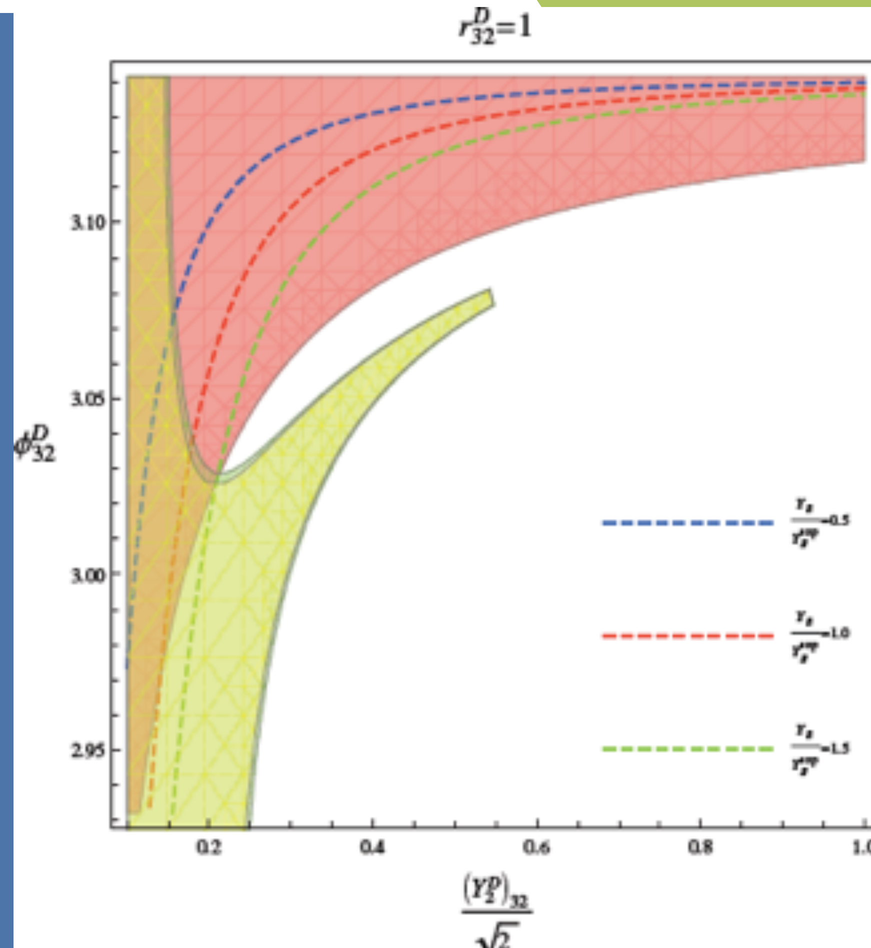
B-s mixing allowed region

Overall allowed region

H. Guo, S. Hong, T. Liu, M. Ramsey-Musolf J. S, in progress

Allowed region





Future projection on the LHCb sensitivity will be added soon

Summary & Outlook

- I present many examples where EW baryogenesis came from a CPV Higgs sector (general arguments).
- There is indeed a natural connection between BAU in EWBG and CPV in the Higgs sector.
- After the ACME results, large CPV effects are possible due to cancellation, future EDMs or LHC searches will soon cover those regions.
- Direct CPV at the LHC or future colliders are worth to look for even after future EMD experiments, especially in the heavy flavor cases (t or b). Great for both LHC & LHCbs!

Plenary sessions

General Talks

Joe Lykken: conference summary
e+e- Colliders: Tomohiko Tanabe
Future Hadron Colliders: Liantao Wang

Confirmed theoretical speakers

Nima Arkani-Hamed: TBA
Kyu Jung Bae: SUSY and dark matter
Brando Bellazzini: Composite Higgs Models
Ralph Blumenhagen: Moduli Stabilization/inflation
Radja Boughezal: Status of Precision SM Higgs Cross Section and Branching Ratio Calculations
Nathaniel Craig: Neutral Naturalness
Mirjam Cvetic: F-theory
Henriette Elvang: Amplitudes
Raphael Flauger: Implications of CMB Observations
Gordon Kane: From underlying Planck scale M-theory to predictions for TeV scale superpartners
Mathew Kleban: Inflation
Mariangela Lisanti: Dark Matter Theory
Steve Martin: Status of weak scale SUSY
Fernando Quevedo: SUSY-breaking/phenomenology in IIB with moduli stabilization
Joe Polchinski: D-brane and anti D-brane dynamics
Lisa Randall: TBA
Yael Shadmi: SUSY Flavor
Jessie Shelton: Higgs in the BMSSM (SUSY and non-SUSY)
Jing Shu: EW phase transition and Baryogenesis
David Simmons-Duffin: The Conformal Bootstrap

International Workshop on Baryon & Lepton Number Violation

Sunday, April 26, 2015 - 5:00pm to Thursday, April 30, 2015 - 5:00pm

University of Massachusetts Amherst

Home Program Plenary Speakers Travel/Visiting Venue & Accommodation Registration

Plenary Speakers

Confirmed Speakers

Vincenzo Cirigliano, Los Alamos National Laboratory
Tim Chupp, U. Michigan
Yanou Cui, Perimeter Institute
Bonnie Fleming, Yale U.
George Fuller, U. California San Diego
Gerald Gabrielse, Harvard U.
Bjorn Garbrecht, Technical U. Munich
Susan Gardner, U. Kentucky
Peter Graham, Stanford U.
Eva Halkiadakis, Rutgers U.
Thomas Hambye, Brussels U.
Patrick Huber, Virginia Tech
Olga Igonkina, NIKHEF
Xiangdong Ji, U. Maryland/Shanghai Jiao Tong U.
Manfred Lindner, MPIK-Heidelberg
Tao Liu, Hong Kong U. Science & Technology
Robert McKeown, Jefferson Laboratory
Richard Milner, Massachusetts Institute of Technology
David Morrissey, TRIUMF
Jose Miguel No, U. Sussex
Stefano Profumo, U. California Santa Cruz
Goran Senjanovic, ICTP Trieste
Geraldine Servant, ICREA & IFAE Barcelona
Masato Shiozawa, Tokyo U.
Giovanni Signorelli, INFN Pisa
Michael Snow, Indiana U.
Jing Shu, Inst. Theoretical Physics & CAS
Jesse Thaler, Massachusetts Institute of Technology
Petr Vogel, Caltech

UMass Amherst Campus

Clockwise from top: Aerial view of campus including Lederle Gradu
Reseach Tower (left) and Du Bois Library (right), Campus Pond with
Old Chapel and Library, and North Residential Area looking Northe
towards the Peace Pagoda.